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1st International Conference on Industrial and Mechanical Engineering and Operations Management (IMEOM)

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1st International Conference on Industrial and Mechanical Engineering and Operations Management (IMEOM)

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Preface

The papers presented at First International Conference on Industrial and Mechanical Engineering and Operations Management (IMEOM), 23-24 December, 2017, Institution of Engineers Bangladesh (IEB), Dhaka, Bangladesh are incorporated in this volume.

With the presentation of papers on Industrial and Production Engineering (IPE) ,Mechanical Engineering (ME) and Operations Management from AUST, IUT, SUST, Khulna University, BUET, KUET, RUET, TGTDCL ,BUTEX, MIST, and Dhaka University, 1st International conference on Industrial and Mechanical Engineering and Operations Management (IMEOM 2017 Dhaka) was successfully held on 23-24 December 2017 at Engineers Recreation Centre(ERC)'s Conference Room and Dhaka Centre's Meeting Room of Institution of Engineers Bangladesh (IEB) Headquarters new building, Ramna, Dhaka 1000, Bangladesh. It was organized by Industrial Engineering and Operations Management (IEOM) Society of Bangladesh and supported by IEOM Society International

Five keynotes and three invited talks were delivered by the academicians and industry professionals from Canada, USA, UK, and Bangladesh. A workshop on academic paper writing and a panel discussion on Industry-Academia collaboration were two more prominent events of the conference.

Prof Dr A.M.M. Safiullah, Vice-Chancellor, Ahsanullah University of Science & Technology(AUST), inaugurated the conference on 23 December 2017 as the Chief Guest of the opening ceremony which was presided over by the Chair of the conference Prof Dr. Md. Nurul Absar Chowdhury, Dean, Faculty of Engineering and Technology, Islamic University of Technology (IUT).

We gratefully appreciate the sponsorship from SK Machinery International, Asian Elevator & Technology and S Tourism. Besides, we sincerely acknowledge the cooperation of Easy Chair online conference management system to effectively manage the conference.

Editorial Board

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Effect of variable viscosity and variable thermal conductivity of biomagnetic fluid flow and heat transfer over a stretching sheet in the presence of magnetic dipole

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Abstract

In this study, we investigate the effects of exponential form of variable viscosity and linear form of thermal conductivity on the flow and heat transfer of biomagnetic fluid over a stretching sheet in the presence of magnetic dipole. In our model, we assume that the fluid viscosity varies with as an exponential function of temperature and thermal conductivity varies as a linear function of temperature. Also we assumed that the sheet temperature are varies with along the sheet and time. The governing are solved by using efficient numerically technique based on central differencing, on a tridiagonal matrix manipulation and on an iterative procedure. The influence of various parameters namely the viscosity and thermal conductivity parameter, ferromagnetic interaction parameter and temperature exponential parameter on the velocity, pressure and temperature fields are presented. The accuracy of the numerical result comparisons with previously published work is satisfactory.

Keywords: Biomagnetic fluid, variable viscosity, variable thermal conductivity, variable temperature, stretching sheet.

1. Introduction

Biomagnetic fluid dynamics is the base of principle of ferrohydrodynamics (FHD) and magnetrohydrodynamics (MHD) which deals with the magnetization and Lorentz force. In biomagnetic fluid dynamics under the applied magnetic field, the mathematical model was first developed by Haik et al. (1999). According to this model based on principle of FHD and considering blood is electrically non-conducting. An extended BFD, the mathematical model proposed by Tzirtzilakis (2005). This model based on principle of FHD and MHD and considering Lorentz force due to induced electric wire. Loukopoulos and Tzirtzilakis (2004) studied the biomagnetic fluid in a channel flow in spatially varying magnetic field. This analysis indicates that the presence of an external magnetic field has a significantly effect on flow of this fluid.

Most of researcher are describes the fluid flow is steady and fluid viscosity and thermal conductivity are constant. However, it is evident that the physical properties of fluid may change with temperature, especially the fluid viscosity and thermal conductivity. Kafoussias et al. (2008) analysis free force convective biomagnetic fluid. They consider their model, the fluid viscosity and thermal conductivity are varies with temperature and also consider the magnetization is vary with magnetic field intensity H. Prasad et al. (2016) studied the MHD flow and heat transfer over a stretching sheet with variable fluid properties. They consider the viscosity is varies as an inverse function of temperature. Salawu and Dada (2016) studied the radiative heat transfer and they considered the viscosity and thermal conductivity are varies with temperature. Makinde et al. (2016) investigated the MHD variable viscosity

reacting flow over a convectively heated plane in a porous medium with thermophoresis and radiative heat transfer. Salahuddin et al. (2015) and Shateyi et al (2010) study the fluid flow and heat transfer over a stretching sheet. They assumed the viscosity is varies with exponential function of temperature.

All the above studies deal with steady flow. But sometimes, the steady state conditions become unstable in some situation. The unsteady state condition is important in the study of fluid flow problem. Manjunatha and Gireesha (2016) analysis the MHD flow and heat transfer in a dusty fluid with variable fluid properties. This analysis is unsteady and consider the fluid viscosity is varies with temperature in exponential form. Vajravelu et al. (2013) investigated unsteady convective boundary layer flow of a viscous fluid with variables fluid properties. Iranian et al. (2015) analysis unsteady MHD flow with variable properties. They consider the fluid viscosity is varies with temperature in exponential form. Further Gnaneswera and Bhaskar (2009), Thakur and Hazarika(2015), Rahman et al. (2012) shows the effect of variable fluid viscosity and thermal conductivity on unsteady MHD flow and heat transfer over a stretching sheet/plate.

Present paper is to study the effects of variable fluid viscosity and thermal conductivity on BFD unsteady boundary layer flow and heat transfer over a stretching sheet. We consider the viscosity is an exponential function of temperature and thermal conductivity is linear function of temperature. The governing equations are solved numerically using approximation technique of two-point boundary value similarity problems Kafoussias and Williams (1993). Investigate the effect of variable viscosity parameter, thermal conductivity parameter, ferromagnetic parameter and temperature exponent parameter on the flow behavior and heat transfer process.

2. Mathematical Formulation

2.1. Governing Equations and Boundary Conditions

Let us consider an unsteady two dimensional flows and heat transfer of a viscous, laminar and incompressible fluid over a stretching sheet. We assume that the fluid viscosity and thermal conductivity are temperature dependent. The geometry configuration of the flow is parallel to x axis where y axis is perpendicular to it shown in fig 1. The sheet is stretched with velocity $U(x,t)=\dfrac{ax}{1-\alpha t}$ along x axis, where a and α are positive constant and the temperature of the sheet is varies with along the sheet and time which is the form by $T_w(x,t)=T_c+T_0\dfrac{dx^r}{\nu}\left(1-\alpha t\right)^{-s}$ (Liu and Andersson (2008)), where T_0 is fixed slit temperature, T_c is ambient fluid temperature. The power indices parameter r and s which determined the variation of sheet temperature. Assume that the fluid is electrically conducted due to an applied magnetic field normal to the stretching sheet and a magnetic dipole is located at the distance d below the sheet.

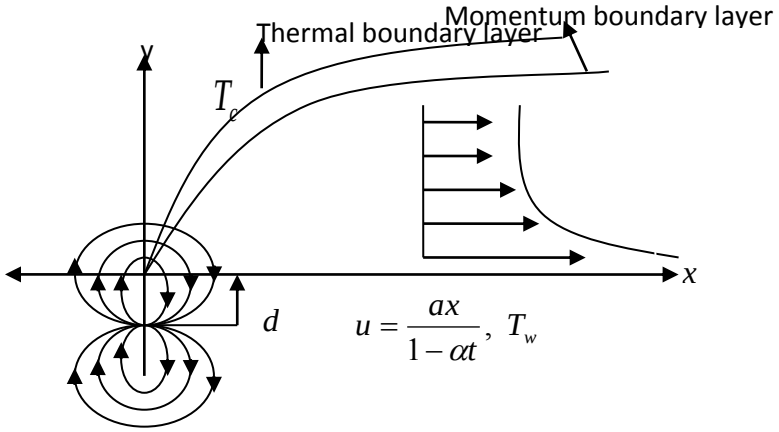

Figure 1: Physical model and coordinate system of the problem

With these assumptions the governing time dependent equations for the problem are (Manjunatha and Gireesha (2016), Tzirtzilakis, and Kafoussias (2010))

Continuity equation:

$$\frac{\partial \mathrm{u}}{\partial \mathrm{x}}+\frac{\partial \mathrm{v}}{\partial \mathrm{y}}=0 \tag{1}$$

Momentum equation:

$$\frac{\partial \mathrm{u}}{\partial \mathrm{t}}+u\frac{\partial \mathrm{u}}{\partial \mathrm{x}}+v\frac{\partial u}{\partial \mathrm{y}}=-\frac{1}{\rho_\infty}\frac{\partial p}{\partial x}+\frac{1}{\rho_\infty}\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right)+\frac{1}{\rho_\infty}\mu_0 M\frac{\partial H}{\partial x} \tag{2}$$

$$\frac{\partial \mathrm{v}}{\partial \mathrm{t}}+u\frac{\partial \mathrm{v}}{\partial \mathrm{x}}+v\frac{\partial v}{\partial \mathrm{y}}=-\frac{1}{\rho_\infty}\frac{\partial p}{\partial y}+\frac{1}{\rho_\infty}\frac{\partial}{\partial y}\left(\mu\frac{\partial v}{\partial y}\right)+\frac{1}{\rho_\infty}\mu_0 M\frac{\partial H}{\partial y} \tag{3}$$

Energy equation:

$$\rho_\infty C_p\left(\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right)+\mu_0 T\frac{\partial M}{\partial T}\left(u\frac{\partial H}{\partial x}+v\frac{\partial H}{\partial y}\right)=\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) \tag{4}$$

The initial and boundary conditions for the velocity, temperature and pressure are:

$$u=U(x,t)=ax(1-\alpha t)^{-1},\ v=V(x,t)=0,\ T=T_w=T_c+T_0\frac{dx^r}{\nu}(1-\alpha t)^{-s}\ \text{at}\ y=0 \tag{5}$$

$$u\to 0,\ T\to T_c,\ p+\frac{1}{2}\rho_\infty q^2=p_\infty=const\ \ \text{at}\ y\to\infty \tag{6}$$

Here x, y are the Cartesian coordinates, u, v are the velocity components along the $x\ and\ y$ axes, respectively, t is the time, a is a positive constants, α is the parameter showing the unsteadiness of the problem, ν is the kinematics viscosity of the fluid, ρ_∞ is the density of the fluid, p is pressure, μ_0 is the magnetic permeability, k is the thermal conductivity. The magnetization is vary with magnetic field intensity H and temperature T, the following relation used in Tzirtzilakis and Kafoussias (2010)

$$M=KH(T_c-T) \tag{7}$$

2.2. Similarity Transformations

The solution of equation (1) may be in the form

$$(u,v)=\left(\frac{\partial \psi}{\partial y},-\frac{\partial \psi}{\partial x}\right) \tag{8}$$

Introducing the usual similarity transformations and dimensionless temperature

$$\eta=\sqrt{\frac{a}{\nu(1-\alpha t)}}y,\quad \psi=\sqrt{\frac{a\nu}{1-\alpha t}}xf(\eta),\ \theta=\frac{T_c-T}{T_c-T_w},\ p=-\frac{a\mu}{1-\alpha t}P(\eta) \tag{9}$$

Assume that the fluid viscosity is assumed to vary as exponential function of temperature where thermal conductivity very as a linear with temperature.

$$\mu = \mu_\infty e^{-b\theta} \text{ and } k = k_\infty (1 + m\theta) \tag{10}$$

Where b is the variable fluid viscosity parameter, m is the thermal conductivity parameter, μ_∞ and k_∞ is fluid viscosity and thermal conductivity far away from the sheet respectively. It is note that $b < 0$ for liquid and $b > 0$ for gas when the temperature at the sheet T_w is smaller than that of the temperature at far away from the sheet T_c i. e. $T_c - T_w$ is positive by Kafoussias et al. (2008).

By using the equation (7)–(10), the momentum equation (2), (3) and energy equation (4) can be written as:

$$f''' - bf''\theta' - e^{b\theta}\left(Af' + \frac{1}{2}A\eta f'' + f'^2 - ff'' \right) - e^{b\theta}\frac{\beta\theta}{(\eta+\delta)^4} = 0 \tag{11}$$

$$P' - e^{-b\theta} f'' + be^{-b\theta} f'\theta' - ff' + \frac{1}{2}A(f + \eta f') - \frac{\beta\theta}{(\eta+\delta)^3} = 0 \tag{12}$$

$$(1+m\theta)\theta'' + m\theta'^2 - \Pr\left(As\theta + \frac{1}{2}A\eta\theta' + rf'\theta - f\theta' \right) - \frac{\delta^2\lambda\beta(\varepsilon-\theta)f}{(\eta+\delta)^3} = 0 \tag{13}$$

With associate boundary conditions are:

$$f = 0,\ f' = 1,\ \theta = 1 \ \ at \ \ \eta = 0$$

$$f' \to 0,\ \theta \to 0,\ P \to -P \quad as \ \ \eta \to \infty \tag{14}$$

Prandtl number, $P_r = \frac{\mu_\infty c_p}{k_\infty}$, viscous dissipation parameter, $\lambda = \frac{\mu_\infty{}^3}{\rho_\infty^2 k_\infty (T_c - T_w) d^2}$, dimensionless Curie temperature, $\varepsilon = \frac{T_c}{T_c - T_w}$, unsteadiness parameter, $A = \frac{\alpha}{a}$, ferromagnetic interaction parameter, $\beta = \frac{\gamma^2}{4\pi^2}\frac{K\mu_0(T_c - T_w)\rho}{\mu_\infty^2}$, dimensionless distance, $\delta = d\sqrt{\frac{a}{\nu(1-\alpha t)}}$.

3. Numerical method

The boundary value problem (11) to (13) along with the boundary conditions (14) are solved numerically using approximation technique to obtain numerical solution of a class of two-point boundary value similarity problems Kafoussias and Williams (1993) and the numerical solutions are obtained in three steps as follows:

(i) it is based on the common finite differences method with central differencing

(ii) on a tridiagonal matrix manipulation and finally

(iii) on an iterative procedure.

In this method, it is essential to select a suitable finite value of n_∞. The step size $h = 0.01$ issued to obtain the numerical solution with n_∞ and appropriate n_∞ values as $(y \to \infty)$ must be determined. The different initial guesses were made taking into account the convergence. The process is repeated until the results are corrected up to a desired accuracy. By trial and error, we get $n_\infty = 5$ and the tolerance between the iterations is set at $\varepsilon = 10^{-4}$. The solution procedure is briefly discussed in Murtaza et al. (2017).

4. Result and discussions

The values of the governing parameters are chosen to be physically representative of the actual blood fluids. We considered by Loukopoulos and Tzirtzilakis (2004), human blood as a biomagnetic fluid. At $T_w = 37^0 C$ (human body temperature) where as the body curie temperature is $T_c = 41^0 C$, For these values of temperature, the dimensionless temperature number is $\varepsilon = 78.5$. For blood, $\rho_\infty = 1050\, kg/m^3$ and $\mu_\infty = 3.2 \times 10^{-3}\, kgm^{-1}s^{-1}$ by Tzirtzilakis (2008). Generally, the specific heat under a constant pressure c_p and thermal conductivity k_∞ of any fluid are temperature dependent. However, the ratio including the above quantities expressed by the Prandtl number can be considered constant with the temperature variation. Therefore, for the temperature range consider in this problem, $C_p = 14.65\, JKg^{-1}.K^{-1}$ and $k_\infty = 2.2 \times 10^{-3}\, Jm^{-1}s^{-1}k^{-1}$ respectively by Tzirtzilakis and Xenos (2013) and hence $P_r = \dfrac{\mu_\infty C_p}{k_\infty} = 21$, Viscous dissipation parameter $\lambda = 6.4 \times 10^{-14}$, The ferromagnetic number β, define as $\beta = \dfrac{I^2}{4\pi^2}\dfrac{K\mu_0(T_c - T_w)\rho}{\mu^2} = \dfrac{M_s B_s \rho d^2}{\mu^2}$, where $M_s = KH(0,0)(T_c - T_w)$, $B_s = \mu_0 H(0,0)$, $H(0,0)$ is the value of magnetic field strength at the point $(0,0)$. For magnetic field equal to 1T to 10T, the blood has reached magnetization of $40 Am^{-1}$. According to the assumptions we calculate the ferromagnetic number $\beta = 0, 41, 82.$ Noted that $\beta = 0$ corresponds to hydrodynamic flow. Here we considered to take the viscosity parameter is -0.6, -0.4, -0.2 and thermal conductivity parameter is 0.14 by Kafoussias et al. (2008).

First we verify the method validation, the present numerical results for $-f''(0)$ are compared with the results obtained in Vajravelu et al. (2013) by setting $\beta = 0$ *and* $f'(0) = 1$ in boundary conditions (14). The comparisons results are found to be good agreement and thus we are confident that the present method is accurate.

Table 1: Numerical values of skin friction $(-f''(0))$ varying with unsteady parameter A.

Unsteadiness Parameter A	$-f''(0)$		
	Vajravelu et al. (2013)	Sharidan et al (2006)	Present result
$A = 0.0$	1.000489	-	1.00045
$A = 0.5$	1.167325	-	1.16725
$A = 0.8$		1.261042	1.26.96
$A = 1.0$	1.320522	-	1.32.40
$A = 1.2$		1.377722	1.37758
$A = 1.5$	1.459660	-	1.45949

In figure 2 to 4 represent the influence of ferromagnetic parameter, viscosity parameter, unsteadiness parameter and thermal conductivity parameter on velocity, pressure and temperature profile. We observed that for increases

ferromagnetic parameter, velocity profile and pressure distribution decreases but temperature increases**.** This fact is due to the presence of a magnetic field which is also called the Kelvin force, which acts against the flow. This resistive force slows down the fluid velocity component i.e. boundary layer thickness decreases and thermal layer thickness increases in fig. 2 and 4.

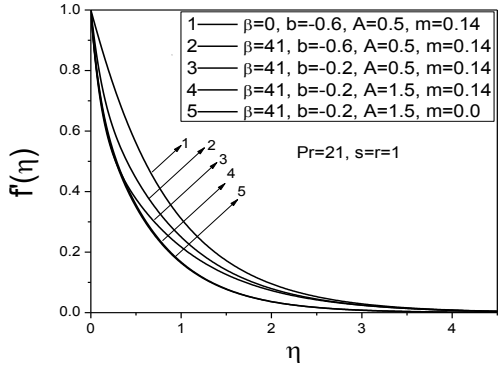

Figure 2. Velocity profiles for different value of β, b, A and m

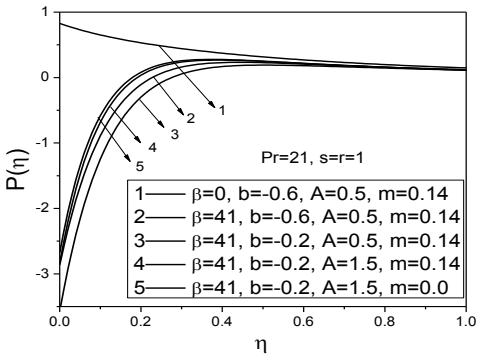

Figure 3. Pressure distribution for different value of β, b, A and m

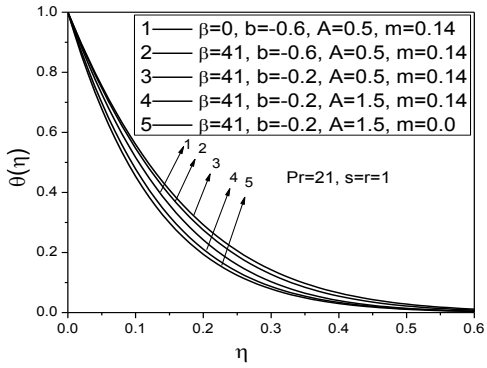

Figure 4. Temperature profiles for different value of β, b, A and m

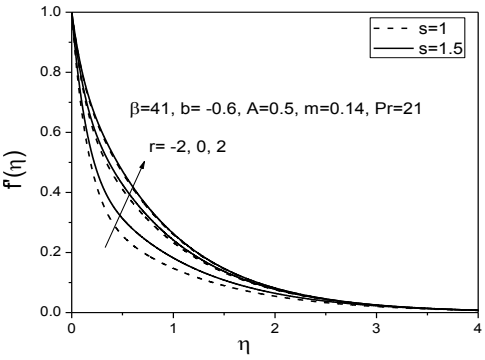

Figure 5. Velocity profiles for different value of r and s

We also observed that the velocity profile decreases and temperature profile increases with the increases viscosity parameter. Physically this phenomenon is due to the fact that with increasing values of viscosity parameter implies the temperature difference is higher. So that the thermal boundary layer is thicker and momentum boundary layer is thinner. The effect of thermal conductivity parameter is negligible for velocity profile but temperature profile is increases as increases thermal conductivity parameter. This fact is due to magnitude of temperature is increases with increases thermal conductivity parameter and thermal boundary layer thickness is also increased in (fig 4). Also we observed that the velocity and temperature are decreases with increasing unsteady parameter A. This implies that reduces momentum boundary layer thickness and less heat is transferred from the sheet to the fluid.

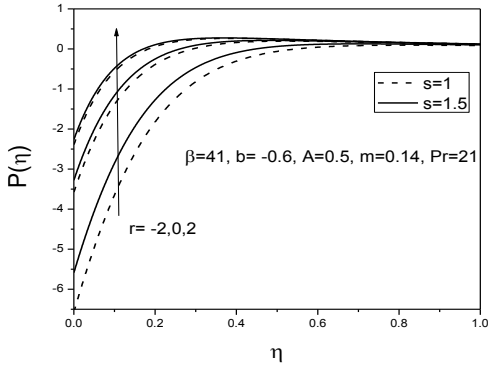

Figure 6. Pressure profile for different value of r and s

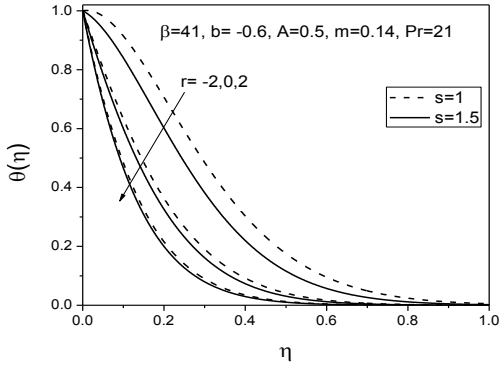

Figure 7.Temperature profile for different value of r and s

The variation of $f'(\eta), P(\eta)\ and\ \theta(\eta)$ for different values of power indices r and s which determined the variation of sheet temperature are presented in fig 5 to 7. Here we observed that when sheet temperature varies only along the sheet and time independent i.e. only r varies and s is constant then velocity and pressure profile are increases and temperature decreases with r increases. we also observed that same behaviors are shown when sheet temperature is varies with time and independent along the sheet, i.e. s is vary and r is constant. It is note that the for $r > 0$ this effect is negligible than $r < 0$ in all profile. Also we observe that for positive value of r, the variation of temperature exponent parameter s has no significance effect in all profiles.

From figure 8 to 10 shows the skin friction ($f''(0)$), wall heat transfer rate $(\theta'(0))$ and wall pressure rate $(P(0))$ with viscosity parameter for various value of ferromagnetic parameter. This figure we observed that $f''(0)$ is increases with increases viscosity parameter while $\theta'(0)\ and\ P(0)$ are decreases. Also we observed that for increases ferromagnetic parameter, $f''(0)$ is also increases while $\theta'(0)\ and\ P(0)$ are decreases.

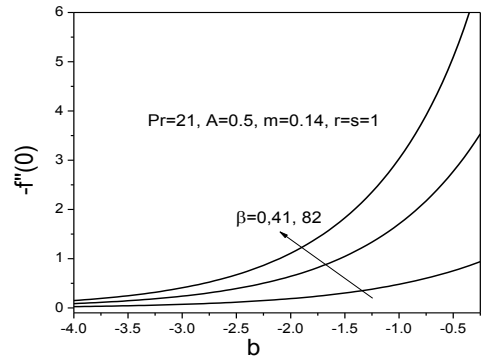

Figure 8. Skin friction coefficient with viscosity parameter b for various values of β

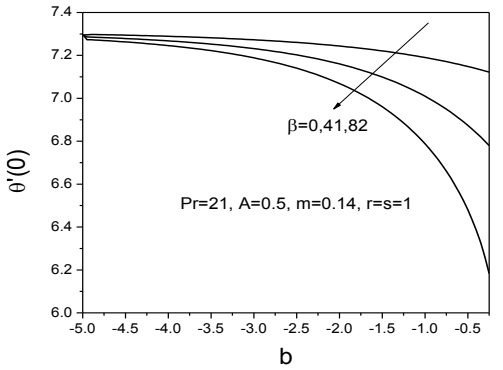

Figure 9. Wall heat transfer coefficient with viscosity parameter b for various values of β

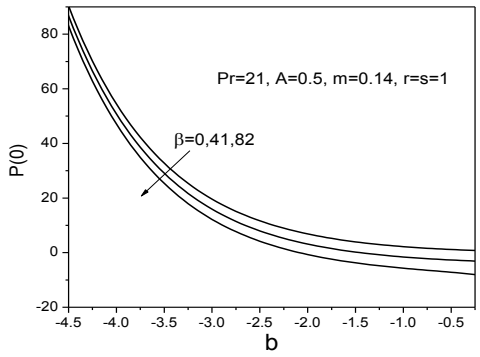

Figure 10. Wall pressure coefficient with viscosity parameter b for various values of β

5. Conclusion

In this paper, the effect of exponential form of temperature dependent viscosity and linear form of thermal diffusivity on BFD boundary layer flow and heat transfer over a stretching sheet has been investigated. The main findings of this analysis can be summarized as follows.

(i) Increase the unsteady parameter A, decreases the velocity and temperature distributions where pressure distribution is increases.

(ii) Effect of variable viscosity parameter b is to decrease the velocity and pressure profiles whereas the skin friction is increases.

(iii) For increasing values of thermal conductivity parameter, the temperature profiles increase while the velocity profiles are not significantly affected.

(iv) Effect of variable viscosity parameter b is to enhance the temperature distribution whereas the reversed behavior has shown in the wall temperature gradient.

(v) Ferromagnetic parameter helps to enhance the temperature profile and reduce the velocity profile, as well as skin friction is increases and rate of heat transfer is decreases.

(vi) Effect of the variation of temperature exponent parameter, increases the velocity and pressure distribution and decreases the temperature with increases the exponent parameter.

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Organization innovation to develop Service systems of TGTDCL

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Abstract

Research has not yet been focused much in public service innovation (a few examples include Borins S. 2001, Hartley 2005, Windrum and Koch 2008, Soren and Torfing 2009, Bason, C. 2010, Gallouj et. Al. 2013, Fuglsang et. al. 2014).The most of the service innovation research has used private profitable firms as their empirical setting (AaS. Tor et.al. 2016). Specifically, there is almost not any research literature regarding organization innovation to develop service systems of national oil gas sector of the developing country like Bangladesh. Bangladeshi National Oil Gas Company (NOGC), Titas Gas Transmission and Distribution Company Limited (TGTDCL) established in 1964 and it is the largest and oldest gas company under Petrobangla. TGTDCL is responsible for distributing natural gas to customers at the household, commercial and industrial level in the greater Dhaka. Titas Gas personnel use traditional filing procedure to deliver its service to the customers. Therefore, Clients, shareholder and Government struggle to get quality services and expected benefit. This research studies do some key questions, Is Traditional service process of TGTDCL well standard? Does TGTDCL need to develop new explanations and models regarding its contractor roles? This study outlines strategies for improving management control and service procedure. Finally, this paper shows how customer, shareholder and stakeholder of TGTDCL can get innovative services, expected benefit and thereby make the customer service of TGTDCL more efficient.

Key Words: Service innovation, organization innovation, Service systems, Customer service.

1 Theory background

Most of the innovation management research has studied innovation practices in manufacturing firms, but in recent years, the service sector has been focused (Aas, Pedersen PE, 2011). A better understanding of how public sector organizations manage their innovation activities is a prerequisite for realizing the potential benefits of innovation in this sector (Kuipers et al., 2014). Innovation practices are likely to vary to some degree between different parts of the public sector (Gallouj & Zanfei, 2013). In addition, Innovation processes in the public sector may vary between different countries due to institutional variations (De Vries et al., 2016). Besides, the results of a recent literature review by De Vries et al. (2016) suggest that most existing studies of public sector innovation have been conducted in liberal market economies such as the USA and the UK, implying that more research from other countries is needed. Therefore, this paper has focused administrative innovation and partly Technical Innovation in Bangladeshi NOGC. Fuglsang and Rønning (2014) emphasized that it is important to identify what the employees really do, and not just to be concerned with formal templates and models when researchers are identifying how innovation activities take place in organizations. Bartos (2002) sets out a definition of innovation appropriate to the public sector: Innovation is a change in policy or management practice that would lead to a lasting improvement in level of service or quantity or quality of output by an organization. In fact, Damanpour (1991) divides major types of organization innovation in based of different relevant literatures such as administrative and Technical, Product and Process, radical and incremental innovation. However, these types of broad categories have some overlapping relations. Service innovations are more often considered as organizational innovations and Service innovations do more often have qualitative and less easily measurable effects (Pedersen 2007). Administrative innovations involve organizational structure and administrative processes; they are indirectly related to the basic work activities of an organization and are more directly related to its management (Kimberly & Evanisko 1981; Damanpour 1991). Technical innovations pertain to products, services, and production process technology; they are related to basic work activities and can concern either product or process (Knight K.E., 1967; Damanpour & Evan, 1984). Service system is the way in which the firm is organized in order to deliver its service to the clients. Drivers of service innovation are generally Resources (Asset, Technology, and People), Management (Service systems, Business

Model, Customer Experience), Value (Economical, Societal, environmental, even emotional nature) (Aas and Pedersen 2010, Kenneth Michael Kjos 2013).Innovation in services is different from innovation in manufacturing essentially because services characterized by intangibility, heterogeneity, perish-ability, increased customer interactivity, and simultaneity between production and consumption (Sampson 2007, Trott 2012). Although, Some Researchers exclude heterogeneity and perishability due to updated technology and recording facility existing now, they concentrate mainly personal skills; interaction and knowledge are the utmost importance in creating a new service innovation (Atuahene-Gima 2005, Lehtinen and Jarvinen 2015). An innovative culture fosters creativity among employees within and across organizations through informal communication, intrinsic motivation, positive work environment and collaborative working arrangements that promote knowledge sharing and learning required to generate new ideas continuously (Hipp and Grupp 2005; Simpson et al. 2006, Pedersen Per E., 2007). Agarwal and Selen (2009, 2014) provide empirical evidence that innovation in services is made possible not only through technical capabilities; rather it is the contribution of soft skills such as collaboration and relationship management that enable the realization of such innovation. Some researchers believe, the measurement of service innovation performance is mostly evaluated based on user perception (Bessant and Tidd 2007, Preissl B 2000). Since, Service delivery and consumption occur simultaneously in services, reducing variability is not always possible as customers may disrupt core operations with their unpredictable behaviour (Frei 2006, Trott 2012). Today, service innovation has developed into a vast field encompassing the study of intangible processes and dynamic interactions among technological and human systems that lead to managerial and organizational change in services (Miles 2001; Den Hertog 2000; A.S Hanneke, Vos 2010,; Trott 2012).

The public sector has different goals, purposes, institutional cultures, chains for implementation and a strong degree of formal procedures that provide different conditions (Robertson & Seneviratne, 1995; Moore, 2005). Moreover, Dynamic capability building is critical for implementing service innovation, and raises the organization's ability to sense and size, create and reconfigure its resource base (Teece 2007) in developing and delivering new service offerings. Organizations need to develop systems and processes for managing the knowledge exchange between the human and non-human entities, integrating knowledge from past innovation projects to current knowledge (De Luca and Atuahene-Gima 2007) and co-evolving their knowledge base toward generating new ideas on an ongoing basis (Storey and Kahn 2010). This study has drilled down the idea how to involve management and field level people ongoing basis to improve the government oil-gas sector's services. In addition, Service innovation is affected by the socio-cultural dynamics such as norms, values, and ethical standards of all actors that form part of the innovation system (Edvardsson et. al. 2011). However, The performance of a Public limited company's administration has correlation with corruption, red tape, quality of Judiciary and size of Shadow economy (Teresa Curristine et.al. 2007, Flikemma M. 2008). Authority of government company are asymmetric not clearly balanced, management sometimes are ill formed, fuzzy and soft, politically motivated not considered management issues (Hartley J. 2005, 2011). Therefore, The development of innovative capacity and create an innovation culture in the public sector one need political as well as administrative support (Borins, 2002; Moore, 2005, Antonio Afonsoet.al 2005; Hartley, 2011). It is also suggested that Service innovation is less technology based (De Brentani, 1991 and Cooper et.al.1995) and not so often driven by R&D efforts (Brouwer, 1997). Interestingly, De Brentani has suggested that service innovations are easily copied and thus, that they are more difficult to protect (De Brentani, 1991). Innovation in service firms is more dependent upon a strong innovation culture than innovation in manufacturing (Aas Tor et.al 2016).

One of the barriers in general of public firms is lack of competitive pressures compare to private firms (Verhoest et al., 2007). In addition, Researchers found that restraining effects on service innovation of government sectors are associated with rejection of innovative projects by political actors, the content of rules and regulations, a conservative attitude of the direct supervisor, the adoption of directive leadership styles, a lack of communication of supervisory expectations, conservative colleagues in the work-group, a complex organizational structure, a perceived lack of appreciation, low provision of job-related knowledge and skills and goal ambiguity (Koen 2015). One side, rewards for successful innovations in the public sector are relatively low, the lack of share ownership opportunities, the generally fixed nature of salaries with minimum bonuses for all employees compare to the private sector (Borins, 2001). Besides, consequences are very costly, unsuccessful innovations can be severe in the public company; with the media and oppositions always being willing to expose public sector failures and publicly humiliate public servants (Walsh 1995; Borins, 2001). Firstly, problem within the public sector is generally high due to the high usage of regulations and prescriptions and the high provision of trainings and manuals towards public employees in order to minimize corruption and to make sure that they act according to official policy. Secondly, the facts that tasks are generally specified to a large extend within public firms, making every public employee and

every department responsible for one little aspect of the total process and whenever exceptions arises, tasks are generally transferred to the colleague responsible for that specific tasks, indicate that task variability may generally be low within public organizations (Rainey, 2009). Another thing, the organizational structures with high degrees of formalization and low degrees of flexibility, the contingencies with regard to strategy and technology, relevant for most public firms causes their managers and policy-makers to adopt organizational structures which are, in general, unfavorable towards service innovation (Rainey & Bozeman, 2001; Rainey, 2009; Fernandez & Moldogaziev, 2012). Now a day, public organizations are under increasing pressure to improve their service quality and safety while at the same time to optimize their efficiency levels (Veld et al., 2010; Decramer et al., 2013; Knies et al., 2015). The importance of developing and implementing more efficient technologies and work processes is likely to become essential for the future performance and survival of public organizations. New public management (NPM) emerged in the 1980s (Hood1991), reaction perceived lack of result in to customer orientedness to the public organization. Here, Organizational legitimacy is a crucial motivator for spontaneous adaptation in the form of innovative behavior and autonomy may be considered stimulating factors (Koen et. al. 2007). NPM gives solutions by enlarging managerial autonomy for internal pressure control by government, external pressure by competitor that ultimate result of more dynamics, more customer oriented, more innovative. However, NPM does not say alternative when no competitor exists in government owned company. Besides, Institutional theory shows how organization behaviors response not solely to market pressures but also to institutional pressures (Pressures from regulating agencies such as state and the professions, social expectation, leading organizations), (Greenwood & Hinings, 1996). Here in Bangladesh institutional pressures alone are not strong enough to change public organizations (government owned) service systems. Theories of Management says (Miles R.E. 1978), Manager's basic task is to closely supervise and control his (her) subordinates (traditional), The manager's basic task is to make each worker feel useful and important (human relation) and The manager's basic task is to make use of his (her) "untapped" human resources (Human resources Model). Moreover, Successful service firms must place greater emphasis on the selection, development and management of employees who work directly with the customer (Atuahene-Gima, 1996). Traditionally, NOGC in Bangladesh has weak emphasis to implement this matter. Innovative employee behaviour that can help to improve the quality of products, professional services and to improve working processes in the company (Jeroen PJ de Jong, DN Den Hartog, 2007). Certain indicators of innovative behaviour depend on the extent to which the organization is able to create an environment that supports the employee's ability to initiate positive change in the work on the basis of intrinsic motivation (Klotchko, Galazhinsky, 2009). An employee has some special motivational characteristics such as independence and internal motivation, high sense of duty, the desire to really test skills in solving problems, the desire to do the job better than it had been expected (Lukianova, Alekseeva, 2011). Organizations have been relying increasingly on their employee's "willingness to contribute beyond formal job descriptions and on their leaders to inspire an empowered workforce (Mohanty J. 2013) accordingly.

2 Purpose of this study

There are at least 16 steps to get gas connection of any clients in Bangladesh (Gas act 2010, Gas marketing rules 2014). Clients face very complex procedure after gas connection services also. Administrative and financial approval procedures are lengthy and time consuming. The objective is to minimize time to deal with official matters and to alleviate burden costs of dealing with hard copy and administration of TGTDCL shall be made flexible and customer centred instead of bureaucratic mentality. The area of this research will cover NOGC service innovation. This research analyze Bangladeshi NOGC to fill up the gap of service innovation literatures such as how organization innovation facilitates the service systems of government oil gas sectors in Bangladesh.

3 Research Approach and Methodology

Social science research may use observational and/or experimental approaches to generate and analyze qualitative and/or quantitative data (Creswell, 2003). Each of these approaches is associated with advantages and disadvantages, depending on the nature of the research question (Johnson and Harris, 2003). This research has taken qualitative observational research method. This research conducts both KII (Key informant Interview) and focus group discussion (FGD) data collection method. FGD has been considered from the client's side of Bangladeshi NOGC. The case study depicts rich picture, systematic inquiry to predict root causes and clear understanding (Yin 2014). What is happening TGTDCL now and how they addressed barrier to develop service systems in the past, this research gets answers by taking KII from different personnel who work at TGTDCL, and this research searches as much as possible available literatures to get conceptual view.

This research prepared a semi-structured interview questions according to expertise knowledge, journals, PhD thesis/papers, annual reports of TGTDCL in Bangladesh. This research has taken 10 KII and 5 focus Group Discussion (FGD) both TGTDCL personnel and clients side. This research has taken interview sample (stratified sample) such that every corner of the employee's representative and stakeholders/Clients cover. This study recorded all interviews by a recorder and transcribed them for analysis. Sources of secondary data will be collected from relevant Books, Annual reports of NOGC, legislation, policies and through personal communication for getting ideas of service innovation at NOGC. The confidentiality and risk of respondent will be considered during the interview and data collection time. This study declares the purpose of this research to the respondents' clearly prior interview.

4 TGTDCL Services

Titas Gas deals with complex Gas distribution services, it has active valve and metering station involves meeting stringent safety regulations and follow other government requirements related to existing and new gas distribution networks. The ultimate goal of a service firm is to make the organization customer centric with the business perfectly aligned to the customer needs and the ability to run the service profitably (Faij G. 2009). Is this true for TGTDCL (Shamuzzoha Md 2017a)? TGTDCL is responsible for distributing natural gas to customers at the household, commercial and industrial level. It runs according to gas marketing rules-2014 and gas act-2010. If any citizen in Bangladesh /foreigner wants to get gas connection needs to follow the 16 steps (Gas Marketing Rules 2014). This study does not only concern taking time for gas connection but also TGTDCL gives services after gas connection to the clients (Shamsuzzoha Md 2017a). Every customer either residential (res.) or Industrial and commercial (I&C) comes for getting services most of the cases for their billing systems (Bill correction), Bill Book collection, gas services such as leakage and RMS repair (Riser or Regulating and Metering Station, Change security seal by Meter & Vigilance, M&V), Gas line pressure correction, remove water or other dust/foreign material/residue from their service line, gas line disconnection (Killing or Temporary disconnection) and reconnection processes, change status or load (meter/regulator Change either for disorder meter/regulator or load changes or rearrange appliances), or declare the change of gas owner name of the customers gas connection etc. Distribution Managers look at the gas distribution line leakage, network problems, blockage and accident. Their role and efficiency normally depend on how Engineering Services Managers and clients communicate and handle it properly. Employee's services are taken care by the administration and accounts section accordingly. Clients do not know where to go or what need to do or they are not aware about their problems. As a consequence, they run to get services. The service procedure and role of different managers has been discussed in the paper Shamsuzzoha Md. 2017a.

5 Findings

5.1 Data Collection: Interview and Focus Group Discussion

KII- Key informant Interview, FGD- Focus Group Discussion

Each interview lasted approximately 30-45 minutes. This research study has taken 10 KII and 5 FGD. Prior to the interviews, consent has been taken each interviewee requesting their participation in the study. The purpose of the research and an assurance of anonymity and confidentiality were stated. Participants' verbatim responses are recorded using a recording device and notes are also taken. The researcher had a set of core questions for guidance in ensuring that same questions are covered for each interviewee so as to have a standard baseline for all interviewed. The interview guide can be seen at appendix A and B. The interviews allowed direct contact with the participants and it made it possible to observe the employees' non-verbal communication as well as emotional response whenever possible. The standard questions asked sought to establish individual's perception and organizational innovation and service systems. Understanding the culture of the TGTDCL and the diversity of the workforce from the employees' perspective is also a focus of the questions.

5.2 KII and FGD Data analysis, Problems background of customer services at TGTDCL

Business nature of TGTDCL is monopolistic; it has inertia among the employees from the very beginning of his inauguration. Therefore, it is difficult to introduce new service systems without customers /stakeholders/ government authority support. Although, relationships between users/customers and service provider are a

fundamental stimulus for innovation processes. In addition, Titas Gas customer's services depend on enlisted contractor and their efficiencies. What the major complexity to engage contractor needs to identify before introducing an efficient customer service systems at Titas Gas. This research concentrates regarding departmental relation and management procedure, organization knowledge management, customer interactions & relations and service systems, contractor role and relations, norms and cultures of TGTDCL. Generally, Government/Authority takes care innovation of manufacturing industry; rather they need to feel support service industry like training or organizational changes. Besides, TGTDCL distribute natural gas about 2.03 million customers for industrial, residential and commercial purposes 24 hours/day. Therefore, continuous maintenance, customer's services and cooperation and coordination are mandatory. In that case, Customer interactions and build dynamic capability may influence customer services. Titas Gas deals different clients by coordinating 28 departments and TGTDCL service depends on other government organization's operations and quick responses also.

According to FGD from client's side, they experience complex systems of TGTDCL and contractor creates barrier, they can't come to Titas Gas office. Clients do not know the responsible officer and responsibility. Most of the clients advise to update the website of TGTDCL with officer's responsibility and communication number. They also say, TGTDCL can write officers information and responsibility in front of the office. Contractor works on behalf of clients and they charged excessive amount of money compare to the government allowance, reports from FGD of client's side. There are significant information gaps regarding Titas Gas procedure and systems among the clients. They get fear about Gas procedure due to contractor and employee roles. Contractor normally takes facility by ignoring the client's wishes. Some of the clients want to engage by themselves instead of barrier created by contractor. Contractor provides them wrong information. Clients normally offer money to contractor on belief and they do not ask about the money receipt. Clients believe that Titas Gas enlisted contractor will give them exact estimation and information. Therefore, TGTDCL needs to train contractor to deal with customers. Here, there is enormous lack about client's vigilance. Consequently, customers do not get expected services. Therefore, Clients should ask everything about the fees and need to be transparent regarding contractor dealings. TGTDCL can send update information to clients by mobile messages, report FGD. They suggest that TGTDCL needs to stop subcontractor procedure and political bias. All valid contractor list need to update TGTDCL website include their Bio data and Photo. They advise, Media can play vital role to reinforce government organization and TGTDCL needs to update their information and procedure to the customer by TV scrolling/daily newspapers and website of TGTDCL.

On the other hand, FGD from contractor sides, Most of the contractor say, they charge money to the clients due to hidden office cost and political manage of local and union leader. They do not want to work with corrupt systems and lengthy file procedure needs lot of signature, table talks make the systems inefficient for customer services. Contractor says, Employee does not work at all, although salary has been increased by Government and Union representative or political influences are responsible to hinder the customer's services. They also suggest that TGTDCL needs to follow strict rules regarding contactor licenses and control original contractor instead of biasness to avoid pilferages of gas uses. There are significant number of fake contractors use other contractor license to give services to the customers. They charge high amount of money to the general clients for getting services collaboration among employees of TGTDCL. So called contractor (Lungi party) needs to control to enter the office and exclude them from file procedure. Communication needs to increase among clients and contractor to increase customer services. Management should introduce restrict rules and feedback taking from subordinates regularly. General customer does not know the actual persons and official fees. They report, Employees avoid their responsibility and they do not follow up without having persons behind the files. Contractors need to go table to table that increase cost.

Important documents need to collect from other government organizations which delay the execution time of TGTDCL services. Standardization of works processes may have an adverse effect on innovation as it hinders the service providers-clients relationship. According to KII, most of the company runs traditionally with conventional staff and they suggest informal communication can enhance customer services. It is very difficult to establish right person to the right place without political support. Supervisory actions are poor due to almost not any competitive pressure and don't get right position with right persons. Management procedure of TGTDCL has vital role to execute effective customer services and delivery systems. According to KII, Official employee hidden and contractor role creates barrier, low level employees do not want to work properly where management have failure regarding this matters. They also suggest that decentralization and low hierarchy can enhance customer services. Manager negative attitude deteriorate Customer Service (CS) and regular coordination meeting and share ideas can

reduce barrier from management side. Most of the KII suggest that Job description is needed to enhance customer services and customer feedback systems may develop at TGTDCL. Employees need to work proactively due to low logistic support at TGTDCL and low informal communication among different cadre (Engineering, accounts and administration) officers. Continuity of management decision and reduce the gap between high and low level officers and appreciate people is also needed to enhance customer services. They also suggest that political will, management positive support and discrepancy control by grip-hand are the outmost important factors to introduce organization innovation and customer services. They report, Task specify the large extent of management team, therefore, task variability is low. If any failure occurs, the arrow goes to the low level officers. According to section one, the best performing company should provide leadership training to project managers to enhance their effectiveness. In that case, Team members of the project should have different and complementary personalities and knowledge. According to KII from different managers, this research convinced that overlapping responsibility and overstaffing of certain departments delay the customer services. The relations among Technical, accounts and general (administration) officers are not well standard and they have poor professional training regarding responsibility and power.. Punishment systems are poor. How to resolve the negligence attitudes of employees need further research study. Material Engineering and Control Department (MECD) purchase material/equipment from different user department's demand every year. Mechanical Engineering Services Department delivers mechanical services to the Customers. Without proper material planning by MECD delivering effective customer services by users department are almost quite impossible (Shamsuzzoha Md 2016, 2017a). Titas Gas has provided integrated computer systems to generate effective reporting of customer services recently. This software has initial impact regarding innovation of reporting purposes but not enough for Titas whole field works and procedures. Titas officers work under the Gas Marketing 2014 and gas act 2010. The gas rules and act can delay the customer service procedure of Titas Gas. The analysis of Gas Marketing Rules 2014 has been kept outside in this research for further study.

According to KII, TGTDCL faces organizational rigidity, traditional attitudes of managers / personnel and managerial structure of enterprise towards changes. Managers are secretive in behavior regarding information and responsibility disclosure and they have inadequate legislative and finance base towards organizational innovation activities. Management, even talented managers do not bother or say to allocate money regarding R&D activities of company that innovate company's service systems. According to KII, Two department's (HRM and Administration) employees have lack of motivation regarding employees and clients services. TGTDCL needs to focus employee level (front line employee) instead of organization level as well logistic support and appropriate managerial control to execute effective service systems.

5.3 Diagnosis and Discussion of problems with finding different solutions at TGTDCL

Clients do not know everything of Titas Gas Services. Titas Management must aware to declare whole procedure of working level to his honorable customers/clients where to go and who are responsible for which works in front of the office premises and TGTDCL website. TGTDCL runs monopoly business at gas distribution sector due to government in nature. However, they should not forget regarding efficiency equivalent to international gas company and general public services. Titas authority should address it with proper job staffing, guidelines, and training. HRM department focus only officers training, employee is also heart of any organization (KII). HRM needs to focus employee training and motivation. TGTDCL administration and HRM department do not act independently and proactively, they do not have sufficient experience regarding customer services (Shamsuzzoha Md 2016). TGTDCL has weak linkage with the Universities or research institutes to share skill or knowledge. One reason, TGTDCL as a state owned enterprise does not have so much interest about organizational innovation because of competitiveness in business. Management should address this issue how to interlink institute and company to get better customer services. Political and administrative will is one way to implement innovative activities of TGTDCL. Another way, Innovative culture, collaborative working arrangements and informal communication can help to find out creative persons to the customer services (CS) areas by giving some incentive tools. The innovative culture, informal relation and collaborative arrangements are essential to be innovative organization (Atuahene-Gima, 1996; garwal and Selen 2009, 2014). According to theory discussed section one, Service concept is generally combination of processes, people skills, Technology and materials that should integrate appropriately. Managers should take decision for every component of services belongs to his/her jurisdiction. Therefore, Selection and appropriate training by initiating HR or Administration Manager is important to implement services of TGTDCL. Here, Management should understand 'service in mind' not only customers but also every stakeholders like employees, managers, contractors to minimize gap between expectations and delivery. In that case, CBA, policy maker and management (Political &

Administrative) can play vital role to withstand company goodwill and revenue management and expected profit. Here, willingness among the employees to change existing routines is more important for service innovations. Moreover, role clarity (job description) and motivation of employees are significant factors to affect employee performance and behavioral change for implementing organization innovation. One way to reduce the gap TGTDCL needs to empower service delivery personnel with delegation of financial power. Government or Titas Board or Management can initiate or get support about delegation of power, training or organizational change boosting service innovation.

This study has convinced that management needs to arise question upon own selves regarding political will and societal culture set up before adapting organizations innovations. This research reminds that the management fashion and international best practice count for nothing unless it makes sense locally. TGTDCL needs to develop incentives policy to motivate employee and politicians to change their behavior. Government needs to develop competitive pressure among service providers of public services (Demand for public services).According to FGD, General clients need to go different table to get services and the whole procedure is more systematic at TGTDCL. This procedure is an old traditional and time consuming solution for TGTDCL. Therefore, any inefficient section of TGTDCL (technical, administration or accounts) can hinder the whole systems of Titas Gas. Moreover, Sectional dual responsibility and secret demand may hinder job execution and customer may not get expected benefit. Internal processes of employee's services are traditional at TGTDCL also. Therefore, Communication and coordination with engineering and accounts section are vital such that execution does not take much time. One can get details service procedure of TGTDCL of the paper Shamsuzzoha Md 2016, 2017a. Here, interaction among technical, administration and accounts personnel (inter-functional conflict) and managerial ability may influence services of clients. Therefore, offering new clues for services to help customers visualize and evaluate services to success service innovation (De Brentani 2001). Managerial control should be practiced by other means, such as direct supervision. Organizations Management should focus on employee commitment, understanding and capability at the beginning of strategic decision making processes regarding organization innovation. Customer's prior information (like behaviour and attitudes) can enhance service innovation and employee motivation in case of government organization like TGTDCL. How to inform or educate customer of TGTDCL is needed another research study. TGTDCL has introduced integrated computer systems for reporting purposes recently. Integrated computer systems (ICS) has some influence regarding CS However, without proper man power and logistic support ICS will not work up to mark whatever TGTDCL wants, report from KII. Moreover, E-government practices reduce time demands but increase task demands on staff members and require more technical skills. Talented employee selection is crucial to enhance technical skill. All employees do not have same technical capacity in nature. HRD needs to identify untapped people at TGTDCL. Employees can produce many new ideas which focus in incremental improvements in the customer service routines. Every day problems generate incremental innovation in the everyday works activities that enhance customer services. Employee should focus problem solving attitude on new ways instead of focusing authority centric attitude. Public sector image plays an important role in terms of attractiveness for talent employee, government responsibility. TGTDCL will need research to know way of boosting goodwill / Image. Besides, TGTDCL has mixed opinion regarding CBA work activities withstanding image. Hence, Public sector Union is more prominent, bargaining is not strictly Managerial, and it is often political affairs. CBA, policy maker and management (Political & Administrative) can play vital role to withstand company goodwill and revenue management and expected profit. Low formalization is needed for the initiation of innovation and high formalization for their implementation (Zaltman et.al. 1973). Service systems can be changed or managed by practical nature of problems and circumference instead of hampering ideological or cultural supremacy. One can consider for introducing new services at TGTDCL considering the following factors such as HRM systems (Training and recruiting), administrative change and decentralization (Work force posting right people on right place), technical departmental procedure, financial controlling systems (financial empowerment), Leadership and Union representative role, and Technology. There is gap between client's expectation and TGTDCL services. TGTDCL needs to consider to reduce the gaps by their knowledge and skills how much benefit providing as a service provider by integrating simultaneous interaction and value production with the clients. However, Qualitative aspect of service providers is difficult in public sector like TGTDCL, since a large bulk of customers of different sectors are involved here and it is often difficult to measure due to intangible effects. Moreover, Innovation related works are not always explicit, visible, and easily recognizable even the initiators themselves. Here, strong political and regulatory body's commitment and selection of management people have vital role to execute dynamic customer services. Vertical integration of Parents Company can reduce cost and better customer service. TGTDCL communicates to Parents Company normally when problem arises. However, it is not effective. TGTDCL should develop communication systems with sister concern Company like PGCL, BGDCL, KGDCL, JGDCL, SGCL and BAPEX for better

customer services (Shamsuzzoha Md 2016). TGTDCL can employ the external knowledge (transferring or sharing knowledge, communication and interaction of same types of organizations) acquisitions that related to organizational innovations. Board of TGTDCL has authority to implement new things; however, it goes to the member (Management) of TGTDCL what they want to arise in to the Board. Finally, attitudes and values are vital to the ways in which people favor to interact with one another, how they organize formally, how they manage, and how they prefer to be managed, what they will accept before thinking organization innovation.

6 Conclusions, Limitations and Further Study

TGTDCL runs with Bangladeshi traditional culture, Smooth cooperation is vital among revenue, Technical and General Department for executing effective customer services. Employees understanding and controlling of their hidden role by management can influence customer services. The agency (contractor) cost can be controlled what the works behind instead of traditional estimation by selecting proper manager and contractor considering their experience. TGTDCL introduces an integrated computer system (ICS) that is a first step of Technical Innovation for services. However, ICS alone is not sufficient enough to execute efficient customer services and Organization innovation. This paper demonstrates that customer's Service innovation is not given due importance at TGTDCL. The reasons for not emphasizing services innovation require further empirical research study that will need a research framework to test our hypothesis / results. This study shows that TGTDCL has lack of motivated people relevant to the staff selection and transfer right places of work force due importance of customer services. The limitations of this study concentrate mainly Bangladeshi state-owned company and have given 10 KII and 5 FGD. The generalization of this research concept will need further empirical and qualitative research in the different contextual factors around the world.

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Appendix A

Interview guide for KII and FGD (Service Provider Side)

How to develop culture & informal communication, collaboration to build up creativity and service innovation at TGTDCL?
How to manage organizational knowledge to innovate organization service systems?
Does the TGTDCL service process value customers and increase simultaneous interaction?
How can administrative innovation favor talented person to serve quick response to the clients (rewards & Punishment)? How to increase functional decentralization and scale of operation?
How to get best way to monitor services by diffusing technology?
Does the contractor role and responsibility favorable to increase customer services of TGTDCL? How to expand/handle it for improvement?
What intrinsic policy of motivation for employees of TGTDCL follows?
How management of TGTDCL follows theory of Management?
The degree of external control of public organization has negative influence on manager desire, but low degree of formalization is needed of innovation of services and high degree of formalization is needed for implementation.
How to do and what your ideas about the TGTDCL regarding this matter?
How to resolve the barrier of TGTDCL?

Appendix B

FGD guide for clients and Contractors side
What types of problems do you get Titas gas services? How to improve TGTDCL service procedure?
Do you think TGTDCL service is very expensive? How to introduce with TGTDCL Contractor to get contract of your services?
What do think about the Contractor role? It is expensive or not? Can you depend on contractor role?
How to improve contractor and service provider roles with the clients?
What barrier do you get from TGTDCL employees and Managers normally? How to reduce this barrier?

Biography

Md Shamsuzzoha is a Manager of Engineering Services Section, Titas Gas Transmission and Distribution Company Limited (TGTDCL), Dhaka, Bangladesh. He earned Bachelor of Science in Mechanical Engineering from Bangladesh University of Engineering and Technology (BUET), Bangladesh, Master of Business Administration from University of Dhaka, Bangladesh and M.Sc. in Petroleum Engineering from University of Stavanger, Norway. He publishes journal and conference papers regualarly. He has about 16 years professional job experience at Mining, Production and Oil & Gas sector in Bangladesh. His research interests include service management, innovative services and innovation for engineers of Public / Government sector of the developing country like Bangladesh. He is a member of IEB, Bangladesh, BUET-Alumni, SPE, Stavanger Section, Tender evaluation Committee, Dhaka - WASA and DUAA, University of Dhaka.

Paper ID: 12

Catalytic Pyrolysis of waste tyres: The influence of ZSM-5 catalyst/tyre ratio on product

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Abstract

In this research, the effect of ZSM-5 zeolite catalyst was investigated on the thermal pyrolysis of catalysis of waste tyres in Bangladesh. The tyres of bus and trucks were pyrolysed in a fixed bed reactor and the derived pyrolysis gases were passed through a condenser. The main objective of this study was to investigate the effect of ZSM-5 on the composition of pyrolytic waste tyres oil. The influences of pyrolysis temperature, catalyst-tyres (CT) ratio on the production of the derived products were also investigated. While the catalyst-tyre (CT) ratio and the pyrolysis temperature were increased the production of char and oil increased but the production of gas was in decreasing trend. Moreover, the CHNS analysis revealed that the percentage of carbon increased from 86.81% to 88.60% and the percentage of Sulfur decreased from 1.325% to 1.064% while the catalyst-tyre ratio was increased from 0.1 to 0.15. It was noticed from the GC-MS data that the certain aromatic compounds were a high amount as the catalyst-tyre ratio was increased gradually The presence of toluene and O-xylene in pyrolytic oil of waste tyres increased significantly with a 0.15 CT ratio and this pyrolytic oil would be potentially used as chemical feedstock in different industries.

Keywords
Catalyst, Waste Tyre, ZSM-5 Zeolite, Pyrolytic Oil

1. Introduction

The large amounts of waste tyre are increasing annually in all over the world and their dumping is creating environmental as well as economical problems [1]. Energy crisis and environmental degradation are the most treacherous problems for human being. The energy crisis problem has become a burning question in Bangladesh. Renewable energy resources of Bangladesh can minimize the energy crisis as an alternative energy source [2]. About 20.5 million bicycle/rickshaw tyres are disposed every year as scrap in Bangladesh [3]. Therefore, the research in oil production by pyrolysis of waste tyres has become a great interest in recent years [4]. The decomposition of waste tyres at high temperature ranging from 300 to 600 ˚C in an inert atmosphere and energy recovery is the basic principle of waste tyre pyrolysis. Pyrolysis of waste tyres for producing oil fuel is an attractive method to recycle the scrap tyres and has become a promising research area in the renewable energy research field. The pyrolysis of tyres produces oils, chars, gases, and steel cords and all of these products are potential to be

recycled. The liquids of tyre pyrolysis (a mixture of paraffins, olefins and aromatic compounds) have a high gross calorific value (GCV) around 41–44 MJ/kg, and therefore, it would be used as an alternative source of conventional liquid fuels [5-7]. In addition the oil contains highly concentrated aromatic compounds such as, benzene, toluene, xylenes and limonene which are being used in different chemical industries [8-11]. Therefore, catalysts are being used to produce the low concentrated single ring aromatic compounds.

In this study, the effects of CT ratio on the composition of the pyrolytic waste tyre oil were investigated. The physical properties of the pyrolytic oil viz. density, kinematic viscosity and gross calorific value (GCV) were measured and also compared with the physical properties of conventional oils like diesel and furnace oil. The property of the pyrolytic tyre oil was also analyzed by CHNS elemental analysis, In addition to, Fourier Transform Infra-Red (FTIR) Spectroscopy and Gas Chromatography (GC) - Mass Spectrometry (MS) were studied to investigate the oil potentiality as a chemical feedstock.

2. Materials and Methods

2.1 Raw Materials

The scrap tyres of buses and trucks were used as feedstock raw materials for the pyrolysis process. These tyres were collected from the car garage of bus and trucks. The scrap tyres were cut into (1.00 × 1.00 × 0.75) cm^3 = 0.75cm^3 for each feedstock of the pyrolysis process.

2.2 Experimental Set-up and Procedure

The batch type fixed-bed fire tube reactor was used for waste tyre pyrolysis process. The length of the reactor feeder was 55.0 cm; the outer and the inner diameter of the feeder were 17.0 cm and 16.3 cm respectively. Figure 1 shows the experimental set-up of the reactor. There were two major components of reactor such as reactor feeder and condenser. The reactor feeder was used for maintaining constant temperature inside the reactor where as the condenser was used for condensing the pyrolytic vapor to liquid [12]. The N_2 gas cylinder was connected to the reactor feeder for ensuring an inert atmosphere in the feeder. About 1.5 kW power capacities were maintained by three tube heaters having a 10 mm diameter. A distributor plate was fitted to support the feedstock, which was placed on a 30 mm distance from the bottom of the reactor. Glass wool and asbestos rope were used for the thermal insulation of the reactor chamber.

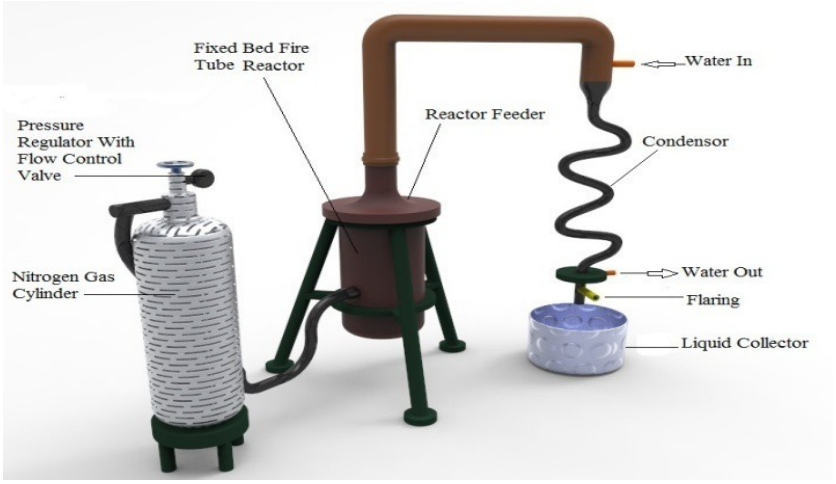

Figure 1: Schematic representation of experimental set-up of the reactor

The experiments were performed for waste tyres of buses and trucks. The inside temperature of the reactor chamber was recorded by the thermocouple sensors. A one kilogram raw material (scrap tyre) was feed into the reactor for each experiment and the powder form of ZSM-5 zeolite catalyst was added to raw materials in the reactor. Before the start of the experiment, The N_2 gas flow was supplied in the reactor for a few minutes before the experiment. The temperature of the reactor was maintained at a 300°C and the temperature was recorded by a temperature recorder. The colourless gas was emitted from the reactor after the decomposition of raw materials (waste tyres).

The pyrolytic gaseous product was passed through condenser and the gas was condensate into liquid pyrolytic oil. The experiments were performed with two different CT ratios of 0.1 and 0.15 sequentially. The oil samples were stored in the beakers.

3. Result and Discussion

3.1 Effect of pyrolysis temperature on product yield

The catalytic pyrolysis of scrap tyres were conducted at different temperature ranging from 300˚C to 600˚C. The authors previous study of catalytic pyrolysis of waste tyre revealed that the liquid production rate increased till to the liquid maximum yield and then the liquid production rate decreased while the pyrolysis temperature was increased gradually [13]. The effect of temperature and catalyst on pyrolysis products of waste tyre is shown in Figures 2 to 4.

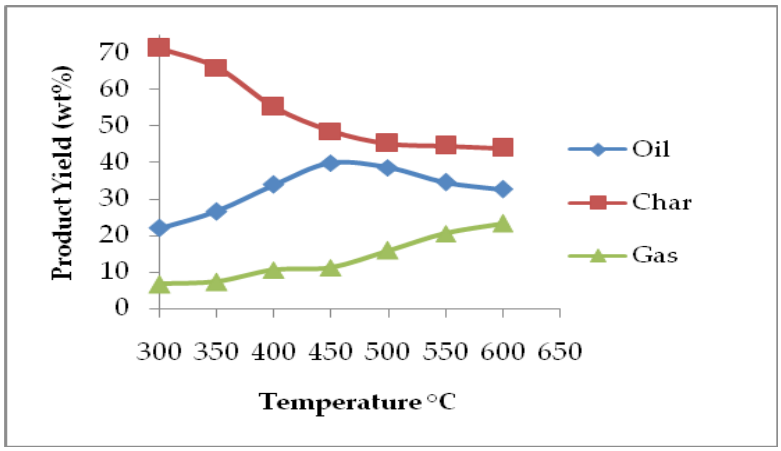

Figure 2: Effect of temperature on product yields for tyre pyrolysis (without catalyst)

For waste tyre pyrolysis associated without catalyst, the maximum yield of liquid 42.0% (wt) was found at 450˚C without catalyst. But the liquid yield has decreased to 32.67 % (wt) at a temperature of 600˚C [12].

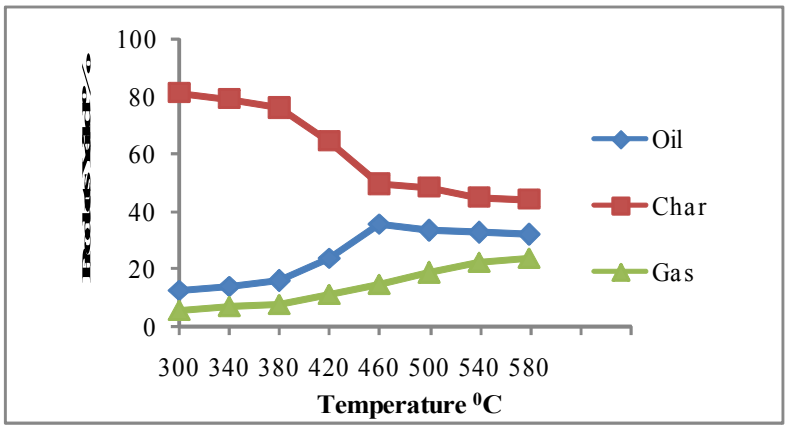

Figure 3: Effect of Catalyst on product yields of tyre pyrolysis (CT ratio 0.1)

The maximum oil yield was about 35.83% (wt) at 460 ˚C and the yield decreased to 31.95% (wt) while the temperature was at 580˚C with the CT ratio of 0.1.

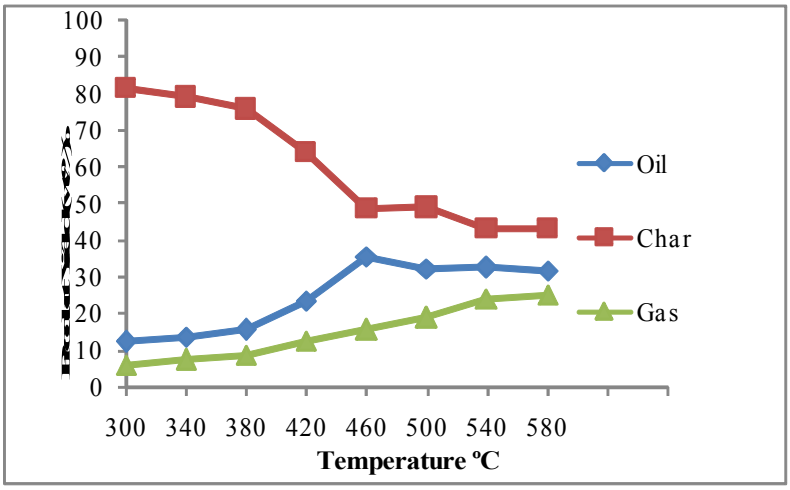

Figure 4: Effect of Catalyst on product yields of tyre pyrolysis (CT ratio 0.15)

Fig. 4 shows the similar temperature effect on oil yield at the CT ratio of 0.15. The oil yield was increasing while the pyrolysis temperature was increased. The maximum oil yield was obtained about 35.63% (wt) at 460 ˚C and then the yield decreases to 31.86% (wt) at a temperature of 580˚C.

3.2 Comparison of Pyrolytic Liquid properties with other commercial fuels

The properties of pyrolytic oil of waste tyre were measured at two different catalyst and tyre ratio such as 0.1 and 0.15. The different properties of pyrolytic oil such as; density, kinematic viscosity and gross calorific value (GCV) were measured and compared with the properties of conventional diesel and furnace oil (see Table. 1).

Table 1: Properties of Raw Pyrolytic Oil, Catalytic Oil with Conventional Diesel and Furnace Oil

Physical Properties	Without Catalyst	Present Study Pyrolytic oil with CT ratio 0.1	Present Study Pyrolytic oil with CT ratio 0.15	Reference With [12]	
				Diesel	Furnace oil
Density (kg/m^3), 30˚C	935.1	915.84	903.92	820 to 860	890 to 960
KinematicViscosity in @40˚cSt (centistokes)	6.59	6.35	6.12	3 to 5	45
Gross Calorific Value (MJ/Kg)	37.98	38.27	38.96	42 to 44	42 to 43

3.3 Elementary Analysis

The elemental analysis of the pyrolytic liquid was carried out at two different CT ratios such as 0.1 and 0.15 respectively and the elemental analysis figures are shown in Fig. 5 and 6. The elemental analysis data of two CT ratio of pyrolytic oil samples are summarized in table. 2.

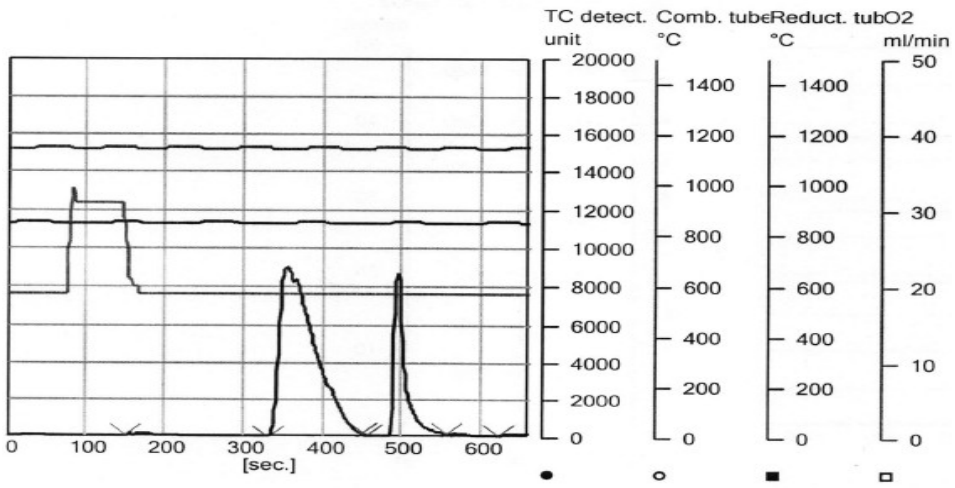

Figure 5**:** Elemental analysis of the sample with catalyst (CT ratio 0.1)

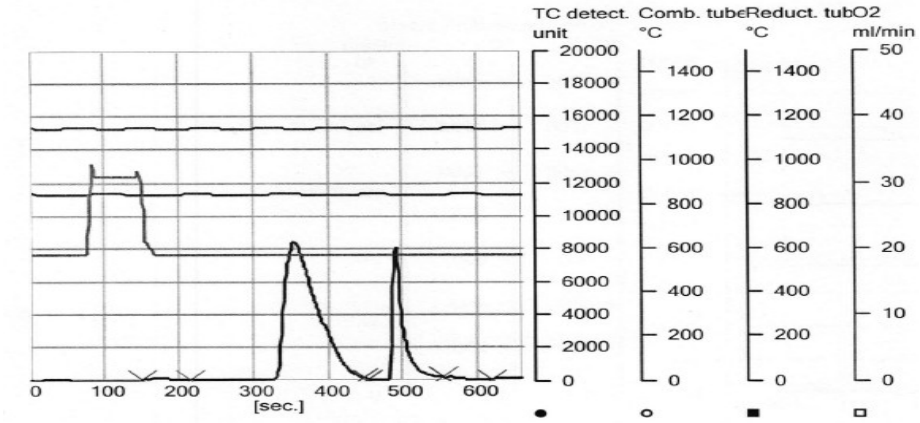

Figure 6**:** Elemental analysis of the sample with catalyst (CT ratio 0.15)

Table 2. Elemental anlysis data of pyrolytic oil samples of different CT ratio.

Elemental Analysis (wt %)	Catalytic Pyrolysis of Waste Tyres with CT ratio 0.1	Catalytic Pyrolysis of Waste Tyres with CT ratio 0.15
Carbon	86.81	88.60
Hydrogen	8.258	8.486
Nitrogen	0.00	0.00
Sulphur	1.325	1.064

3.4 FTIR Spectroscopy Data Analysis

It was noticed from the results of FTIR analysis that the pyrolytic oil contained the hydrocarbon compounds are quie similar for different CT ratio. While the CT ratio changed from 0.1 to 0.15 the rate of catalytic cracking increased and the aromatic content in the liquid fuel was increased significantly. The presence of aromatic compounds increases the octane number in liquid fuels. FTIR results are given in Table 3.

Table 3: FTIR Functional Groups and data of Pyrolytic Compounds

Absorbance Range (cm^{-1})	Functional Group	Class of Compound	Present Study CT ratio 0.1	Present Study CT ratio 0.15
4400-4670	C-H	Aliphatic	4385-4667	4377-4475
4000-4350	C-H	Aromatic	4007-4328	4065-4329
3670-4000	O-H	Hydroxyl group	3681-3938	3677-3943
2000-2700	C=C, C=N	Alkynes, Aliphatic Nitrites	2047-2246	2046-2358
1750-2000	C=O	Carboxylic Acid	1802-1939	1795-1991

3.5 Gas Chromatography - Mass Spectrometry (GC-MS) Data Analysis

The main products of solid heavy automotives are condensable liquids. It is difficult to quantify the various diversified and numerous components of the pyrolytic oil samples. GC/MS analysis is a very efficient quantification process and this process was carried out with the pyrolysis liquids of 0.15 CT ratio. The GC-MS analysis is carried out to investigate the nature and the presence of different compounds of the pyrolytic liquid [14]. The results of GC-MS analysis of pyrolytic oil of scrap tyre was summarized in Table 4. The GC-MS analysis revealed the presence of chemical compounds; retention time and the percentage area of different compounds were compared to the total area of the chromatogram. This comparison gave the estimation of relative concentration of the pyrolytic liquid compounds. The GC-MS results of tyre pyrolysis liquids 0.15 CT ratio showed that the concentrations of toluene, o-xylene, D-limonene, napthalene was high comparing with other compounds.

Table 4: GC - MS data analysis and tentative compounds found for 0.15 CT ratio catalytic pyrolysis of waste tyre.

Peak	Ret. Time	Area %	Name of the Compounds
1	3.05	1.69	Pentane, 2,4-dimethyl-2-nitro-
2	3.092	1.08	Oxetane, 2,2,4-trimethyl-
3	3.567	7.55	Toluene
4	3.783	0.70	3-Hexanone
5	5.267	1.46	Ethylbenzene
6	5.442	8.11	o-Xylene
7	5.925	1.46	1,3,5,7-Cyclooctatetraene
8	5.983	1.57	Benzene, 1,3-dimethyl-
9	7.3	1.00	Hydroperoxide, 1-ethylbutyl
10	7.55	0.66	1,2,6-Hexanetriol
11	7.742	2.07	Benzene, 1-ethyl-3-methyl-
12	7.783	1.46	Benzene, 1-ethyl-2-methyl-
13	7.933	0.66	Mesitylene
14	8.308	0.87	.alpha.-Methylstyrene
15	8.642	2.47	Mesitylene
16	8.75	1.00	Benzene, 1-ethenyl-2-methyl-
17	9.475	1.61	Mesitylene
18	9.533	2.05	o-Cymene
19	9.675	4.49	D-Limonene
20	9.875	0.49	Indane
21	10.133	1.06	Benzene, 1-propynyl-
22	11.483	1.10	Benzene, 1-methyl-3-(1-methylethenyl)-
23	12.425	0.50	Benzene, 1,2,3,4-tetramethyl-
24	13.3	1.93	Cycloprop[a]indene, 1,1a,6,6a-tetrahydro-
25	13.483	1.73	2-Methylindene
26	14.358	4.80	Naphthalene
27	16.083	0.97	Caprolactam
28	16.333	0.73	1H-Indene, 1,3-dimethyl-

29	16.492	1.07	1H-Indene, 1,3-dimethyl-
30	16.6	0.78	Naphthalene, 1,2-dihydro-3-methyl-
31	17.3	3.86	Naphthalene, 2-methyl-
32	17.683	1.97	Naphthalene, 2-methyl-
33	17.925	0.61	Cyclohexasiloxane, dodecamethyl-
34	18.958	0.76	1H-Indene, 1,1,3-trimethyl-
35	19.05	0.77	Biphenyl
36	19.183	0.60	Trichloroacetic acid, undecyl ester
37	19.333	0.77	Naphthalene, 2-ethyl-
38	19.542	2.48	Naphthalene, 2,6-dimethyl-
39	19.808	1.11	Naphthalene, 1,2-dimethyl-
40	19.867	1.54	Naphthalene, 2,6-dimethyl-
41	20.192	1.67	Quinoline, 2,4-dimethyl-
42	20.767	1.01	Cycloheptasiloxane, tetradecamethyl-
43	20.875	0.83	Acetamide, 2,2-diphenyl-N-(3,3,5-trimethylcyclohexyl)-
44	20.942	1.52	Oxalic acid, monoamide, N-(4-chlorophenyl)-, nonyl ester
45	21.217	0.73	Phenol, 2,5-bis(1,1-dimethylethyl)-
46	21.625	1.69	Naphthalene, 2,3,6-trimethyl-
47	21.908	0.75	Naphthalene, 2,3,6-trimethyl-
48	22.425	0.74	Fluorene
49	22.725	0.50	9H-Fluorene, 9-methyl-
50	23.292	0.57	Cyclooctasiloxane, hexadecamethyl-
51	23.9	0.56	Octadecane, 2,6,10,14-tetramethyl-
52	24.225	0.69	Chamazulene
53	25.058	0.95	Phenanthrene
54	25.208	0.65	Cyclononasiloxane, octadecamethyl-
55	26.375	0.50	Dotriacontane
56	26.442	0.63	Phenanthrene, 4-methyl-
57	26.675	0.53	Phenanthrene, 4-methyl-
58	26.883	0.51	Cyclodecasiloxane, eicosamethyl-
59	28.242	0.72	Heptadecanenitrile
60	30.825	8.20	Phenol, 2,4-bis(1,1-dimethylethyl)-, phosphite (3:1)
61	32.358	4.45	Bis(2-ethylhexyl) phthalate

4. Conclusion

The pyrolysis of waste tyres with different catalyst-tyre ratio such as 0.1 and 0.15 was carried out successfully. The pyrolytic liquid yield was the maximum (35.63%, wt) at 460˚c temperature and then decreased gradually while the temperature was increased. While the catalyst-tyre ratio was increased from 0.1 to 0.15, the sulfur content has decreased as well as the percentage of carbon content has increased from 86.81% to 88.60%. It was also observed that the gross calorific value (GCV) was better with a 0.15 CT ratio than 0.1 CT ratio. Moreover, The FTIR and GC-MS analysis showed that the amount of aliphatic and aromatic compounds was high for 0.15 CT ratio. The pyrolytic oil of waste tyres with a high catalyst-tyre (CT) ratio could be recommended as a environment friendly and a potential fuel for its high calorific value, low content of sulfur and the presence of high content of aromatic compounds**.**

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Introduction of HR policy in Automobile sector in Bangladesh

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Abstract

With its strong influence on the country's economic and industrial development it is indeed one of the major drivers of our economy. Moreover, economic liberalization coupled with its technological, cost and manpower advantage have made Bangladesh one of the prime business destination for many global automotive players. The sector has moderate direct employment and significant indirect employment; it is estimated that the sector provides direct and indirect employment to over 3 million people. This paper will hopefully be able to answer most of the questions arises against of the importance of HR policy in automobile industry and the guideline to the pathway of HR policy in Bangladesh. The result of the analyses performed was the development of an original theoretical framework which aims to help managers understand and analyze flexibility and its relationship with unplanned change in manufacturing systems.

Keywords
HR Policy, Automobile industry

1. Introduction
The Pre-1980s era was defined by a closed market, availability of outdated models and limited supply of vehicles leading to limited growth of the market. The industry was in its nascent stages without any significant players in the market and neither were there a significant base of customers. Automobiles were largely unaffordable and objects of desire for most people. This changed in the next few years of 1983 to 1993 wherein Toyota enter the market. The era saw the formation of several joint ventures in the space of commercial vehicles and auto components. With the de-licensing of the automotive sector in 1993, several global players entered the market as a consequence of which the market grew, leading to stiffer competition and a large variety of products for the customers to choose from - currently, the customer has over 30 Auto Original Equipment Manufacturers (OEM's) to choose two wheelers, three wheelers, passenger vehicles and commercial vehicles from; and this is only expected to grow further, with the recent advent of foreign players.

2. Current Employment Scenario at Automobile Sector in Bangladesh
The Automotive Industry, by its very nature, has considerable forward and backward linkages and thus employs a significant number of personnel. Automobile Manufacturers and distributors of Bangladesh has estimated that the Bangladeshi Automotive Industry provides direct and indirect employment to over 3 million people. Direct employment includes personnel working with automobile OEM's and auto component manufacturers (about 30% to 40%). Indirect employment includes personnel working in the enabling industries, such as vehicle finance and

insurance industry, vehicle repair, vehicle service stations, vehicle maintenance, vehicle and component dealers, drivers, cleaners etc (about 60% to 70%).

Though the availability of personnel in this industry in terms of numbers is not such an at a broad level, it is the quality of the personnel employed, both in terms of knowledge & skills which is not appropriately matched to the requirements of the automobile industry in Bangladesh. Hence one of the key areas at the industry level where significant gaps exist today is the availability of skilled manpower and the problem is not so much in terms of quantity, but more in terms of quality of manpower available. This also leads to lower productivity of the automobile sector in Bangladesh as compared to other nations producing automobiles as seen in the figure below. More so, the problem is destined to aggravate going forward considering the kind of growth and development that is foreseen for the Bangladeshi Automotive Industry. As the industry progresses along its growth path, in order to provide for comprehensive growth, it will become imperative to track the enablers of market and industry and at the same time capture and react to the changing skill requirements in each of these areas along with the skill requirements of the mainstream industry.

The broad trends evident in the structure of the industry across the Bangladesh – in particular, the shift towards the new Member States – and in the composition of occupations, with the growth of engineering and other higher level jobs, are likely to continue over the next 5-10 years. This is likely to be the case under each of the different scenarios, though to varying extents and with differing implications for the scale of future skill requirements. There are unlikely to be new kinds of job emerging as such but existing jobs will tend to change in terms of the skills and competences required and the relative importance attached to these.

An increase in the numbers employed with these skills is likely to be a necessary condition for the optimistic scenario to become a reality. But this requires the industry to be sufficiently attractive to enable companies to recruit people with the relevant skills, which depend in turn on the prospects for growth in the industry.

3. Objectives

As an extension of research in this context, three clusters of organizational practices (work systems, HR policies, and leadership) would be associated with two clusters of employee-level psychosocial outcomes (person-focused, organizational-focused) which, in turn, would be related to employee performance was hypothesized. It was found that work systems and HR policies related to both person-focused (comprising individual job satisfaction, health, self-esteem, and social support) and organization-focused (comprising organizational commitment and perceptions of organizational justice) outcomes. The leadership cluster had a strong association with the person-focused outcomes. Organizational – but not personal-focused outcomes were associated with employee performance comprising employee effectiveness, self-ratings of performance, turnover, and absenteeism.

This paper relates to the part of the framework which deals with flexibility of structural manufacturing resources. First of three different grade companies are selected for proper analyze. Secondly, proper data will come out will the mixing of different grade companies. So, According to the analysis, HRM department should work on the following departments: Admin department, Accounts & finance department, Marketing Department & Technical department.

Table 1: Job responsibility of each department of an automobile company

Administration	Accounts	Marketing	Technical
Monitor and evaluation the employees of the company	Prepare the budget for each month	Preparing the marketing plan, brochure, leaf-let, other advertising policies	Inspection of the vehicle
Prepare and maintain the information of clients database	Prepare the everyday expenses.	Visit customers door and try to bring new customer	Troubleshooting of the vehicle
Total HR will be maintain and develop the HR policy	Forecasting the Finance management in every two month	Forecasting the upcoming marketing strategy and modification as required	Preparing the inspection report
Assist the Accounts to prepare the budget for each month	Financial management of creditors and debtors	Arrange seminars, tour etc for promotion	Preparing the job card
Assist on coordination with every departments	Cost collection from each department		Issue requisition form, dispatch form or inventory form

Prepare the monthly report of the organization, collecting the information from the various departments.	Maintain the track of procurement		Job distribution to the technicians
Legal and Govt. activities will be maintain by this department	Bill preparing		Supervision of the vehicles works practically
Arrange training, tour etc under this department.			Inspection of total working process and finally road test of the converted vehicle
Conflict management will be done by this department			Maintenance of the workshop related equipment
Procurement of anything from in house trading department or from out side			Workshop management

4. Productivity with HRM

The various alternatives called for changes in the ongoing process, organizational structure, infrastructure and technology used in the organization. The anticipated changes with respect to various alternatives are shown at the following figure:

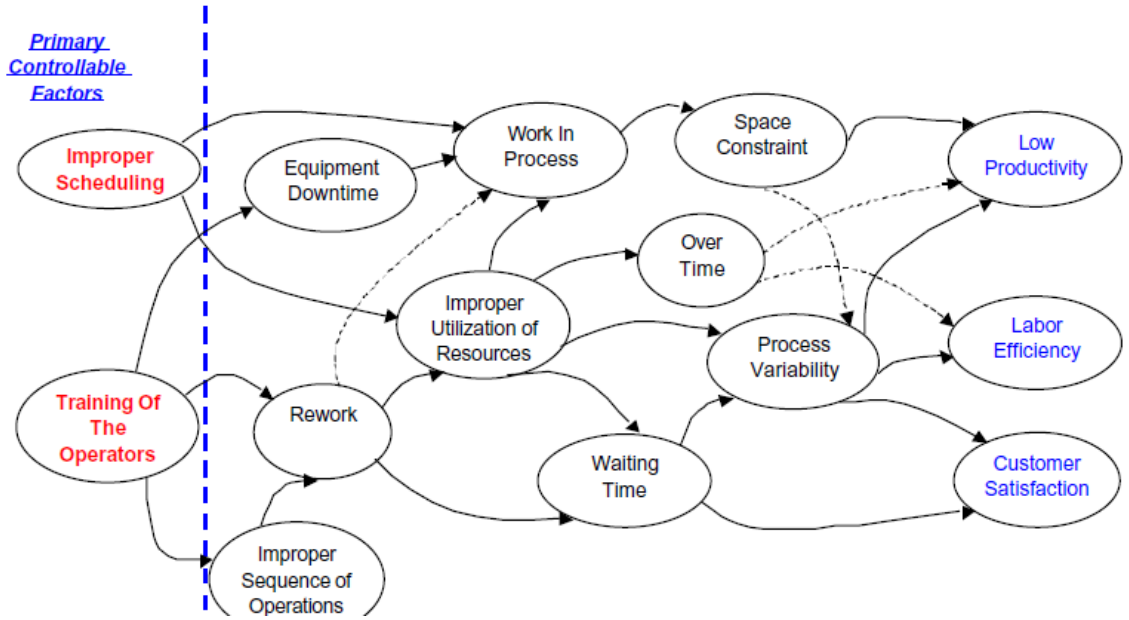

Fig 1: Productivity achieved through HRM practice

Since the repair shop runs five eight-hour days per week plus necessary overtime to complete that day's incoming work, it was modeled as a terminating system. All alternatives were run for ten replications, and each replication comprised ten eight-hour days (two calendar weeks), thereby permitting the routine construction of confidence intervals using the Student-t distribution inasmuch as results from these replications were pairwise independent.

5. Manufacturing process

Some characteristics which would be desirable, according to the literature, for the workforce to possess in a company aiming to achieve higher levels of flexibility are discussed below:

5.1 Multiple and better skills

The larger the range of skills of a worker, the more flexible he or she is, either in terms of the mix of products or in terms of interchangeability of workers between workstations that can be produced in order to cope with absenteeism and temporary shortages.

5.2 Ability to make decisions/solve problems

This is a particularly important characteristic in order to obtain quick responses to changing circumstances. It allows decentralization of decision making and therefore avoids wasting time waiting for decisions to be made in upper echelons.

5.3 Ability to work in teams

Integration is important in order to achieve product flexibility. Multi-functional task forces or teams are being increasingly used when a company needs to launch a new product or change an existing one. Design engineers, for instance, need to have close contact with the production team so that manufacturing problems can be foreseen at the design stage, avoiding a future waste of time and effort. This kind of interaction should happen between all the areas involved and teamwork seems to be the most appropriate approach.

5.4 Communication capability

To achieve integration, efficient communication, intra- and inter-areas is essential. The more this communication is practiced, the easier it becomes. Some areas of the company have their own jargon which should be standardized or at least understood by the other areas with which they interact. In this way misunderstanding is minimized and misunderstandings can be resolved quickly and effectively.

5.5 Ability to understand the process as a whole

A good appreciation of the process as a whole helps understand the consequences of the decisions which become more consistent. This would avoid making decisions which would lead to undesirable consequences as well as making it possible to identify decisions which lead to consequences which are desirable at other stages of the process.

5.6 Ability to adapt to new situations

This helps avoid resistance to change which can jeopardize flexibility. The acceptance of change as an intrinsic part of the production process rather than an exception is important in dealing with changeable or unpredictable environments.

5.7 Ability/disposition for continuous learning

This characteristic known as “learning organization” is a condition for the creation of an effective capability of the system to adapt to new circumstances. Resistance to change is (at least partially) a result of fear of the unknown, often caused, by lack of information. If there is the predisposition to learn then the barriers of resistance are more easily broken.

6. Analysis and Recommendation

6.1 Human resource and skill requirements related to the emerging trends in the industry

Several emerging trends are seen in the Automotive Industry in Bangladesh. These trends will in turn give rise to the corresponding human resource and skill requirements. For example, more number of electronics engineers will be needed to work on the increasing electronic content of vehicles, design engineers will need to work on complicated engine designs, and design as well as manufacturing personnel will be needed for hybrid vehicles. Similarly, personnel to work on the emerging regulatory trends will be needed – for example, design engineers will need to have advanced knowledge of emission and safety regulations. This will also lead to increasing human resource and skill requirements at the supplier’s end.

6.2 Increasing cost of human resources due to the advent of foreign players

With the advent of foreign players in the OEM space and with the demand-supply situation w.r.t. skilled human resources in the Automotive Industry in Bangladesh being as it currently is, personnel currently employed at OEM’s / Tier I suppliers are found to be “industry-ready” and they are thus being attracted by the foreign players into their

fold. Thus a major challenge currently being faced by OEM's / Tier I suppliers, is retaining their skilled employees, thus leading to increasing cost of human resources.

6.3 Increasing recruitment of graduate engineers

A recent trend seen in the Automotive Industry in Bangladesh is the recruitment of BSc graduates at the same level as Engineering varsities or diploma engineers. It is observed that BSc graduates are able to adapt to the manufacturing environment and learn quickly – they need to be given the same amount of training (6 months to one year) that is generally provided to fresh BSc or diploma engineers. Also, the attrition of diploma engineers for higher studies is not found in BSc graduates. Going ahead, as the Auto Industry further focuses on the design and development function, science graduates may also be required in the design and development field (e.g. chemists / physicists may be required in companies that produce castings / forgings). The industry perceives this trend to increase going ahead, and BSc graduates are expected to account for an increasing proportion of the workforce employed in the Automotive Industry in Bangladesh.

6.4 Shortfall of human resources in vehicle design and styling functions

Styling of vehicles is a key competitive advantage for OEM's, but at the same time styling and design capabilities are significantly lacking in Bangladesh – this is why most auto OEM's in Bangladesh depend upon design houses abroad for styling of the vehicles being developed by them. With the increase in product development activity in Bangladesh, the need for developing design capabilities in the country is increasing dramatically. This is also being driven by the need for developing vehicles as per the tastes of fast growing local and Asian markets. The Bangladesh's OEMs over the years have set up in-house design centres for enhancing their capabilities to develop products to suit customer choices which are fast changing. The global OEMs have also felt the growing need for developing vehicles as per local requirements and have started setting up design houses in Bangladesh. The focus on developing vehicle design capabilities in Bangladesh is driving the need qualified manpower with the requisite capabilities. Availability of qualified and talented vehicle designers is being considered as one of the biggest bottlenecks in designing vehicles in Bangladesh. The supply side is also currently limited, with the Master in Design course being offered by some Engineering college. However, in order to build competencies of global levels, continuous availability of a large pool of qualified and talented designers will be necessary.

6.5 Increase in human resource requirements for vehicle financing and vehicle insurance

Vehicle financing and vehicle insurance are underlying support systems for the Automotive Industry in Bangladesh and these may be considered as the enablers of growth of the Automotive Industry. The enabler segments are associated with providing indirect employment to personnel in the Auto Industry.

6.6 Increasing proportion of women in the workforce

The Automotive Industry in Bangladesh is characterized by maximum proportion of the workforce being male. Women employed in the Auto Industry in Bangladesh, are mainly employed in functions such as design, HR, finance and in support office functions. This has primarily been the case due to the low availability of women who take up courses such as mechanical engineering in college. Companies, especially auto OEM's and Tier I suppliers, are making a conscious effort to increase the participation of women in the workforce, including in the core operations function. Whether or not women will participate in the operations workforce though, remains to be seen.

6.7 Skills that will be required due to the upcoming Inspection and Maintenance regime

Mandatory inspection and maintenance regulations, including vehicle scrapping norms for old vehicles since they contribute to a larger portion of carbon dioxide emissions are expected to come into being in the near future. These norms will help implement stricter safety and emission regulations and will in turn lead to employment in certain new areas covering the vehicle scrapping chain. For example, the role of car dealers will diversify as they will additionally serve as intermediaries between the customer and the scrapping industry. There will be an increased need for dismantlers, scrap dealers and vehicle cutters and the absolute number of these units as well as the employment at existing units will correspondingly increase. Other agencies involved will include OEM's, insurance agencies, RTO's etc. and these agencies will need separate personnel for vehicle scrapping related work or will need to train their existing personnel specifically for this purpose.

6.8 Multi-product integrated dealerships and the corresponding need for multi-skilled sales and service personnel

Currently in Bangladesh, OEM's have their own dealerships that sell cars of only of one particular OEM - thus a Tata passenger car dealer is an exclusive Tata dealer and will not sell passenger cars of, say, Hyundai. This situation is expected to undergo a change in the near future, with multi-brand car sales dealerships setting up base. Carnation Auto plans to retail new as well as used cars of different brands under the same roof. Such an initiative is expected to bring about a sea-change in the way cars are sold currently by making available one-stop solutions to customers and also allowing them to compare new cars at a single location. Such an initiative is expected to lead to the need for multi-skilled sales and service personnel who are able to sell as well as service multiple car models and brands with the same efficiency.

6.9 Organized used car industry

The used car industry in Bangladesh has traditionally been unorganized, and has been characterized by small players buying and selling vehicles and direct seller-to-buyer interaction. This scenario is already changing, with the advent of players such as Maruti True Value and Mahindra First Choice. The organized used car market provides several advantages to the end-customer - since vehicles purchased by used car dealers are thoroughly tested and valued accordingly, customers can be more sure of the quality of the product bought from used car dealers as against from unorganized players. The further proliferation of used car dealerships is also expected to expand the need for certain skill sets in the industry – for example, a greater number of personnel are in demand for testing, inspecting and valuing used cars, sales personnel are expected to not only sell used cars but also to aid in purchasing used cars, drivers are required for test-driving used cars, etc.

6.10 Additional training of service personnel

With the aim of increasing personnel efficiency, a vigorous personnel-training program could be implemented on a periodic basis. Such an implementation presumably would decrease rework and excessive "work in process". These decreases would then improve utilization of resources, reduce waiting time of the customers, and thereby improve the overall productivity, labor efficiency, and customer satisfaction.

6.11 Hiring additional service personnel

The number of bays cannot be increased due to space constraints, but in this scenario additional employees would be hired on a permanent basis. From a deterministic spreadsheet model, the investigators identified major repairs as the bottleneck; an additional employee already having the required skills to undertake such repairs could be hired. With the help of the additional worker, the process would presumably flow more smoothly than before, and this alternative should also reduce excessive WIP as well as overburden on employees. It could also be expected to improve customer satisfaction by reducing waiting times.

7. Conclusion

This paper provides an empirical review of HRM practices and outcomes in the automotive context. It also suggests that managing with a high-involvement orientation is associated with positive consequences for individuals and organizations within the automotive industry. The results from this study provide support for the role of employee-level psychosocial outcomes as mechanisms between HRM practices and employee performance, supporting an idea that is often discussed but rarely tested in the literature. These results need to temper by the fact that this meta-analysis was based on a relatively small number of studies in one industrial sector, thereby limiting the generalizability of the model. In addition, this paper is not espousing the view that technologically-focused systems are of little value in automotive industries, but rather that taking a more humanistic approach to how they are implemented may benefit all parties involved. The results offer guidance to researchers and practitioners interested in researching and managing the human side of automobile manufacturing

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Feasibility Study of Solar Energy in Bangladesh for Sustainable Development

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Abstract

Bangladesh, a developing country is facing difficulty to achieve an overall sustained progress in the economy due to the lack of a sound energy security. Immense quantity of energy is needed for the development and economic progress of the country. In this context, alternatives of conventional energy sources, renewable energy resources can be the sustainable solution for the energy security. The current demand for energy considerably increasing that was close to exceed the provision and forecast determines that this projection are going to be enlarged additional in close to future. Within the case of the rising energy drawback in Bangladesh, renewable energy particularly solar energy will play a major role during this case. This paper presents the summary of the renewable energy resources in Bangladesh and also the proportion of solar energy feasibility. It will additionally provide the key points of obstacles to implement the use of solar energy in Bangladesh and moreover as government policies and future conceive to overcome this case. When considering all the matter, the solar energy in some regions is satisfactory to operate pumps and additionally for generation of electricity. In this paper, future prospect of solar energy in Bangladesh have been reviewed comprehensively and presented. This work compiles latest literatures in terms of journal articles, conference proceedings, web materials, reports, books, thesis, handbooks on energy and renewable energy resources in Bangladesh.

Keywords
Solar energy, renewable energy; sustainable development; energy policy.

1. Introduction

Limited supply of energy however unlimited wish of power got to drive USA looking for various sources. Of the many on the market possibility of renewable energy, solar systems have captured interest for an extended time. The modern development of solar turbines was started from 1973 and the main achievement of this development lies in the improvement of aerodynamic efficiency and reliability, leading to lower costs per kWh generated. Recently worldwide capability of solar energy reached 159.213 MW and Asia accounted for the most important share of latest installations (40. 4 %).If this current trend are continuing then solar capability doubles each 3 years. [1]. however this statics doesn't full this energy crisis state of affairs in Bangladesh. The rural populations are bereft of the advantages of electricity, this contemporary input of civilization. Moreover, routine closing, reduction of generation capability due to prolonged use on the far side economic life and also the alternative contributory factors result of such shortage of generating capability, compared to the demand. Thus, limitation became inevitable throughout the country throughout peak hours. Therefore new energy supply is then looking out.

2. Geographic Location and Present Energy Consumption of Bangladesh

The availability of the foremost helpful style of energy, electricity, is extraordinarily little. consistent with, Electricity Generation and Consumption in Bangladesh, 2005-2006, installation capability 5275 MW and additionally average demand and average generation area unit 4300-4500 MW and 3200-3300 MW. So, per capita generation and per capita consumption area unit 167 KWh and 136 KWh. From the whole energy in Bangladesh major comes from oil and coal 56% wherever, solar and geothermal take places 5% of the whole energy. For renewable energy sector, future in electrical phenomenon put in capability is 800 kilowatt and turbines are 20 KW.

3. Solar System

Solar panels square measure the medium to convert solar energy into the wattage. Sun beam is absorbed with the panel material and electrons square measure emitted from the atoms that they're finite. This releases current so solar energy is born-again into wattage [6]. once PV cells square measure joined physically and electrically and placed into a frame they type a solar array or PV module. Panels joined along type a solar battery. The sunlight striking on panels, i.e. irradiance or insolation (incoming star radiation), is measured in units of watts per square meter (W/m^2).We can use solely twenty fifth of daylight radiation for PV module [7]. The PV system power output (DC) has more or less a linear relationship to the insulation. Victimization the radiation on the market on the tipped surface the hourly energy output of the PV generator will be calculated per following equation:

$$P = A \cdot X^2 + B \cdot X + C \text{ (in Watts)}$$

Where, x= solar radiation, P = Power generation, and A, B, C are constants, which can be derived from measured data. By using above formula, we can predict solar power generation at any solar radiation.

4. Policies and Projects of Solar Energy in Bangladesh

The different institutes, universities and research organizations (both public and private) are carrying out research and development (R&D) activities in various fields of renewable energy technologies. R&D activities of Bangladesh are characterized by many constraints, including the lack of expertise and financial assistant. All after that, some researcher are working to reach the certain goal of improving electricity problem. At present, power is entrusted by the Ministry of Energy and Mineral Resources (MEMR) to foster the development of RETs in Bangladesh. The following associations are working simultaneously are- Bangladesh Power Development Board (BPDB), Local Government Engineering Department, Renewable Energy Research Center- University of Dhaka, Center for Energy Studies, Bangladesh University of engineering and Technology (BUET), Bangladesh Center for Advanced Studies (BCAS), Bangladesh Rural Advancement Committee, Grameen Sakti (GS), Renewable Energy Program (REP).

At present, several solar resource assessment programs (WERM, SWERA, and WRAP of BPDB) are ongoing in the country. An independent institution, Sustainable Energy Development Agency (SEDA), shall be established underneath the businesses Act, 1994, as a concentrate for sustainable energy development and promotion, 'sustainable energy' comprising renewable energy and energy efficiency. SEDA can take into account providing subsidies to utilities for installation of solar, solar, biomass or the other renewable/clean energy projects. In 1998, The Government of Bangladesh (GoB) upraised tariff and Value Added Tax (VAT) from solar photovoltaic and solar turbines. Evasion of VAT or misuse of this opportunity is that the common phenomena in Bangladesh.

5. Present Scenario of Solar Energy in Bangladesh

Solar radiation varies from season to season in Bangladesh. So we might not get the same solar energy all the time. In "fig.1" the monthly average solar radiation pattern is shown. Daily average solar radiation varies between 4 to 6.5 KWh per square meter. Maximum amount of radiation are available in the month of March-April and minimum in December-January [11]. According to IDCOL, the total capacity of solar energy based installations in Bangladesh appears to be 20.75 MW [12]. The amount is significant considering the upward trend of the number of SHSs (Solar Home System) installations in the country. The "fig. 2" shows the approximate division wise SHSs installation. The

figure illuminates that the distribution of the SHSs is highest in the Dhaka district whereas lowest in the newly formed district Rangpur.

5.1 Solar Energy Programme under Grameen Shakti

Grameen Shakti is experimenting with the possibility of developing systems to utilize solar energy in the coastal areas of Bangladesh. GS installed 4 hybrid power stations (combination of solar turbine and diesel generator) in four cyclone shelters of Grameen Bank. Power generated from the solar turbines is connected to four cyclone shelters for lighting.

5.2 Solar energy Programme under Rural Electrification and Renewable Energy Development Credit (RERED)

The World Bank (Europe is a major funder) invested US$136 million (96 million Euros) over a six-year period in these off-grid solar systems, through the country's Rural Electrification and Renewable Energy Development Credit (RERED). In October 2011 the World Bank provided another US$172 million (121 million Euros), bringing the total the bank funded to US$308 million (217 million Euros) [9]. Since 2003, the RERED has done much to advance electricity in Bangladesh: it has established grid connections and built new electric lines, but the most transforming of its efforts is the installation of small rooftop solar photovoltaic systems in areas where no electricity has ever been produced. The solar systems are small; in addition to running lights, they operate water pumps and power minimal refrigeration for medicine. The World Bank's loan funded about 300,000 of the solar systems, and homeowners pay the loans back to partner organization intermediaries through installments. The solar project is expected to displace 260,000 tones of CO2 emissions over the next 15 years based on reduced kerosene use.

6. Cost Analysis and Sustainable Development

In the last 4th January 2009, the Caretaker Government at its fag end has formulated plans to spread solar facility to more villages, sub urban areas and cities. To support the spread it is suggested to lessen the tariff and taxes from the imported items. The maximum electricity that a solar panel can produce is 130 Watt. By this panel, 11 CFL (compact florescent lamp) of 6 watt power and a 17-20 inches back and white TV can run. Fan conducted on DC current can also be run by this solar energy. To procure a solar panel one has to pay 15% down payment, the rest is covered by installments, total costs stand at Taka 68000. Direct purchase costs 2 thousand 720 less. The maintenance cost for the panel is very low. The companies also give 20-25 years of warranty.

Grameen Sakti and few other companies are working to provide solar energy to the villages in Bangladesh. The companies are also interested to extend the service to the city dwellers. In this sector, there is scope for both local and foreign investment. There is also scope for both private and public entrepreneurship. It is learnt that the amount of investment in this energy sector in rural area per year is more than 2500 crore. 60% of this invested in solar panel, total of which requires to be imported from outside. 25% is invested in battery and the rest 15% in small mechanical parts. Batteries and accessories are all produced in the country. In near future, the solar panel will also be produced locally. According to the insiders of the serving companies- about 20 thousand workers including 5 thousand engineers work in this sector. They hope that 1 lac people will work in this sector by 2015. Now, more than 3 lac houses (.3m) of 465 upazilla of all the districts and 16 islands are getting the light of solar energy. The beneficiaries of this system are about 3 millions. 44 megawatt electricity is produced everyday from the solar projects in Bangladesh [10].

As a survey on kuakata the following data is obtain per KWh cost of each type of Power generation and it is clearly shown that Hybrid is cost effective.

Table 1. Cost of Renewable energy with different mode

Description	Solar speed	Generation Mode	Cost/kWh (Taka)
Power Generated 100 kW, Location Kuakata	5.5 m/s	Diesel only	29.7
		Solar-Diesel	16.3
		PV-Solar-Diesel	16.8
		PV-Solar	19.8
		Solar	24.4

Table 2 CO_2 reduction potential with respect to different power mode

Type of Renewable Energy	Indicative Potential	In place of conventional generation using	CO_2 reduction potential ($MtCO_2$/ year)
Hydro electricity	300 MW	Grid	1.4
Solar home systems	50 W × 2 million	Kerosene & Grid	1.5
Solar lights for poor	10 W × 2 million	Kerosene	0.6
Solar diesel hybrid	100 kW × 300	Diesel generator	0.1
PV diesel hybrid	100 kW × 300	Diesel generator	0.1
Solar electricity generation	200 MW	Diesel generator	2.1
Grid connected PV	200 MW	Grid	0.8
Total			6.6

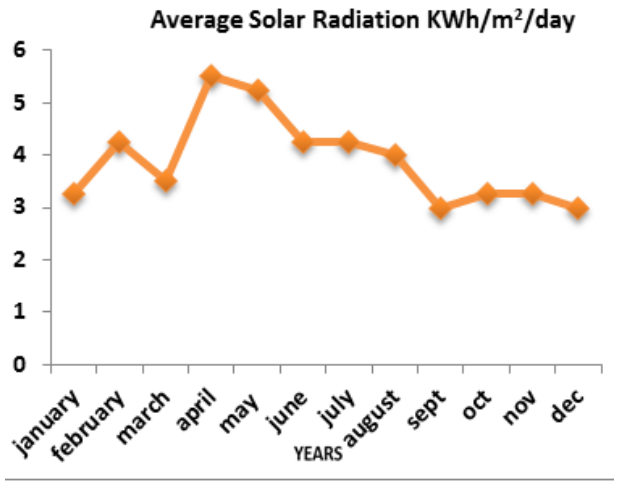

Figure 1.Monthly average solar radiation profile in Bangladesh.

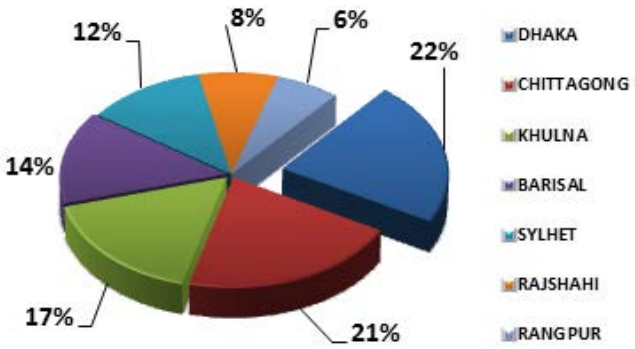

Figure 2. Distribution of the SHSs (Solar Home System) in seven divisions in Bangladesh [13].

7. Recommendations

7.1 Implementing in Hybrid system

In many areas, the solar strength is too low to support a solar turbine or solar farm, and this is where the use of solar power or geothermal power could be great alternatives or hybrid can be a good alternative. Because of low insolation and high solar speed in Monsoon, a solar-solar-hybrid backed up by a diesel generator is a necessity for the sake of uninterrupted supply.

7.2 Gathering Information

A central information point does not exist, instead information is scattered among various sectors. Making a center where public, private organization can require data. Also, the potential of solar energy has not been fully explored in Bangladesh, mainly due to lack of reliable solar speed data.

7.3 Some suggested measures to promote large scale solar farms

There is the need to create more financial support avenues to promote large scale solar farms. A ‘solar fund’ in line with the one in UK can be created in India to support solar projects. Such a fund will provide equity finance for small-scale solar energy projects and will offer investment.

7.4 Geographic information systems for solar sitting

Latest methods like Geographical Information Systems (GIS) have to be utilized for large area screening of prospective sites for solar power development. Solar speeds at the height of a solar turbine depend strongly on terrain elevation, exposure, slope, and orientation to prevailing solar, which can be calculated from a GIS-based Digital Elevation Model (DEM). In addition, with the appropriate database, a GIS can account for other factors that affect solar site suitability, such as the distance to transmission lines, proximity to protected areas, and type of vegetation cover.

7.5 Segmentation of the entire Bangladesh

Under the availability of solar energy, Bangladesh can be divided into two different regions – one Macro (National) region and another one is Micro (Local) region. Economic solar speeds are available only at very specific coastal and offshore island sites. In other parts of Bangladesh, i.e. Chittagong Hills Tracts, Panchagar etc., however, there may also be ‘pockets’ of solar speeds, depending on formation of ‘thermals’, ‘tunnel-effects’. Further work in this direction is being continued. However, the general observation on the critical factor of good solar speed availability is that, the ‘roughage factor’ in the frontal zone of a solar turbine or solar farm site must be minimum to avoid frictional deceleration of solar speeds. On this consideration, one should go as close to the sea as possible.

7.6 Focusing on solar energy management system

As there is no certain management system is followed in Bangladesh so the government of Bangladesh will work on it.

8. Conclusion

Solar Energy has also made some inroads but its potential is mainly limited to coastal areas, and offshore islands with strong solar regimes. These coastal settings afford good opportunities for solar-powered pumping and electricity generation. Although solar energy has not been fully explored, it has the potential to be a source of decentralized energy for Bangladesh. However, based on current turbine technology, for solar energy to be economically viable it has to deliver to a solar turbine an average annual solar speed of at least 5.36 m/s and above. The critical months (lower solar velocities), as has been analyzed through these studies are the winter months (November - February). Good solar speeds (4m to 7m/s) are available during the summer and especially the monsoons, when the solar energy insolation remains low. With improved design for solar turbines, financial package, political will to support large-scale solar projects through public sector undertakings, and a remunerative price for solar generated electricity, it is hoped that solar energy will play a supplementary role to meet the growing power demands in the country.The typical spatial scale for changes of the diurnal cycle apparently depends on many factors such as the area covered by sea breeze, the geometry of the coastal region, or the mutual orientation of the land and sea and the direction of air flow. From the above analysis it might be concluded that the daily cycle of solar speed should be taken into account when a solar farm is planned in the vicinity of a specific site.

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A Multi-objective Mathematical Optimization Approach to a Three-echelon Green Supply Chain Management Subject to Disruption at Plant

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Abstract

The objective of this research is to develop a reactive mitigation plan for a three-echelon Green Supply Chain Management where disruptions occur at manufacturing plants. The mathematical model developed here is a multi-objective optimization problem which at the same time minimizes both total supply chain cost and total CO_2 emission. This model considers back order, lost sales and outsourcing costs to mitigate the effects of disruptions. The multi-objective optimization problem is formulated as a single-objective one by using Weighted Sum approach and ε-constraint approach. For solution methodology, Branch and Cut algorithm is used. Then the solutions from two approaches are compared and discussed hereafter.

Keywords

Green Supply Chain, Disruption, Outsourcing Cost, Lost Sales Cost, Branch and Cut Algorithm, Weighted Sum Approach

1. Introduction

A supply chain is a network that receives inputs or raw materials from suppliers, produces final products at its manufacturing facilities and delivers those products to customers through a distribution network. An ideal three-echelon supply chain network has multiple entities (such as manufacturing plants, distribution centers and retailers) in each echelon. A supply chain network that considers environmental impacts is termed as Green Supply Chain (GSC). As the concerns for our environment is increasing day by day, the GSC is emerging in business sectors. Most of the companies are focusing on this issue. The environmental impacts could be the carbon dioxide (CO_2) emission during the transportation and production, and the waste from scrapped products etc. Supply chain can face many uncontrollable problems, which cannot be predicted in advance. Interruptions of any forms are called disruptions in supply chain. The disruptions at plant can occur due to- material shortage, machine breakdown, labor strike, or any form of man-made or accidental disturbances.

A considerable number of studies on disruptions management can be found in the supply chain literature. In the early 1990s, researchers tended to embed supply disruptions into classical inventory models (2015). Examples include Arreola-Risa & DeCroix (1998), Berk & Arreola-Risa (1994), Gupta (1996), Parlar & Berkin (1991), and Parlar (1997). In a similar fashion, following an economic production quantity (EPQ) system, Xia et al. (2004) developed a disruption recovery model and suggest a production/inventory plan so as to restore the original (pre-disruption) production plan. The most recent works include the works of Paul et al. (2014). They developed a reactive mitigation

approach to manage supply disruption in a three-tier supply chain. They extended their work by developing a quantitative model for disruption mitigation in a supply chain (2016). Ali et al. (2015) developed a mathematical optimization approach to disruption management considering disruptions to suppliers and distribution centers.

Green supply chain management received with hundreds of papers in the past decade. Azadeh et al. (2015) established a goal programming approach for multi-objective Green Supply Chain Management. Heris Golpira (2013) designed a robust bi-objective green supply chain network management model. Nurjanni et al. (2017) developed a mathematical modeling approach based on a multi-objective optimization model for Green Supply Chain design. Their model deals with the trade-offs between the costs and environmental impacts. Tognetti et al. (2015) studied a multi-objective optimization for Green Supply Chain network design which deals with trade-offs between environmental and economic objectives. Niakan et al. (2013) worked with similar type of objectives. Wang et al.'s (2005) multi-objective optimization models consider CO_2 emissions and costs. For a number of carbon- and fuel-pricing scenarios, Fahimnia et al. (2014) examined economic and environmental trade-offs.

All the researches about disruptions management were considered for a normal supply chain network. Also tons of works were performed on managing GSC, but not considering disruptions at manufacturing plants. So there is a gap to focus on. This research focuses on GSC management subject to disruptions at manufacturing plants.

2. Research Objectives

It is very important to manage the disruptions by revising the distribution plans. Again it is also very important to minimize environmental impacts of supply chain. Many researches were carried out previously where the researchers either worked on GSC or disruptions management. No study was done considering the disruptions management in GSC. That is why this study is carried out.

This research has certain clear objectives. These are-

- To develop a supply chain distribution plan for an ideal three-echelon supply chain.
- To develop a revised plan for the same supply chain subject to disruptions at manufacturing plants.
- To minimize the overall supply chain cost which comprises the production, holding, transportation and operation costs after disruptions occur.
- To minimize the total emission of carbon dioxide (CO_2) gas emitted from manufacturing plants during production process and gas emitted during transportation between stages.

These objectives lead to form a bi-objective optimization problem where focus is to minimize total supply chain costs and total CO_2 emission after disruptions take place at manufacturing plants.

3. Mathematical Model

The description of the proposed mathematical model for is explained in four sub-sections, namely problem definition, model elements, model formulation and Multi-objective formulation, respectively.

3.1 Problem Definition

Revising the distribution plan can be done by updating some of the parameters in the same mathematical model, for example, the newly disrupted plant, the start time of the disruption, the disruption duration, the quantity produced before starting the revised plan and the demand to be filled, to represent the changed scenario in order to re-optimize the plan for the current disruption. After every disruption, the plan is revised for a finite period in the future, for as long as disruptions occur in the system.

Suggested heuristics for reactive mitigation are capable of dealing with single occurrence of sudden disruption. In this study, the three different policies for managing a sudden disruption are considered. It is assumed that both manufacturer and customer agree with these policies. The policies are as follows:

- **Back orders:** if a production quantity is lost, the portion of demand that cannot be filled at the scheduled time, but that will be delivered at a later date when available, is known as the back orders quantity. This Policy uses the spare capacity of manufacturing plants to produce the unfulfilled demand.
- **Lost sales**: if the system is not capable of filling demand after a disruption and customers will not wait for stock to be replenished, demand is lost.
- **Outsourcing**: if the production system is not capable of filling the demand on time, as an alternative to lost sales a manufacturer may want to purchase some items from another company at a higher cost and then deliver those items to the customers.

Lost sales and outsourcing policy are substitute of each because these options are applicable when the system is not capable of recovering with its spare capacity and the back orders option. In such cases, the management will have two options, either lost sales or outsourcing. Sometimes, lost sales is not a good option because it may involve additional hidden cost resulting in a higher cost than the outsourcing. So, outsourcing option will be utilized, instead of lost sales, in the recovery plan only when the outsourcing cost is less than the lost sales cost.

The total CO_2 emission is classified into five groups. These are: emission from-manufacturing plants, transportation of goods from plants to DCs, handling goods at DCs, operating at DCs and, transportation of goods from DCs to retailers. So our first objective will be to minimize total supply chain cost and our second objective will be to minimize this total emission while adopting the mitigation planning after disruptions occur.

3.2 Model Elements

A summary of the parameters and variables is outlined in Table 1.

Table 1: Parameters of variables of the model

No.	Notation	Description
1	i	Plant index
2	j	DC index
3	k	Retailer index
4	I	Number of plants
5	J	Number of DCs
6	K	Number of retailers
7	P_i	Production quantity of plant i under ideal conditions
8	CP_i	Maximum production capacity of plant i under ideal conditions
9	CD_j	Maximum handling capacity of DC j
10	X_{ij}	Transportation quantity from plant i to DC j under ideal conditions
11	Y_{jk}	Transportation quantity from DC j to retailer k under ideal conditions
12	D_k	Demand for retailer k
13	p_i	Production cost per unit at plant i ($ per unit)
14	TKM	Transportation cost per unit kilometer distance ($ per km)
15	H_{1i}	Holding cost per unit per period at plant i ($ per unit per period)
16	H_{2j}	Handling cost per unit at DC j ($ per unit)
17	H_{3k}	Holding cost per unit per period at retailer k ($ per unit per period)
18	Z_j	A binary variable (1 or 0)
19	OC_j	Operating cost at DC j ($ per unit)
20	SC_i	Spare capacity of plant i
21	Z_{mj}	A binary variable (1 or 0)
22	t_n	Start time of disruption at the n^{th} plant as a fraction of period
23	T_{dn}	Disruption duration for the n^{th} plant as fraction of period
24	P'_{im}	Production quantity after disruption at plant i in period m
25	X'_{iim}	Transportation quantity from plant i to DC j after disruption in period m
26	Y'_{jkm}	Transportation quantity from DC j to retailer k after disruption in period m
27	D'_{km}	Quantity received by retailer k after disruption in period m
28	D'	The production quantity loss after a single disruption
29	L	Lost sales cost per unit ($ per unit)
30	B	Back orders cost per unit per period ($ per unit per period)
31	S	Outsourcing cost per unit ($ per unit)
32	D^*_k	Quantity received by retailer k during disruption
33	M	Number of periods in recovery window
34	E_{fi}	Rate of released CO_2 to produce one unit of product at plant i
35	E_{hj}	Rate of released CO_2 to handle one unit of product at DC j
36	E_t	Rate of released CO_2 to transport one unit of product per unit distance
37	OE_j	Operating emission at DC j
38	d_{1ij}	Distance between plant i and DC j
39	d_{2jk}	Distance between DC j and retailer k

3.2 Assumptions of the study

In this study, we make the following assumptions:

- There is no inventory buffer and safety stock in the system.
- Demand at the retailer is known.
- No inventory policy is maintained at the Distribution Centers (DC), DC just store the products what they are provided.
- Disruptions at different manufacturing plants are considered to be independent.
- The number of periods in a recovery window is decided by the management of the manufacturing organization.
- Scenario based uncertainty has been incorporated.
- Fulfillment of demand at retailer means customers are served.
- All customers should be served.

3.3 Model Formulation

Formulation are done for three scenarios, namely, for ideal plan, for when disruptions occur and for reactive mitigation plan.

3.3.1 Formulation for ideal plan:

Costs:

Costs at Plant:

Production cost = $\sum_{i=1}^{I} p_i P_i$ (1)

Average holding cost = $\sum_{i=1}^{I} \frac{1}{2} H_{1i} P_i$ (2)

Transportation cost = $TKM * \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij}$ (3)

Costs at DCs:

Operating cost = $Z_j \sum_{j=1}^{J} OC_j$ (4)

Handling cost = $\sum_{j=1}^{J} \sum_{i=1}^{I} H_{2j} X_{ij}$ (5)

Transportation cost = $TKM * \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk}$ (6)

Costs at retailer:

Average holding cost = $\sum_{k=1}^{K} \frac{1}{2} H_{3k} D_k$ (7)

The total supply chain cost (*TC*), which is the first objective function (f_1) is derived using equations (1) to (7) and equals the total plant cost + total DC cost + total retailer cost, where P_i, X_{ij}, Y_{jk}, Z_j are decision variables.

$$TC = \sum_{i=1}^{I} p_i P_i + \sum_{i=1}^{I} \frac{1}{2} H_{1i} P_i + TKM * \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij} + Z_j \sum_{j=1}^{J} OC_j + \sum_{j=1}^{J} \sum_{i=1}^{I} H_{2j} X_{ij} + TKM * \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk} + \sum_{k=1}^{K} \frac{1}{2} H_{3k} D_k \quad (8)$$

The constraints are:

$P_i \leq CP_i; \forall i$ (9)

$P_i = \sum_{j=1}^{J} X_{ij}; \forall i$ (10)

$\sum_{i=1}^{I} X_{ij} = \sum_{k=1}^{K} Y_{jk}; \forall j$ (11)

$\sum_{i=1}^{I} X_{ij} \leq Z_j \times CD_j; \forall j$ (12)

$\sum_{j=1}^{J} Y_{jk} = D_k; \forall k$ (13)

$\sum_{i=1}^{I} P_i = \sum_{k=1}^{K} D_k$ (14)

P_i, X_{ij}, and $Y_{jk} \geq 0$ and integer and Z_j is binary $\forall i,j,k$ (15)

The production quantity of each plant is less than or equal to its maximum capacity of that plant (equation (9)), the constraints for distribution from the plant to DCs and from DCs to retailers are equations (10) and (11) respectively, the capacity constraints of the DCs is equation (12), the demand of the retailers equation (13) and total production is equal to total demand equation (14), while constraint in equation (15) is a non-negativity and integer condition of the decision variables.

CO_2 emission:

CO_2 emission at Plant = $\sum_{i=1}^{I} E_{fi} P_i$ (16)

CO_2 emission during transportation from plants to DCs = $E_t \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij}$ (17)

CO_2 emission from operating at DCs = $Z_j \sum_{j=1}^{J} OE_j$ (18)

CO_2 emission from handling at DCs = $\sum_{j=1}^{J} \sum_{i=1}^{I} E_{hj} X_{ij}$ (19)

CO_2 emission during transportation from DCs to retailer = $E_t \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk}$ (20)

$$\boldsymbol{Total\ CO_2\ Emission} = \sum_{i=1}^{I} E_{fi} P_i + E_t \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij} + Z_j \sum_{j=1}^{J} OE_j + \sum_{j=1}^{J} \sum_{i=1}^{I} E_{hj} X_{ij} + E_t \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk} \quad (21)$$

Here our second objective function (f_2) is to minimize total CO_2 emission.

3.3.2 Formulation of plan when disruption occurs at plant:

If there is a disruption at the n^{th} plant for duration of T_{dn} with a start time of t_n, the production quantity loss after a single disruption can be determined using equations (22) and (23).

If $t_n + T_{dn} < \frac{P_n}{CP_n}$

$$D' = CP_n * T_{dn} - \sum_{j=1}^{I} min\{SC_i, CP_i * (1 - t_n - T_{dn})\} \quad (22)$$

If $t_n + T_{dn} > \frac{P_n}{CP_n}$

$$D' = CP_n * \left(\frac{P_n}{CP_n} - t_n\right) - \sum_{j=1}^{I} \min\{SC_i, CP_i * (1 - t_n - T_{dn})\} \quad (23)$$

Again if $CP_n * t_{dn} < SC_n$,

$$P'_n \leq CP_n(1 - t_{dn}) \quad (24)$$

$$\sum_{i=1}^{n} P_i' \geq \sum_{i=1}^{n} P_i + D' \quad (25)$$

Costs:

Costs at Plant:

Production cost = $\sum_{i=1}^{I} p_i P_i$ (26)

Average holding cost = $\sum_{i=1}^{I} \frac{1}{2} H_{1i} P_i$ (27)

Transportation cost = $TKM * \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij}$ (28)

Costs at DCs:

Operating cost = $Z_j \sum_{j=1}^{J} OC_j$ (29)

Handling cost = $\sum_{j=1}^{J} \sum_{i=1}^{I} H_{2j} X_{ij}$ (30)

Transportation cost = $TKM * \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk}$ (31)

Costs at retailer:

Average holding cost = $\sum_{k=1}^{K} \frac{1}{2} H_{3k} D_k^*$ (32)

The total supply chain cost,

$$TC = \sum_{i=1}^{I} p_i P_i + \sum_{i=1}^{I} \frac{1}{2} H_{1i} P_i + TKM * \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij} + Z_j \sum_{j=1}^{J} OC_j + \sum_{j=1}^{J} \sum_{i=1}^{I} H_{2j} X_{ij} + TKM * \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk} + \sum_{k=1}^{K} \frac{1}{2} H_{3k} D_k^* \quad (33)$$

The constraints are:

$P'_i \leq CP_i$; $\forall i, i \neq n$ (34)

$P'_i = \sum_{j=1}^{J} X_{ij}$; $\forall i$ (35)

$\sum_{i=1}^{I} X_{ij} = \sum_{k=1}^{K} Y_{jk}$; $\forall j$ (36)

$\sum_{i=1}^{I} X_{ij} \leq Z_j * CD_j$; $\forall j$ (37)

$\sum_{j=1}^{J} Y_{jk} = D_k^*$; $\forall k$ (38)

$\sum_{i=1}^{I} P'_i = \sum_{k=1}^{K} D_k^*$ (39)

P'_i, X_{ij}, and $Y_{jk} \geq 0$ and integer and Z_j is binary $\forall i,j,k$ (40)

CO_2 emission:

CO_2 emission at Plant = $\sum_{i=1}^{I} E_{fi} P'_i$ (41)

CO_2 emission during transportation from plants to DCs = $E_t \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij}$ (42)

CO_2 emission from operating at DCs = $Z_j \sum_{j=1}^{J} OE_j$ (43)

CO_2 emission from handling at DCs = $Z_j \sum_{j=1}^{J} \sum_{i=1}^{I} E_{hj} X_{ij}$ (44)

CO_2 emission during transportation from DCs to retailer = $E_t \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk}$ (45)

$$\boldsymbol{Total\ CO_2\ Emission} = \sum_{i=1}^{I} E_{fi} P'_i + E_t \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X_{ij} + Z_j \sum_{j=1}^{J} OE_j + \sum_{\boldsymbol{j=1}}^{\boldsymbol{J}} \sum_{\boldsymbol{i=1}}^{\boldsymbol{I}} E_{hj} X_{ij} + E_t \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y_{jk} \quad (46)$$

Here our second objective function (f_2) is to minimize total CO_2 emission.

3.3.3 Formulation for reactive mitigation plan:

In this section, a mathematical model for revising the production and distribution plan for a finite planning period after the occurrence of a production disruption, with the objective of minimizing the total supply chain cost, is developed. As the recovery strategy involves back orders, outsourcing and lost sales options, there are additional cost equations for them. The back orders cost is determined as the unit back orders cost multiplied by the number of back orders units and the time delay (Paul et al., 2015b), the lost sales cost is the unit lost sales cost multiplied by the number of lost sales units (Paul et al., 2015b) and the outsourcing cost is the quantity outsourced by the unit purchase cost.

If there is a disruption at the n^{th} plant for duration of T_{dn} with a start time of t_n, the production quantity loss after a single disruption can be determined using equations (47) and (48).

If $t_n + T_{dn} < \frac{P_n}{CP_n}$

$$D' = CP_n * T_{dn} - \min\left\{\sum_{j=1}^{I} SC_i, \sum_{i=1}^{I} CP_i * (1 - t_n - T_{dn})\right\} \quad (47)$$

If $t_n + T_{dn} > \frac{P_n}{CP_n}$

$$D' = CP_n * \left(\frac{P_n}{CP_n} - t_n\right) - \min\left\{\sum_{j=1}^{I} SC_i, \sum_{i=1}^{I} CP_i * (1 - t_n - T_{dn})\right\} \quad (48)$$

As this quantity needs to be filled during the recovery window, back orders, lost sales and outsourcing options are considered so that the total supply chain cost during this time can be minimized.

Costs at Plant:

Production cost = $\sum_{m=1}^{M} \sum_{i=1}^{I} p_i P'_{im}$ (49)

Average holding cost = $\sum_{m=1}^{M} \sum_{i=1}^{I} \frac{1}{2} H_{1i} P''_{im}$ (50)

Transportation cost = $TKM * \sum_{m=1}^{M} \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X'_{ijm}$ (51)

Costs at DCs:

Operating cost = $Z_{mj} * \sum_{m=1}^{M} \sum_{j=1}^{J} OC_j$ (52)

Handling cost = $\sum_{m=1}^{M} \sum_{j=1}^{J} \sum_{i=1}^{I} H_{2j} X'_{ijm}$ (53)

Transportation cost = $TKM * \sum_{m=1}^{M} \sum_{k=1}^{K} \sum_{j=1}^{J} d_{2jk} Y'_{jkm}$ (54)

Costs at retailer:

Average holding cost = $\sum_{m=1}^{M} \sum_{k=1}^{K} \frac{1}{2} H_{3k} D'_{km}$ (55)

Back orders cost = $B * \sum_{m=1}^{M} Units\ delay\ at\ period\ m * delay_m$

$$= B * \left[\sum_{m=1}^{M} m\left(\sum_{i=1}^{I} P'_{im} - \sum_{i=1}^{I} P_i\right)\right] \quad (56)$$

Outsourcing cost = $S * \left(M \sum_{i=1}^{I} P_i + D' - \sum_{m=1}^{M} \sum_{i=1}^{I} P'_{im}\right)$ (57)

Lost sales cost = $L * \left(M \sum_{i=1}^{I} P_i + D' - \sum_{m=1}^{M} \sum_{i=1}^{I} P'_{im}\right)$ (58)

If $S \leq L$, then the lost sales cost = 0, otherwise the outsourcing cost is zero.

The total supply chain cost (TC), which is the first objective function (f_1) is derived using equations (49) to (58) and equals the total plant cost + total DC cost + total retailer cost + back orders cost + outsourcing cost + lost sales cost, where P'_{im}, X'_{ijm}, Y'_{jkm} and D'_{km} are decision variables.

$$\boldsymbol{TC} = \sum_{m=1}^{M} \sum_{i=1}^{I} p_i P'_{im} + \sum_{m=1}^{M} \sum_{i=1}^{I} \frac{1}{2} H_{1i} P_{im} + TKM * \sum_{m=1}^{M} \sum_{j=1}^{J} \sum_{i=1}^{I} d_{1ij} X'_{ijm} + Z_{mj} * \sum_{m=1}^{M} \sum_{j=1}^{J} OC_j +$$

$$\sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{i=1}^{I} H_{2j}X'_{ijm} + TKM * \sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J} d_{2jk}Y'_{jkm} + \sum_{m=1}^{M}\sum_{k=1}^{K}\frac{1}{2}H_{3k}D'_{km} + B * [\sum_{m=1}^{M} m(\sum_{i=1}^{I} P'_{im} - \sum_{i=1}^{I} P_i)] + S * (M\sum_{i=1}^{I} P_i + D' - \sum_{m=1}^{M}\sum_{i=1}^{I} P'_{im}) + L * (M\sum_{i=1}^{I} P_i + D' - \sum_{m=1}^{M}\sum_{i=1}^{I} P'_{im}) \quad (59)$$

The constraints are:

$P'_{im} \le CP_i; \forall i,m$ (60)

$P'_{im} = \sum_{j=1}^{J} X'_{ijm}; \forall i,m$ (61)

$\sum_{i=1}^{I} X'_{ijm} = \sum_{k=1}^{K} Y'_{jkm}; \forall j,m$ (62)

$\sum_{i=1}^{I} X'_{ijm} \le Z_j * CD_{jm}; \forall j,m$ (63)

$\sum_{j=1}^{J} Y'_{jkm} = D'_{km}; \forall k,m$ (64)

$M\sum_{i=1}^{I} P_i + D' \ge \sum_{m=1}^{M}\sum_{i=1}^{I} P'_{im}$ (65)

$D'_{km} \le D + (D - D_k^*); \forall k,m$ (66)

P'_{im}, X'_{ijm}, and $Y'_{jkm} \ge 0$ and integer and $Z_j$is binary $\forall i,j,k,m$ (67)

The production quantity of each plant in the revised plan is less than or equal to its maximum capacity in the revised plan (equation (60)), the constraints for distribution from the plant to DCs and from DCs to retailers are equations (61) and (62) respectively, the capacity constraint of the DCs is equation (63), the constraint for the quantity received by each retailer is equation (64), the total lost sales quantity, which should be non-negative, is equation (65), demand constraints (66) and the non-negativity and integer condition of the decision variables is presented in equation (67).

CO_2 emission:

CO_2 emission at Plant = $\sum_{m=1}^{M}\sum_{i=1}^{I} E_{fi}P'_{im}$ (68)

CO_2 emission during transportation from plants to DCs=

$E_t\sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{i=1}^{I} d_{1ij}X'_{ijm}$ (69)

CO_2 emission from operating at DCs =$Z_j\sum_{j=1}^{J} OE_j$ (70)

CO_2 emission from handling at DCs = $Z_j * \sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{i=1}^{I} E_{hj}X'_{ijm}$ (71)

CO_2 emission during transportation from DCs to retailers

$= E_t\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J} d_{2jk}Y'_{jkm}$ (72)

$$Total\ CO_2\ Emission = \sum_{m=1}^{M}\sum_{i=1}^{I} E_{fi}P'_{im} + E_t\sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{i=1}^{I} d_{1ij}X'_{ijm} + Z_j\sum_{j=1}^{J} OE_j + Z_j * \sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{i=1}^{I} E_{hj}X'_{ijm} + E_t\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{j=1}^{J} d_{2jk}Y'_{jkm} \quad (73)$$

Here our second objective function (f_2) is to minimize total CO_2 emission.

3.4 Multi-objective Formulation

Weighted Sum Approach

The weighted sum method is the most basic one for multi-objective problems. It is actually an approach that is combining several objective functions into a single one. For this problem, it can be mathematically formulated as:

$minimize\ w_1f_1 + w_2f_2$

$subject\ to\ the\ constraints\ (60)\ to\ (67)$

$where\ w_1, w_2 \ge 0\ and\ w_1 + w_2 = 1$

ε- Constraint Approach

This method is another approach that is transforming a multi-objective optimization problem, but in a different way. The method includes a prioritization of one objective function, which is set as the function to be minimized, while the rest of the objective functions are transferred in constraints.

The mathematical formulation for this problem can be formulated as:

$minimize\ f_1$

$subject\ to\ f_2 \le \varepsilon$

$where\ \varepsilon\ is\ the\ highest\ bound\ on\ CO_2\ emission$

3.5 Solution Approach

The solution of the disruption management model through the following steps:

Step 1: Input all the information about production and distribution under ideal conditions.

Step 2: Obtain an ideal production and distribution plan by solving the mathematical model for ideal plan.

Step 3: Input a production disruption scenario involving a disrupted plant, disruption start time (t_n) and distribution duration (T_{dn}).
Step 4: Determine the production and distribution plan by solving the mathematical model for when disruption occurs.
Step 5: Determine the demands at retailer that are not fulfilled during disrupted period.
Step 6: Determine the production and distribution plan by solving the mathematical model for reactive mitigation plan.
Step 7: Record the results and determine the different costs.
Step 8: Stop.

4. Result Analysis

A hypothetical case is presented illustrating the production and the distribution problem. In this case supply chain has been considered whose production capacity at different plants, holding costs at different points, operating cost of distribution centers, maximum production capacity, maximum holding capacity, distance from one point to another, demand at retailer, emission due to production, holding and operating distribution center are known.
The test problems are solved using the 'Branch and Cut' algorithm using CPLEX 12.6 solver through MATLAB.

Weighted Sum Approach

The proposed problem contains two objectives. The two different objectives are combined into a single objective by scalarization. It is mathematically formulated as:

$$min\ w_1 f_1 + w_2 f_2$$
$$\text{where},\ w_1 + w_2 = 1;$$

For the recovery period, many possible values of cost function and CO_2 emission function are obtained. From figure 1 and figure 2 it can be seen that as the weight assigned on respective function increases the value of the function decreases. In figure 3 the possible combinations of the objective functions are shown in pareto frontier.

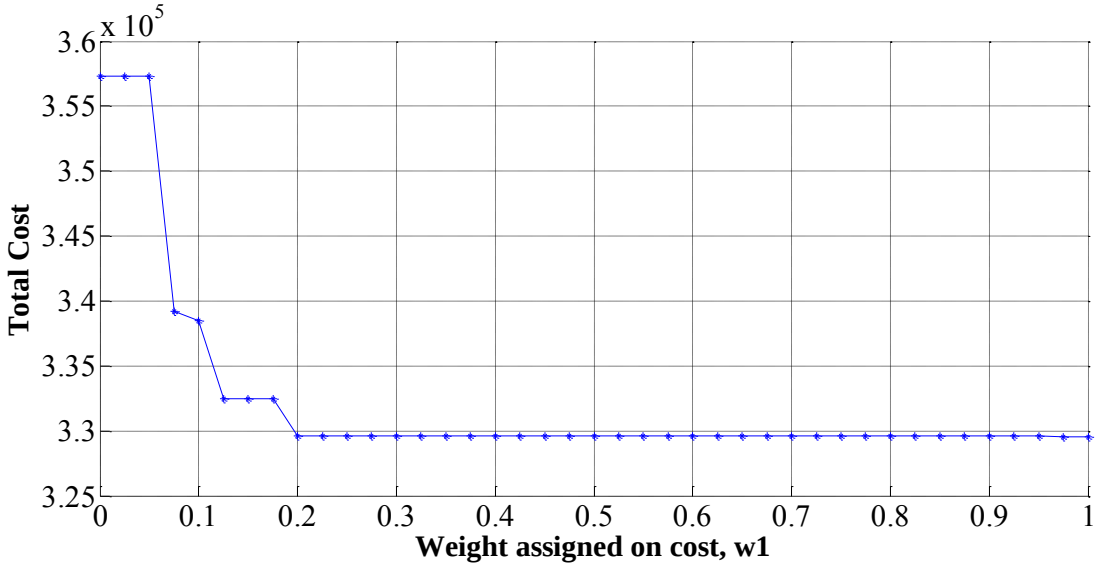

Figure 1: Variations of Cost with respect to Weight

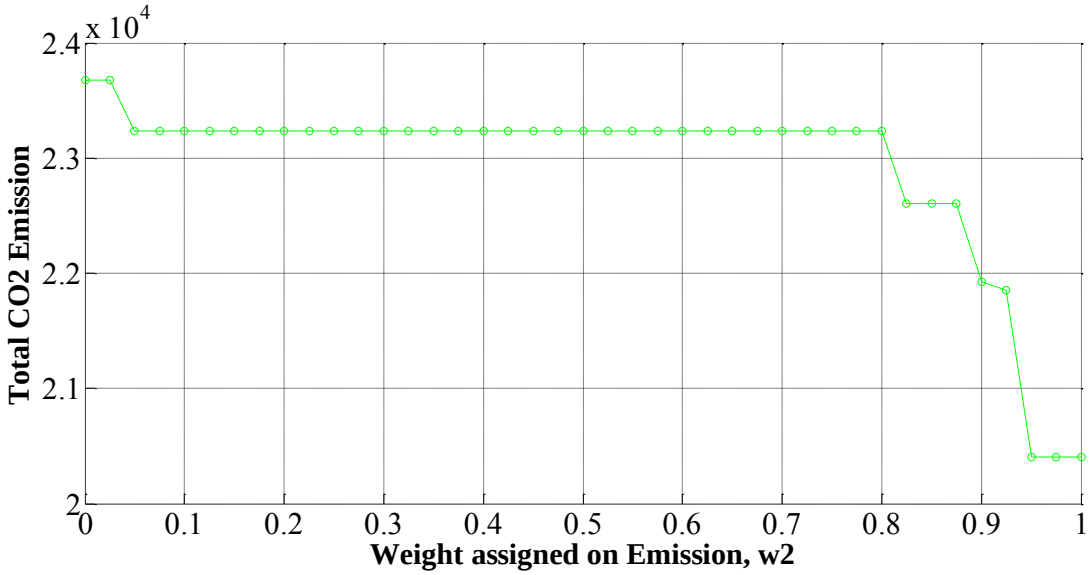

Figure 2: Variations of CO_2 emission with respect to Weight

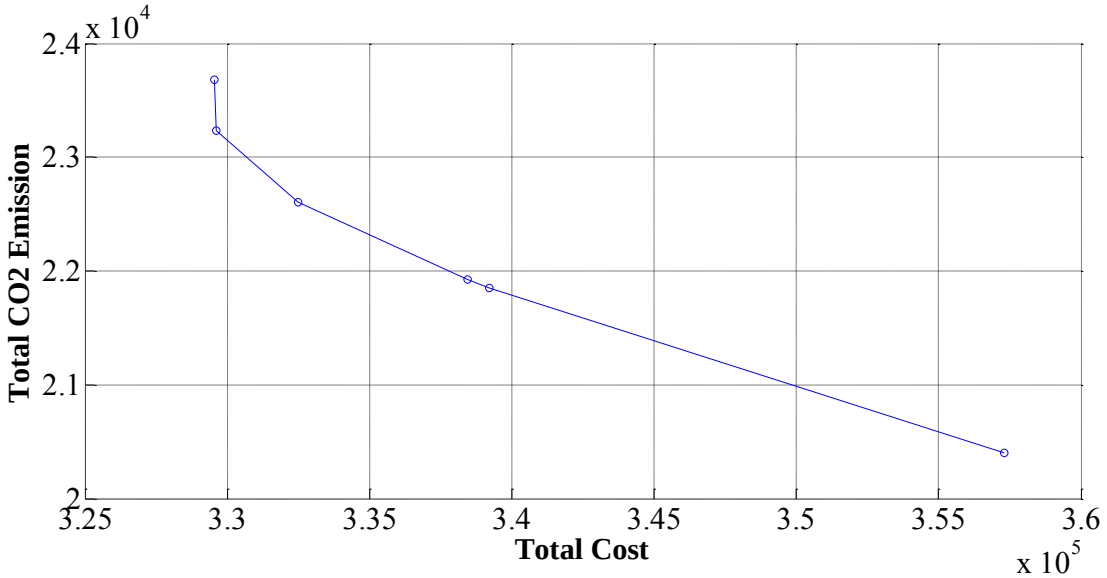

Figure 3: Pareto Frontier

In figure 4, the variation of outsourcing cost and backorder cost with respect to the weight assigned on cost is shown. It is observed that when the weight on the cost function is lower than 0.125 the supply chain system outsources products. For weight assigned on cost functions valued from 0.125 to 0.95 the supply chain doesn't use the outsourcing option, it only uses the backorder option. But when the weight is increased to .975 or 1 the supply chain again uses the outsourcing option. It happens because the supply chain lessens operating cost of a DC by turning off a distribution center which stores a very few products and outsources those products.

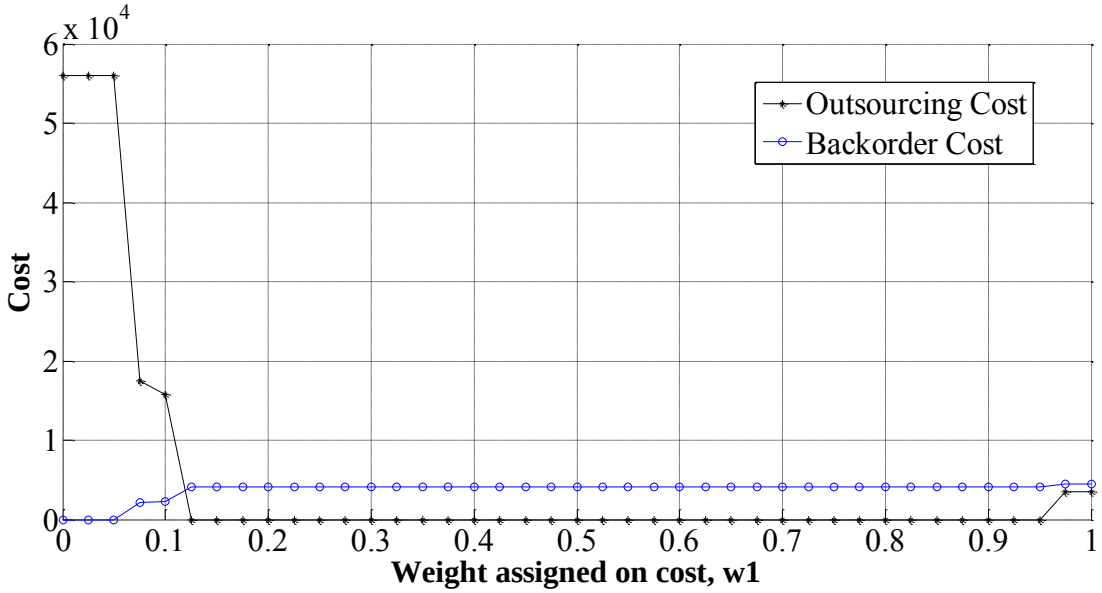

Figure 4: Variations of Outsourcing Cost and Backorder Cost with respect to Weight assigned to Cost Function

In figure 5, it is observed that the revised plan uses no additional cost when the disruption durations are less than or equal to 0.20 and 0.30 for disruptions at plant 1 and 2 respectively. This is because the system utilizes the spare capacity of the disrupted period to fill the quantity lost. However, then there is an increasing trend in the total supply chain cost because of the introduction of back orders and outsourcing costs in the solutions.

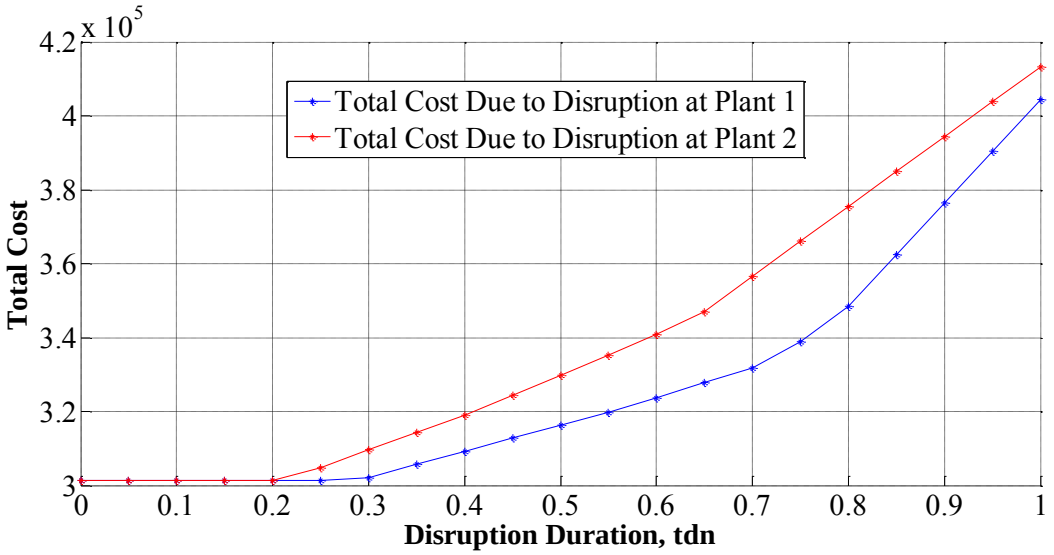

Figure 5: Variation of Total Cost due to Disruption at Different Plants

In figure 6, The CO_2 emission is observed to be constant after the disruption durations more than 0.8 and 0.65 for disruptions at plant 1 and 2 respectively. This is because the system uses the outsource option mainly after this.

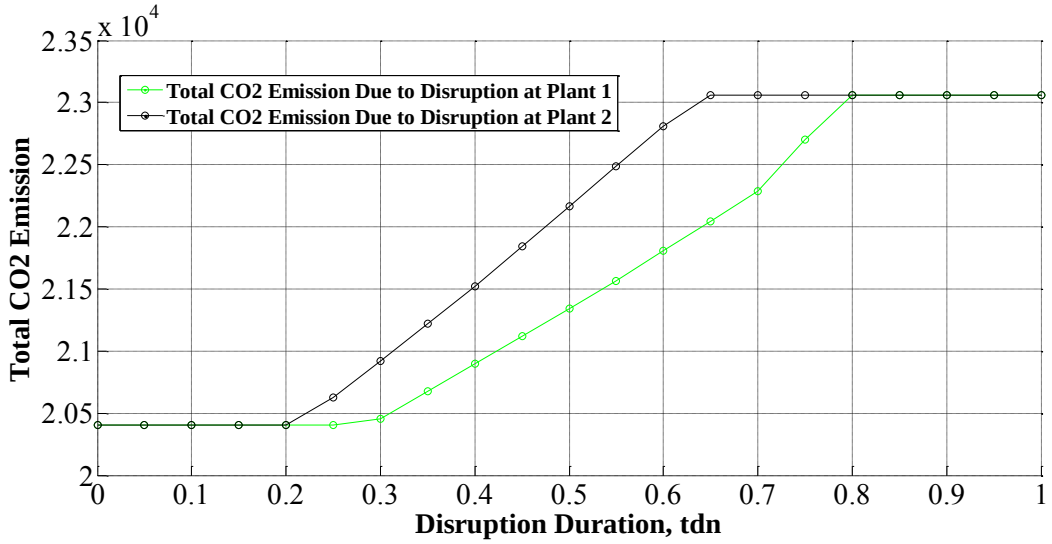

Figure 6: Variation of Total CO_2 Emission due to Disruption at Different Plants

In figure 7, it is observed that the revised plan uses Outsourcing cost significantly after the disruption durations are 0.65 and 0.80 for disruptions at plant 1 and 2 respectively. The backorder cost gets constant after disruption duration of 0.65 and 0.80 for disruptions at plant 1 and plant 2 respectively.

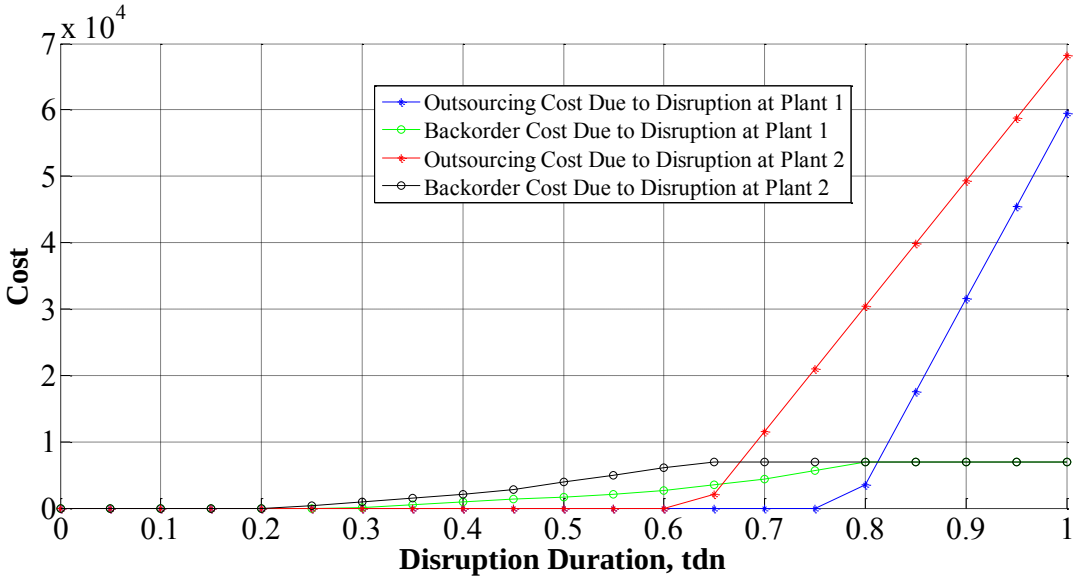

Figure 7: Variation of Outsourcing Cost and Backorder Cost due to Disruption at Different Plants

ε - Constraint Approach

This method is another approach to transform a multi-objective optimization problem into a single objective optimization, but in a different way. The method includes a prioritization of one objective function, which is set as the function to be minimized, while the rest of the objective functions are transformed in constraints.

The cost function is to be minimized (optimized), constraint to the emission function. The problem is formulated as:

$$min\ f_1$$
$$Subject\ to,\ f_2 \leq \varepsilon$$

For epsilon constraint approach it requires previous knowledge about the supply chain system to set the value of epsilon. Here, epsilon is the highest bound on the total CO_2 emission.

In figure 8, variation of total cost with respect to epsilon is shown and in figure 9 pareto frontier for the recovery period is shown. Eight possible combinations of the objective functions are obtained for the recovery period.

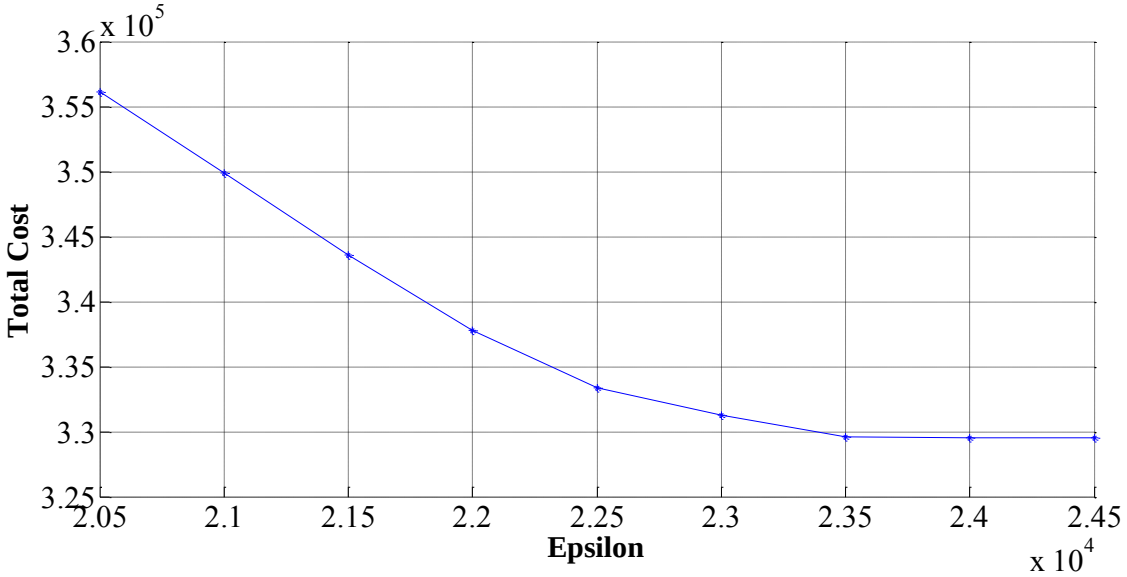

Figure 8: Variation of Total Cost with respect to Epsilon (Bound on Emission Function)

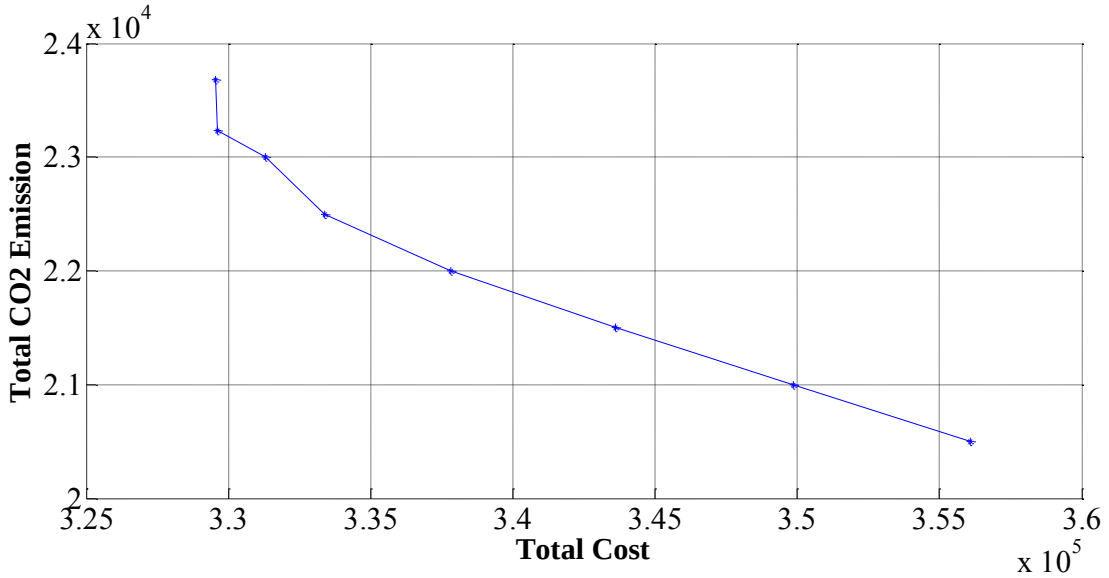

Figure 9: Pareto Frontier: Recovery Period

In figure 10 it is observed that the supply chain outsources all of the disrupted products when the value of epsilon is low. With increasing the value of epsilon the outsourcing cost decreases. When the value of epsilon is 23500 the outsourcing cost becomes zero. With further increase epsilon the supply chain system lessens its cost by turning off a distribution center and outsourcing a few products.

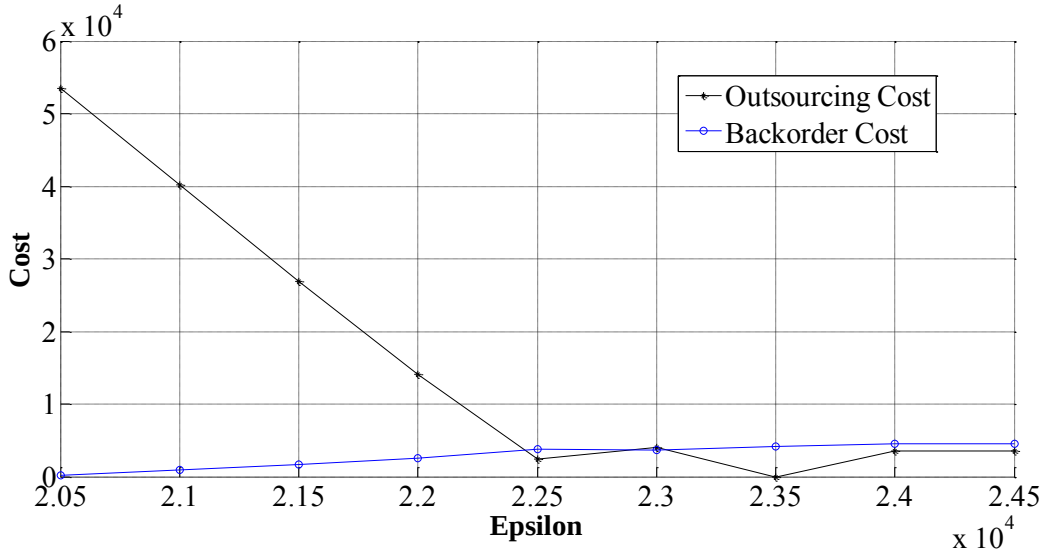

Figure 10: Variation of Outsourcing Cost and Backorder Costs with respect to Epsilon (Bound on Emission Function)

In figure 11, it is observed that the revised plan uses no additional cost when the disruption durations are less than or equal to 0.20 and 0.25 for disruptions at plant 1 and 2 respectively. This is the same result as found in the weighted sum approach. In figure 12, the CO_2 emission is observed to be constant after 0.8 and 0.7 disruption durations of plant 1 and plant 2 respectively. This is because the system has no production capacity after these disruption durations and uses the outsourcing option afterwards.

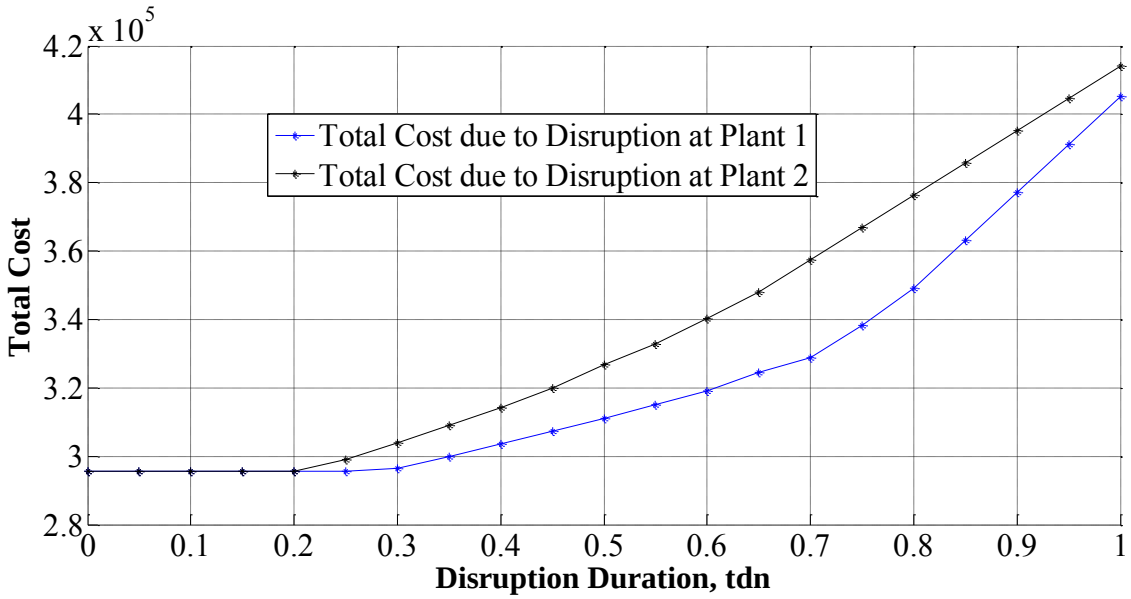

Figure 11: Variation of Total Cost due to Disruption at Different Plants

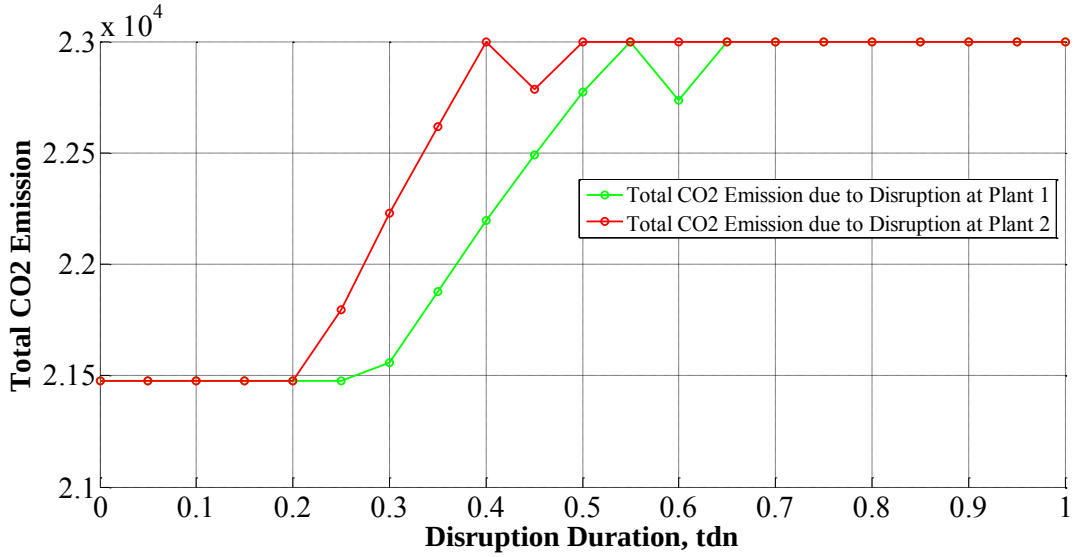

Figure 12: Variation of Total CO_2 Emission due to Disruption at Different Plants

In figure 13, it is observed that the supply chain system starts to outsource products mainly after disruption duration of 0.7 and 0.75 for plant 1 and plant 2 respectively; however the system uses the backorder option from 0.35 and 0.25 disruption durations respectively for plant 1 and plant 2.

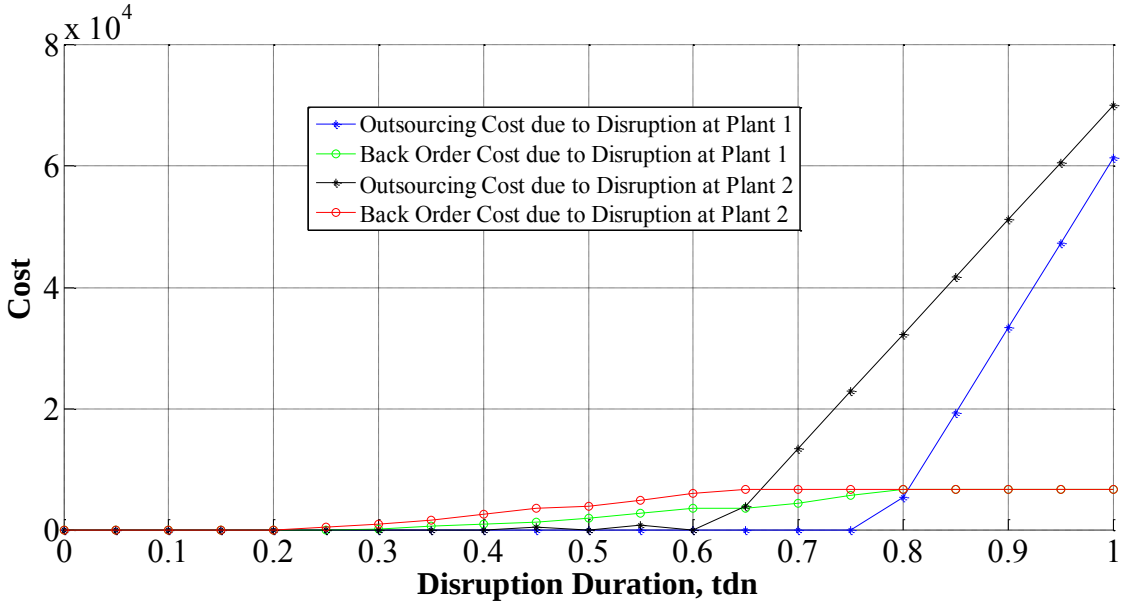

Figure 13: Variation of Different Types of Cost due to Disruption at Different Plants

In reality, the weighted sum approach and the epsilon constraint are same. For epsilon constraint approach it is needed to select which objective need to be optimized and which objective should have bounded value. This is problematic as for many values of $\boldsymbol{\varepsilon}$ values there will be no feasible solution. Assigning $\boldsymbol{\varepsilon}$ values also require previous knowledge of the system. Epsilon Constraint actually represents subset solutions of the weighted approach method solution.

Sixteen different disruption scenarios were taken directly from the examples of Paul, 2016 and their parameters are presented in Table 1. The disruption start times are classified as early, middle and late, and disruption durations as low, medium and high. As when the disruption start time was in the late range, it was not possible to have a high disruption duration, because the latter was dependent on the former, two scenarios (1-L-H and 2-L-H) were absent

from the design of this experiment. The weighted sum approach is used, the weight on cost function and the CO_2 emission function are assigned 0.15 and 0.85 respectively.

Table 1: Different Test Scenarios

Scenario No	Disrupted Plant	Disruption Start Time	Disruption Duration	Scenario Name
-	1	.60 (late)	-	-
1			0.35(medium)	1-L-M
2			0.20(low)	1-L-L
3		.30 (middle)	0.55(high)	1-M-H
4			0.33(medium)	1-M-M
5			0.20(low)	1-M-L
6		0.10 (early)	0.70(high)	1-E-H
7			0.50(medium)	1-E-M
8			0.18(low)	1-E-L
-	2	0.55 (late)	-	-
9			0.30(medium)	2-L-M
10			0.15(low)	2-L-L
11		0.35 (middle)	0.60(high)	2-M-H
12			0.40(medium)	2-M-M
13			0.10(low)	2-M-L
14		0.05 (early)	0.75(high)	2-E-H
15			0.30(medium)	2-E-M
16			0.12(low)	2-E-L

For different test scenarios the results are tabulated in table 6.2 and the variations of total cost, total CO_2 emission and different types of costs.

Table 6.2: Results at Different Test Scenarios: Weighted Sum Approach

	Branch And Cut Algorithm			
Scenario No	Total Cost	Total Emission	Outsourcing Cost	Backorder Cost
1	324254	22075	0	2500
2	301289	20402	0	0
3	332484	22602	0	4100
4	304642	20657	0	340
5	301289	20402	0	0
6	340714	23130	0	5700
7	317653	21613	0	1700
8	301289	20402	0	0
9	310560	21107	0	940
10	301289	20402	0	0
11	343477	23406	0	6060
12	320625	21824	0	2020
13	301289	20402	0	0
14	368938	23731	21000	6900
15	310560	21107	0	940
16	301289	20402	0	0

5. Conclusion and Recommendation

5.1 Conclusion

In this paper, a new model for multi-objective optimization of supply chain network design is presented which has the goal of developing quantitative approaches for managing any changes in data and for generating reactive mitigation plan. The objective is to minimize the effect of the disruption. In particular, the model proposed is formulated as a MILP multi-objective optimization model. It is formulated out of two objective functions focused on minimizing the costs and CO_2 emission. In this model the distribution centers have given the ability to be turned on or off. The aim of the model is to optimize the design of supply chains network under disruption at plant, by selecting appropriate production and distribution plan and selecting distribution centers (DCs). Moreover, the paper considered three alternative options to manage disruptions, Backorder, Lost sales and Outsourcing. The model is applied to a hypothetical case example, designed for the purpose of this research, for proving its functionality and furthermore analyzing the outcomes from the optimization. Two approaches, weighted sum approach and epsilon constraint approach were used to design the problem. For solution methodology 'Branch and Cut' algorithm solver is used. Several numerical examples were presented and experiments to analyze the results and usefulness of the models. The new model considers the distribution of products to the retailer more efficiently and provides efficient cost management by providing the option for the distribution center to be turned on or off. This model tries to recover the ecological sustainability and company profitability at the same time when disruption occurs. The model found out that it is sometime preferable to outsource some products rather than producing it by the system. Because opening a distribution center for a few products is less efficient than outsourcing.

5.2 Future Recommendation

However, the model has some limits that should be taken into considerations for its future development. First, it is a single product problem, meaning only one type of products is considered, but in reality very few supply chain exhibits only one product. Second, it is a model that deals with scenario based uncertainty and does not include stochastic behaviors of the data. Including the uncertain behavior of future scenarios along with the stochastic nature of the data in such models should be taken into considerations. Thirdly, no inventory policy at the distribution center is taken considered. In the model the distribution center only store the products which are given to them. Most importantly, the demand at the retailer is taken to be known exactly but in reality that doesn't happen. So a better model can be developed considering uncertain demand. Moreover, mode of transportation, safety stock, lead time, inventory buffer, none of these cases are considered, they can be considered in future work. The time periods in recovery windows are not determined based on any quantitative factors, they are just based on the decision of the supply chain manager. A quantitative approach to determine the time periods in recovery window can be developed. There could be more objectives such as to minimize waste, to minimize CO emission. Different shipment policies can also be considered.

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Appendix

Sample data used for result analysis are given in the tables below:

I	**2**		**M**	**2**		**B**	**4**
J	**3**		n	**1**		**S**	**70**
K	**6**		t_n	**0.2**		**L**	**75**
TKM	**1**		t_{dn}	**0.6**			
E_t	**.2**						

CP_1	**2000**		$p1$	**19**		H_{11}	**1.2**		E_{f1}	**.8**
CP_2	**2700**		$p2$	**22**		H_{12}	**1**		E_{f2}	**.6**

CD_1	**2500**		OC_1	**10000**		H_{21}	**1.5**		OE_1	**200**		E_{hj1}	**0.08**
CD_2	**2000**		OC_2	**8500**		H_{22}	**1.2**		OE_2	**120**		E_{hj2}	**0.15**
CD_3	**1500**		OC_3	**6750**		H_{23}	**0.8**		OE_3	**75**		E_{hj3}	**0.175**

D_1	**450**		H_{31}	**1.5**		E_{hk1}	**0.1**
D_2	**500**		H_{32}	**1.2**		E_{hk2}	**0.12**
D_3	**650**		H_{33}	**0.8**		E_{hk3}	**0.125**
D_4	**725**		H_{34}	**1.75**		E_{hk4}	**0.08**
D_5	**800**		H_{35}	**1**		E_{hk5}	**0.15**
D_6	**1000**		H_{36}	**0.9**		E_{hk6}	**0.175**

d_{111}	**3**		d_{211}	**6**		d_{221}	**8**		d_{231}	**6**
d_{112}	**4**		d_{212}	**2**		d_{222}	**5**		d_{232}	**2**
d_{113}	**5**		d_{213}	**4**		d_{223}	**3**		d_{233}	**8**
d_{121}	**5**		d_{214}	**3**		d_{224}	**2**		d_{234}	**6**
d_{122}	**6**		d_{215}	**6**		d_{225}	**6**		d_{235}	**6**
d_{123}	**3**		d_{216}	**4**		d_{226}	**4**		d_{236}	**7**

Bleaching Process Parameter Stabilization Using Artificial Neural Network in a CCNO Refinery Plant

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Abstract

The goal of the study is to develop an accurate Artificial Neural Network (ANN) based model to stabilize the key parameters of a CCNO (Crude Coconut Oil) refinery plant predicting the output oil color, given the input parameters. The study is focused both on the bleaching process which ensures the color transparency of the oil and deodorization process which determines the Free Fatty Acid (FFA) content in oil. At first, the key parameters are observed and detected, and then these are used as inputs of the ANN model. A multi-layer feed-forward network has been designed using backpropagation training algorithm. The research strives for finding out the best model with the least mean squared error. A comparison of ANN predicted result against the industrial real data is conducted. It is proven in this research that the ANN model developed, can be used to estimate the quality of refined coconut oil and also stabilize the input parameters.

Keywords
Artificial Neural Network, Crude Coconut Oil, Bleaching Process, Deodorization Process, Predicted Model, Backpropagation, Oil Quality

1. Introduction
Oil refinery is a process of removing some features and components from crude oil, which has a negative effect on the quality of the oil. From the very ancient time, coconut oil has been used as a skin moisturizer, hair oil, cooking oil and so on. For health and quality issue, 100% crude coconut oil should not be used, a certain amount of refined coconut oil has been mixed with it. Therefore, crude coconut oil has to undergo refining process to remove impurities.

During the process of refining, some parameters play a vital role in ensuring the quality of the refined oil. Stabilizing those key parameters are requisite for the overall efficiency of the plant. If the parameters are randomly determined for each run, the grade of the output oil will not be identical for all batches. In current practice, especially when a new plant starts functioning for the first time, the operators have to run the process again and again to get a pellucid idea of how changing the parameters is affecting the oil quality. This manual trial and error technique is time consuming and expensive. And there is no other system for predicting the output quality precisely without running the plant physically. Linear Regression (LR) can be a replacement of it but again, most of real life problem is nonlinear, which can't be estimated properly by LR. Therefore, to embrace the non linear characteristic of the problems, the appliance of ANN for predicting refined oil quality and stabilizing the key parameters has been explored in this paper.

Artificial Neural Network (ANN) is a computational modeling tool that has been used in many areas for modeling complex real-world problems (2014). It is one of the most buzzing topic of technology world. ANN is getting popular among researchers due to its ability to learn from training data and engage what had been learned to categorize pattern from unseen test data (2010). The most well-known training algorithm is Back Propagation (BP) algorithm (1986). Total sum of mean squared error can be minimized using this algorithm.

The main objectives of the study are: (a) identifying the key parameters that control the quality of the output refined oil, (b) stabilizing them by exploring different neural network architectures, (c) leaving room for flexibility of

changing the quality of the output in future. A feed forward neural network with Back Propagation algorithm has been designed in this study.

2. Process Description

Refining process is vital in removing impurities like Free Fatty Acid (FFA), coloring pigments, metal contents and other contaminants in the crude oil (2011). Removing them is done in two steps- bleaching and deodorization process. In bleaching step, the color of the crude oil is reduced to colorless. The process begins with the feeding of citric acid in crude oil tank. Citric acid is used to cleanse the metal from the oil. Using pump, the metal free oil is elevated and passed through heat exchanger which increases the overall temperature up to 65-70°C. Valves are used to control the flows. Then the oil goes to phosphoric acid knife mixture and through overflowing the mixture, it flows to retention tank. A 15 minute rest period is provided in this state for the reactions to be completed. After that, oil is again heated up to 95-110°C. For reacting with bleaching earth and activated carbon, this extend of temperature is necessary. Maintaining the right temperature and air pressure is very pivotal as they have direct influence on the reaction of the chemicals. If the temperature is too high, phosphoric acid will decompose itself. After raising the temperature to above mentioned level, bleaching earth is fed into slurry mixing tank along with the oil. When the slurry mixing tank is almost full, oil circulates to bleacher and there, activated carbon is fed. Vacuum is must for both slurry mixing tank and bleacher. Thus color pigments are removed. From bleacher, oil flows to Pressure Leaf Filter (PLF). After that, polish filter comes for further polishing. When the oil is finally well filtered and colorless, deodorization process begins. The bleaching part is illustrated in Figure 1.

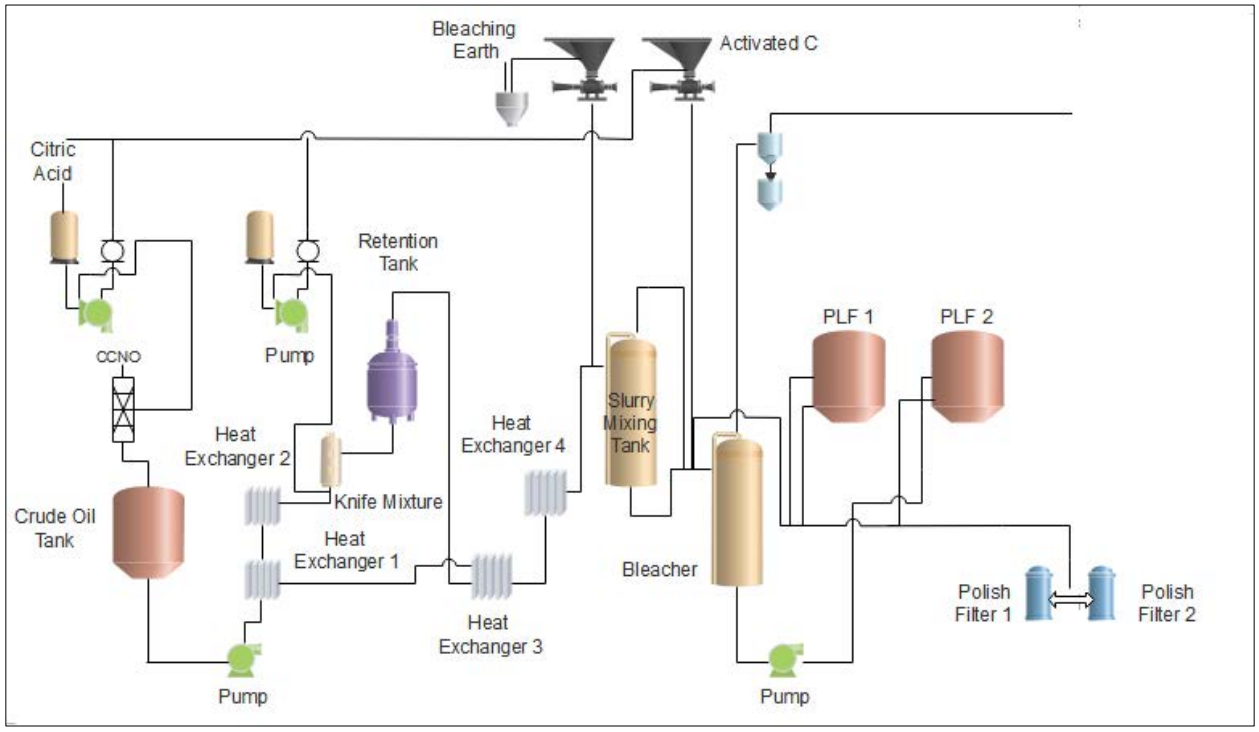

Figure 1: Bleaching Process

Deodorization process begins with the drift of colorless oil to bleached oil tank. From there, it is pumped to candle tank for final filtration, as any further existence of carbon is highly restricted. From the candle tank, oil passes through heat economizer where the temperate is elevated up to 110-200°C. And after that, temperature is further raised to 220-240°C. Oil then flows to Stripper. In Stripper, most of the FFA contents get detached from the oil. That semi FFA free oil goes to deodorizer. In deodorizer, there are three trays which ensure the total detachment of the FFA content. After purifying the oil from FFA, its temperature is reduced to 55-75°C in two steps. Throughout the whole deodorization process, vacuum is strictly maintained. The deodorization part is illustrated in Figure 2.

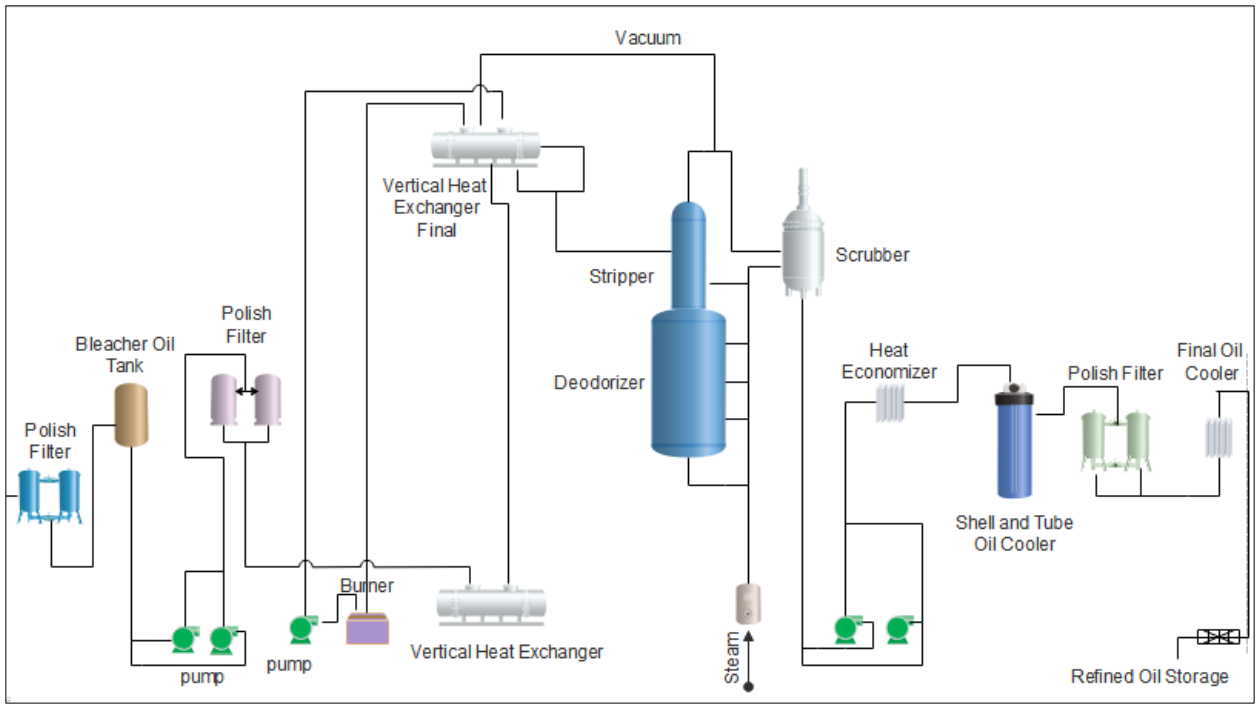

Figure 2: Deodorization Process

2.1 Artificial Neural Network Technology

The idea of the neural network were inspired by the flexibility and robustness of the human brain. The first step towards neural network came in 1943 when Warren McCulloch, a neurophysiologist, and a young American mathematician, Walter Pitts, wrote a paper on how neurons might work (1943). In 1949, Donald Hebb wrote a book named "Organization of Behavior" reinforcing this concept of neurons and their working method. This topic became popular around 1985 when the method of backpropagation for training neural networks was introduced by Rumelhart et al. (1986). Hundreds of papers were published during the early 90s (2000). For the last ten years, ANN attracts a vast number of researcher as it offers an alternative approach of computing and understanding human brain. Nowadays neural models are enjoying resurgence and there is a substantial amount of research in the area of neural networks, because of their ability to represent nonlinear relationships, useful in making function approximation, forecasting, and recognizing patters (2002).

Artificial neural network offers a non-linear approach to predict possible output after training the model with test data. It process information in a same way a human brain does. The network is composed of a large number of highly interconnected neurons, working to solve a specific problem. Neural network models include Perceptron, Radial Basis Functions, Probabilistic Neural Networks, and several others (1990). Among these, Perceptron models are most frequently used. A schematic diagram of the basic structure of Multilayer Perceptron (MLP) is illustrated in Figuare 3, with input layer, hidden layers and output layer. The nodes are connected with each other with the calculated values called weights. Weights represents the strength of the connections.
Each neuron in hidden layer receives weighted inputs plus bias from each neuron in the previous layer, as given by equation (1).

$$Z_i = \left(\sum_{k=1}^{N_{j-1}} X_k^{j-1} W_{k,i} - b_k \right) \quad (1)$$

Where, X_k^{j-1} denotes the input from k –th node in the j-th layer, $W_{k,i}$ is the weight of the link between node k and all the nodes in the previous layers, and b_k is the bias to the node. This sum is passed along to an activation function, which performs the nonlinear behavior of the model.

By the term "Architecture of the neural network", it defines how different nodes are arranged in layers of neural network. The behavior and accuracy of the neural network greatly depend on the architecture. A Feed neural network consists of one input layer and one output layer and between them one or several "hidden layers". The size and number of hidden layers varies from problem to problem. Too many hidden layers or insufficient number of hidden layers –

both yields poor output prediction. So, the size and number of this middle layer have to be determined carefully so that overall error of the prediction is lowest.

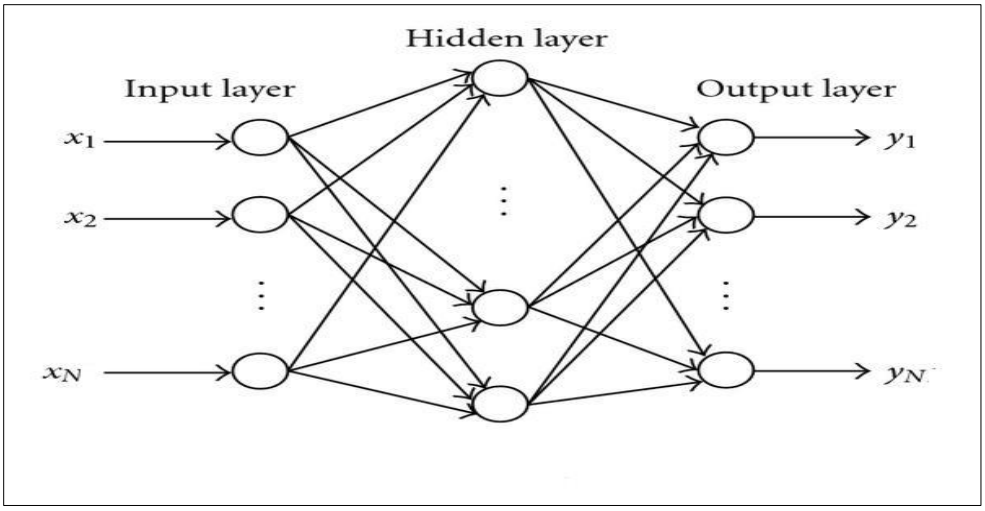

Figure 3: Schematic of a three-layered neural network model

3. Model Development

The development of the ANN model for stabilizing process parameters has been done through following the 4 steps:

3.1 Selection of inputs and outputs

In a giant project like oil refinery, there are lots of parameters on which the final output oil depends. But among them, many have negligible effect or they are constrained by real life factors, like availability, plant characteristics, price etc. So detecting the key parameters is very crucial and first step of ANN model development. Therefore, the bleaching and deodorization process of refinery plant have been surveyed and the log books have been scrutinized in order to detect the key parameters. The input and output parameters of both bleaching and deodorization process have been shown in Table 1 and Table 2 respectively.

Table 1: Inputs and output of bleaching process

Inputs	Output
CCNO flow rate (kg/hr.)	Refined Oil Color (unit)
Bleaching earth dosage (%)	
Air Pressure (mbar)	
Temperature (°C)	

Table 2: Inputs and output of deodorization process

Inputs	Output
Deodorizer Body Temperature (°C)	FFA Content (%)
Spraying Steam Pressure (kg/cm^2)	

3.2 Data Collection

One of the most important step of working with ANN is collecting data. Collecting data is vital because not always there is a guarantee of getting large amount of relevant data. Generally, a huge amount of data are needed for learning step. The more data are fed, the more accurate predicted output can be obtained. But there is an upper bound of how much data should be fed. Crossing the boundary will yield increased error in prediction.

However, Data for this research have been collected from the refinery plant of a CCNO production company of Bangladesh. In case of bleaching process, total 315 sets of data has been taken from different shifts of refinery plant. For deodorization process, total data set number is 513. These data sets has been divided into two portions- one is for

training and another one is for validation. For testing purpose, another 10 sets of data have been collected for both process.

3.3 Preprocessing of data

Data should be pre- processed before feeding into ANN model. Here, the inputs and output data have been standardized. Standardization has been accomplished by removing the mean and scaling to unit variance.

3.4 Training and Testing Neural Network

Determining the network architecture is the most crucial task in developing neural network. This is because the complexity of the relationship between input and output is relative to the number of hidden neurons (2014). To mitigate the problem, the training starts with smallest network with one hidden layer and then it is increased to improve performance. One of the popular procedure of calculating error is calculating mean squared error (MSE). The optimum number and size of the hidden layer are determined by the smallest MSE. The equation of the MSE is defined as follows:

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(Y_t - Y_N)^2 \quad (2)$$

Training a neural network is an iterative process. It uses nonlinear optimization algorithm to obtain the optimal values of the weights. An error back propagation is the most widely used learning algorithm (2001). Initially, the connection weights are randomly determined. Corrections to the weights are obtained through the iteration process. In this study, a multi-layer feed forward perceptron (MLP) has been used, with three types of activation functions: logistic, rectifier linear unit (reLU) and tanh.

Once developing the neural network architecture, encoding the algorithm has been conducted. Two types of algorithms has been written here: one for training and another for predicting. Both algorithms are written in Python language and executed through Anaconda Prompt. Four entities has been varied to get a combination with least mean s error (MSE). They are: iteration number, number of hidden layer, size of hidden layer and type of activation function.

4. Result Analysis and Discussion

The network architecture has an essential influence on the predicted result. Two different kinds of architecture have been used for this study: one for bleaching and another one for deodorization process. These two are discussed below.

4.1 Bleaching Process

The number of input and output nodes is equal to the number of input and output parameters respectively. By varying the size and number of hidden layer, type of activation function and number of iteration, the optimal network architecture has been determined based on the minimum MSE of the network. Therefore, the optimal architecture of the neural network for bleaching process is a multilayer feed forward network of 1 input layer with 4 neurons, 3 hidden layers with 15, 13 and 20 neurons respectively, and 1 output layer with one 1 neuron. The feed forward network topology can be noted as ANN (4:15:13:20:1). The iteration number for this topology is 45 and for activation function, rectifier linear unit (reLU) has been used. The optimum network topology of the ANN model for bleaching process is shown in Figure 4.

The value of mean squared error for this combination is small with the value of 0.0219. A comparison between predicted and actual oil color has been shown in Table 3.

Table 3: Comparison between predicted and actual oil color (bleaching)

No.	CCNO Flow rate (kg/hr.)	Bleaching Earth Dosage (%)	Air Pressure (mbar)	Temperature (ºC)	Color content in Refined Coconut Oil (unit)	
					Predicted	Actual
1[a]	2111	2.7	42	104	1.19	1.20
2[a]	2769	1	53	100	1.02	1.00
3[a]	2420	2.6	39.72	90.4	0.91	0.90
4[a]	2479	2.6	42	100	0.98	0.90
5[a]	2643	2.6	47.19	100.2	1.00	0.90
6[a]	2769	1	53	100	1.02	1.00
7[a]	2771	2.6	45	100	1.10	1.00

8 [a]	2403	2.7	48	101	1.17	1.20
9 [a]	2738	3	41	99.5	1.20	1.30
10 [a]	2760	2.6	52	99.4	1.10	1.10
11 [a]	2000	1.9	52.11	100	0.74	0.6
12[b]	2200	2	35	95	0.87	1.00
13 [b]	2340	2.4	50	100.1	1.00	1.20
14 [b]	2459	2.7	46	97.5	0.89	1.10
15 [b]	2516	2.8	50	98.5	1.09	1.10
16 [b]	2920	3	39	100	1.21	1.20
17 [b]	3021	2.1	51	100.9	0.88	1.00
18 [b]	2660	2	46	99	0.91	1.10
19 [b]	2398	2.5	39.71	90.2	0.92	0.9
20 [b]	2200	3	48	90	0.91	0.80

[a] Training Data
[b] Testing Data

From the Table 3 above, the results are quite good. The developed ANN based model is capable of recognizing pattern of unseen data from testing time and predict approximately accurate output. Any plant can choose the oil quality from the predicted oil color and stabilize their key parameters accordingly. There is also a room for flexibility. For changing oil color that is oil quality, there is no need to test run the whole plant in new dimension of parameters. This ANN based model can do the work by predicting the output, given the input data.

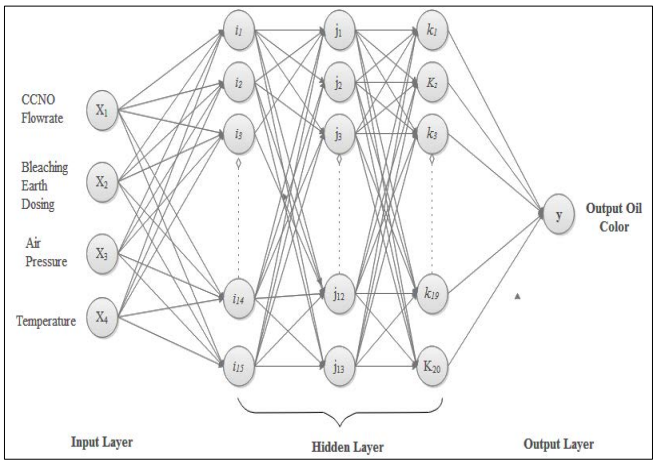

Figure 4: ANN Architecture for Bleaching Process

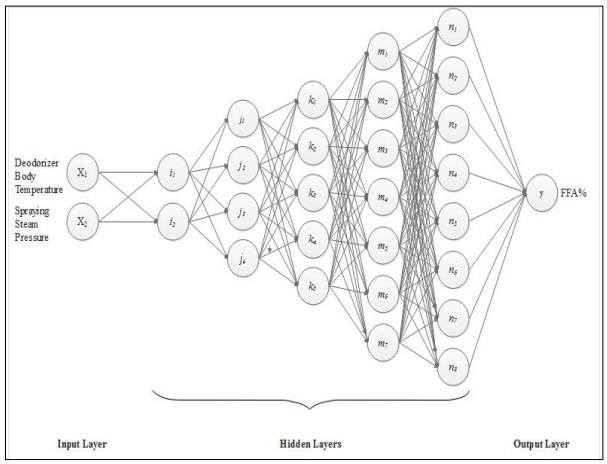

Figure 5: ANN Architecture for Deodorization Process

4.2 Deodorization Process

Same as bleaching process, the number of input and output nodes is equal to the number of input and output parameters respectively. By varying the size and number of hidden layer, type of activation function and number of iteration, the optimal network architecture has been determined based on the minimum MSE of the network. Therefore, the optimal architecture of the neural network for deodorization process is a multilayer feed forward network of 1 input layer with 2 neurons, 5 hidden layers with 2,4,5,7,8 neurons respectively, and 1 output layer with one 1 neuron. The feed forward network topology can be noted as ANN (2:2:4:5:7:8:1). The iteration number for this topology is 6826 and for activation function, rectifier linear unit (reLU) has been used. The optimum network topology of the ANN model for bleaching process is shown in Figure 5.

The value of mean squared error for this combination is very small with the value of $2.8694698e^{-05}$. A comparison between predicted and actual oil color has been shown in Table 4.

Table 4: Comparison between predicted and actual oil color (deodorization)

No.	Deodorizer Body Temperature (°C)	Spraying Steam Pressure (kg/cm^2)	`FFA Content (%)	
			Predicted	Actual
1[a]	234	0.5	0.038	0.038
2[a]	236	0.4	0.040	0.040
3[a]	234	0.4	0.038	0.039
4[a]	237	0.4	0.040	0.040
5[a]	233	0.4	0.038	0.039
6[a]	235	0.5	0.038	0.037
7[a]	232	0.45	0.037	0.036
8[a]	241	0.6	0.039	0.040
9[a]	228	1.4	0.040	0.040
10[a]	223	1.3	0.035	0.035
11[a]	223	1.4	0.035	0.035
12[b]	229	1.3	0.041	0.040
13[b]	227	0.7	0.035	0.036
14[b]	231	0.7	0.033	0.033
15[b]	220	0.7	0.036	0.038
16[b]	216	0.8	0.037	0.035
17[b]	232	0.8	0.036	0.036
18[b]	228	1.3	0.039	0.038
19[b]	233	0.4	0.038	0.040
20[b]	231	0.5	0.035	0.034

[a] Training Data
[b] Testing Data

From the Table 4 above, the results are fairly good. The developed ANN based model is capable of recognizing pattern of unseen data from testing time and predict almost accurate output. Any plant can choose the oil quality from the predicted oil color and stabilize their key parameters accordingly. There is also a room for flexibility. For changing oil color that is oil quality, there is no need to test run the whole plant in new dimension of parameters. This ANN based model can do the work by predicting the output, given the input data.

5. Conclusion

In this study, a multilayered feed forward ANN model has been developed for both bleaching and deodorization process. For bleaching process 3 hidden layers were needed to minimize the MSE, where for deodorization process, 5 hidden layers were necessary. Among all activation functions, the reLU function yields least MSE, so it has been selected for the ANN model. The prediction results were fairly good with high degree of precision. So, it has been proven that, these models can be used to stabilize the key parameters and to estimate the quality of the refined coconut oil. As ANN model accuracy greatly depends on the number of data set, so further increasing the number of data could yield better prediction with lesser MSE.

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Design of Accessible Wheelchair Ramp for Public Transport

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Abstract

Movement accessibility is a vital empowering agent of methodologies to battle destitution through improving access to training, work, and social administrations. However, there are no unique facilities for the disabled individuals in Bangladesh in the transportation sector. People using wheelchair find hard to embark and disembark into a public transport. This paper represents the design parameters of wheelchair ramp on local buses so that people with physical disabilities in Dhaka city can gain access to public transportation. We focused on a simple and economical construction of the ramp, durability, easy and cost-efficient installation on the public bus with easy maintenance. The outline of the ramp is completed after careful assessment of different public transport buses around Dhaka city. Accessible design of the model is based upon the guidelines of Americans with Disabilities Act (ADA). The 3D model of the wheelchair ramp was created using SolidWorks. The model can be installed on public buses around Dhaka city with a simple modification of bus door and sitting arrangement. This design is based on manual mechanism because it was focused on low-cost installation on local public buses. A further modification of the ramp for the reduction of the ramp's weight is under consideration.

Keywords

Wheelchair ramp, Disability, Transportation, Modeling, SolidWorks

1 Introduction

Many individuals with mobility impairments are reliant on public transportation for performing activities of everyday living, taking part in social activities, or engaging in recreational opportunities. Individuals with incapacities are 2.5 times more prone to encounter transportation challenges than physically fit individuals (National Council on Disability 2005). Many countries have legislation requiring that these challenges be addressed but in Bangladesh, effective responses are generally very limited. Action to enhance the circumstance is compelled by the genuine lack of information on the entrance and portability needs of disabilities and elderly individuals and in addition to asset constraints.

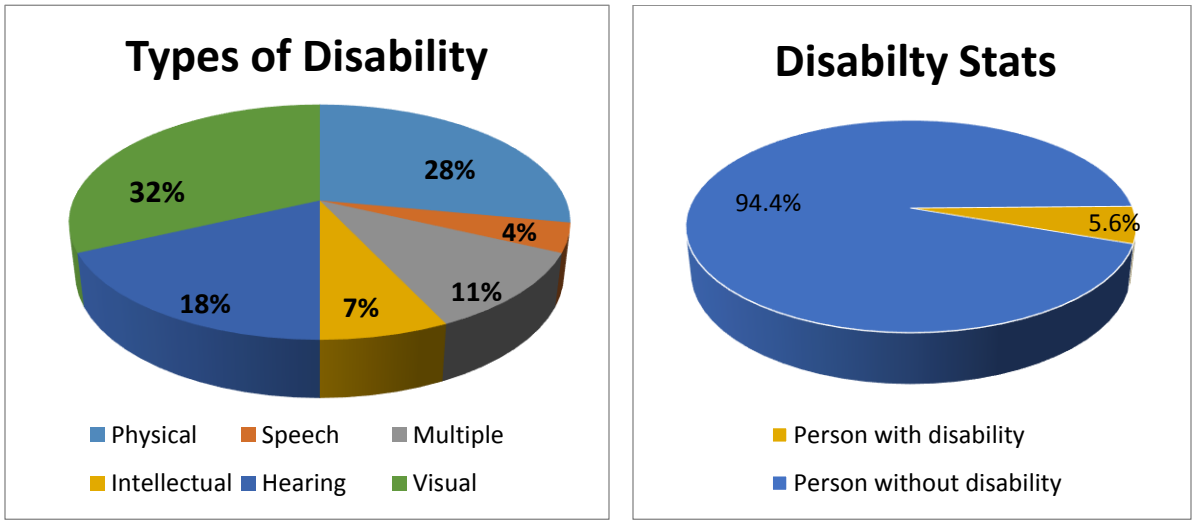


Figure 1 Percentage distribution of population by disability stats and types

People using wheelchair find hard to embark and disembark into a public transport. Use of wheelchair ramp is an essential feature for the easy movement of the disabled people. In Dhaka city local buses don't have any wheelchair ramps. This paper is about the design of wheelchair ramp for local buses in Dhaka city.

1.1 Background

Historically, step entrances in travel transports displayed a hindrance to boarding and landing for wheeled portability clients. Electromechanical lifts at first were utilized to address this accessibility barrier; in any case, lifts are viewed as unsuitable on the grounds that they are inclined to breakdown, require transport driver help, make long stacking and emptying delay, and are not useful for ambulation aid user. The development of low-floor transport plans in the late 1980s brought down the passage and leave stature by 3– 4 inches (Blennemann 1991), in this way diminishing physical requests and stumbling dangers (Schneider and Brechbuhl 1991; Rutenberg 1995). Contrasted with wheelchair lifts, access ramps have a less difficult plan that is less inclined to breakdown and requires less support (Blennemann 1991; Schneider and Brechbuhl 1991; Rutenberg 1995). Ramps empower wheeled portability clients to load up vehicles all the more watchfully and in less time (Blennemann 1991; Rutenberg 1995).

1.2 Previous Ramp Research

The accessibility of ramps for structures was first assessed in the late 1970s (Steinfeld, Schroeder, and Bishop 1979), which prompted the 1:12 slope standard now required for available structures. For wheelchair clients, slopes of 1:3 couldn't be consulted without help; the unassisted passage was workable for some with inclines in the vicinity of 1:4 and 1:6; and slope inclines shallower than 1:6 were considerably simpler to cross independently. Sweeney et al. (1989) assessed 13 versatile ramps extending from 1:12 to 1:3 with 45 members speaking to a different age go, wheeled portability gadgets, and practical levels. The creators revealed that ramp slopes of 1:12 to 1:7 could be consulted without hardly lifting a finger by 88% of the self-impelling manual wheelchair clients (n=18), contrasted with 52% of a similar gathering for the 1:6 slope. Each of the seven power wheelchair clients crossed the 1:12 to 1:7 inclines without hardly lifting a finger, contrasted with 66% of a similar gathering for the 1:6 slope. Nuanced translation of these discoveries is troublesome in light of the fact that the estimation scales were not depicted for evaluating convenience, and the information was totaled for slopes extending from 1:12 to 1:7.

Blennemann (1991) assessed slope inclinations from 1:16 to 1:5. The discoveries depended on "workshops" including an unreported number of wheelchair clients, their parental figures, and more established grown-ups. Manual wheelchair clients explored the 1:10 incline without trouble, revealed some trouble with slopes in the vicinity of 1:10 and 1:6, and were not able to arrange slopes of 1:5 without help. Power wheelchair clients arranged inclines as steep as 1:6 without trouble; in any case, they revealed a dread of toppling at a slope of 1:5. Authoritative translations of this information are unrealistic on the grounds that the client bunches were not all around verbalized, the information accumulation strategies were not depicted, and the estimation scales were not portrayed.

Sanford, Story, and Jones (1996) assessed the ease of use of 6 ramps extending from 1:8 to 1:20 for 171 members who utilized a scope of versatility helps. The authors presumed that slopes more extreme than 1:12 and longer than 30 feet are hard to use by manual wheelchair clients. In spite of the fact that these discoveries give a phenomenal beginning stage, the information mirror an exploratory slope length (30') that isn't comparable to the regular length (~6') of access inclines in travel vehicles.

It is hard to get indisputable slope rules from the above writing since key variables (e.g., incline length, incline slope, populace contemplated, and estimation apparatuses) are very dissimilar and regularly ambiguously depicted. In this paper, the outline of the wheelchair slope is centered on these rules.

1.3 Scope

The design of the wheelchair ramp is focused on:

- ADA guidelines for accessible design
- Simple construction
- Easy installation

The fabrication of the wheelchair ramp is focused on:

- Availability and cost of the material
- Cost of installation on public bus transportation in Dhaka city.
- Durability and Sustainability
- Maintenance

The design of the ramp is carried out after careful evaluation of different local buses around Dhaka city.

This outline applies to individuals who utilize wheelchairs as well as to the individuals who experience issues climbing stairs, for example, individuals who have joint inflammation or hemiplegic and the individuals who utilize walkers, supports or sticks.

1.4 Parameters Considered

- ❑ Ramp Slope

The slope is the term used to depict how steep a ramp is. The slope is critical in light of the fact that it influences that it is so hard to go up and down the ramp. In the event that the slope is excessively steep, the slope might be excessively troublesome for somebody, making it impossible to utilize or can be risky.

To determine the slope: divide rise by the run of a ramp. Run is not the length of the ramp. The distance horizontally (not along the slope) from the top of the ramp to the bottom.

- ❑ Ramp Width

Ramp width depends on the width of the wheelchair and availability of the space.

- ❑ Ramp elevation

The height a ramp can lift from the ramp landing.

- ❑ Ramp length

The length of the ramp depends on the slope and the elevation of the ramp.

- ❑ Ramp landing/platform :

The landing of the ramp has to be on a platform having a minimum height of 30 inches.

- ❑ Modification of Bus

After evaluation of different local buses around Dhaka city, the following height of the bus floor and width of the door are found

- Average Height of the bus floor: 30- 36 inches
- Average Door Width: 24-30 inches

So the modifications for the installation of the ramp are

- Door width: minimum 39 inches of free space
- Introduction of folding seats (in front row) to facilitate the wheelchair

1.5 Goals

- Accessible design for safe and comfortable movement for a person with physical disabilities
- Economic fabrication of ramp
- Easy and cost-efficient installation on a public bus that has no accessibility
- Durability and Sustainability

2 Design Concept and Approach

The 3D design of the wheelchair ramp was prepared using solid works simulation 2013.The ramp design is based on Accessible Design.

2.1 Accessible Design

Accessible design is a design process in which the necessities of individuals with inabilities are particularly considered. Accessibility sometimes alludes to the characteristic that items, administrations, and offices can be freely utilized by individuals with a variety of disabilities.

Accessibility as a design concern has a long history, yet public awareness about accessibility expanded with the section of enactment, for example, the Americans with Disabilities Act (ADA). The ADA is a civil rights law that denies victimization people with disabilities in every aspect of public life, including occupations, schools, transportation, and all public and private places that are open to the general public.

2.2 ADA guideline

- ADA Standards REQUIRE a 1:12 slope ratio which equals 4.8 degrees or one foot of
- Wheelchair ramp for each inch of rise. For instance, a 30 inch rise requires a 30 foot handicap wheelchair ramp.
- ADA Guidelines REQUIRE a Minimum 5' x 5' Flat, unobstructed area at the top and bottom of the ramp.
- ADA Standards REQUIRE wheelchair ramps to have a Minimum 36 inches of clear space across the wheelchair ramp.
- ADA Code REQUIRE a Minimum Turn Platform size of 5' x 5'.
- ADA Guidelines for Wheelchair Ramps allow a MAXIMUM run of 30 feet of wheelchair ramp before a rest or turn platform.
- ADA Ramp Guidelines REQUIRE handrails that are between 34" and 38" in height on both sides of the wheelchair ramps

2.3 Initial Design Consideration

Initial designing of the ramp was done after considering the following points:

- Who's the primary user?
- What kind of assistive gadget does the individual utilize (stick, props, walker, manual or electric wheelchair, mechanized 3-wheel truck)?
- Will the individual utilize the slope freely or will help be required?
- Who will give assistance and what are that individual's capacities?
- Which entryway is best for the ramp?
- Placement of existing door handles and swing direction of doors.
- Where is the best place to access transportation?
- How will the ramp affect available space?
- How will the ramp appear?
- What will the establishment cost be?

2.4 Dimension of the Ramp

- ❑ Ramp slope

The accessibility of access ramps is influenced by their slope, which is frequently described by a ratio, a:b, indicating a rise of an inch for every b inch in run. The Americans with Disabilities Act Accessibility Guidelines (ADAAG) for Transportation Vehicles stipulate that ramp slope may vary from 1:4 to 1:12, depending on the overall rise (U.S. Access Board and Department of Transportation 1998).

Table 1 Ramp slope

Slope (rise: run)	Gradient (%)	Angle (°)
1:2	50.0%	26.6
1:4	25.0%	14.0
1:6	16.7%	9.5
1:8	12.5%	7.1
1:10	10.0%	5.7
1:12	8.3%	4.8
1:14	7.1%	4.1
1:16	6.3%	3.6
1:18	5.6%	3.2
1:20	5.0%	2.9

1:12(ADA recommended)
Maximum 1:6 (Use with assisted)
Available local Bus Height in Bangladesh is around 30-36 inches, then -

- According to slope 1/12, ramp length will be 30-36ft
- According to slope 1/6) ramp length will be 15- 18 ft

However, it is not practical and feasible because a lot of space is required also weight and cost will be significantly increased. We can overcome the height problem by introducing platform with a height of 24-30 inches.
For a platform of 24 inches and bus height of 30-36 inches:
Slope of 6 inches rise: 1/12 (Recommended by ADA)
Slope of 12 inches rise: 1/6 (Maximum condition)

- ❑ Ramp Elevation**:** Recommended 6 inch, Maximum 12 inches
- ❑ Ramp Length**:** 72 inches
- ❑ Ramp Width**:** The width should be 32 inches for ramp and 39 inches for bus door.

2.5 Safety Features

Installation of safety features including handrails, guardrails or crutch stops.

- **Handrails** should represent factors including a person's height, arm and hand strength, how the rails are utilized. The preferred material is wood. Metal piping is sometimes used but may present a problem for exposed skin in the wintertime. It should be introduced on bus stop's ramp landing pedestrian.
- **Guardrails** and edging called "crutch stops" or "bump boards" are additionally great security factors that shield users from slipping off the side of a ramp or landing. Guardrails are mounted along the structure's perimeter, Crutch stops are curbing mounted on, or a few inches above, the surface of the structure's perimeter.

3 Initial Design

The initial design of the ramp and its parts were designed using solid works 2013.All the dimensions are in INCH. After studying a number of models the following design was chosen for the project. The design is suitable for simple construction and installation on local buses.

3.1 3D view of the parts and assembly:

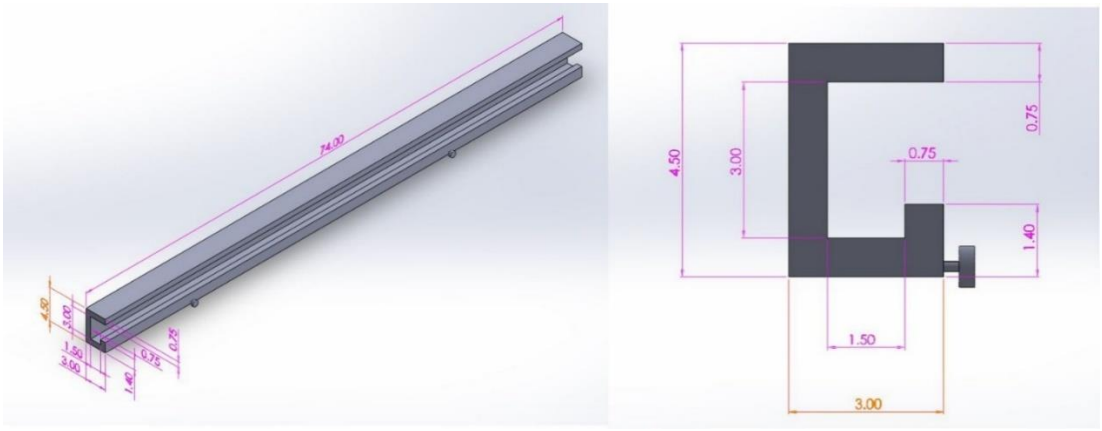


Figure 1 Channel 3D

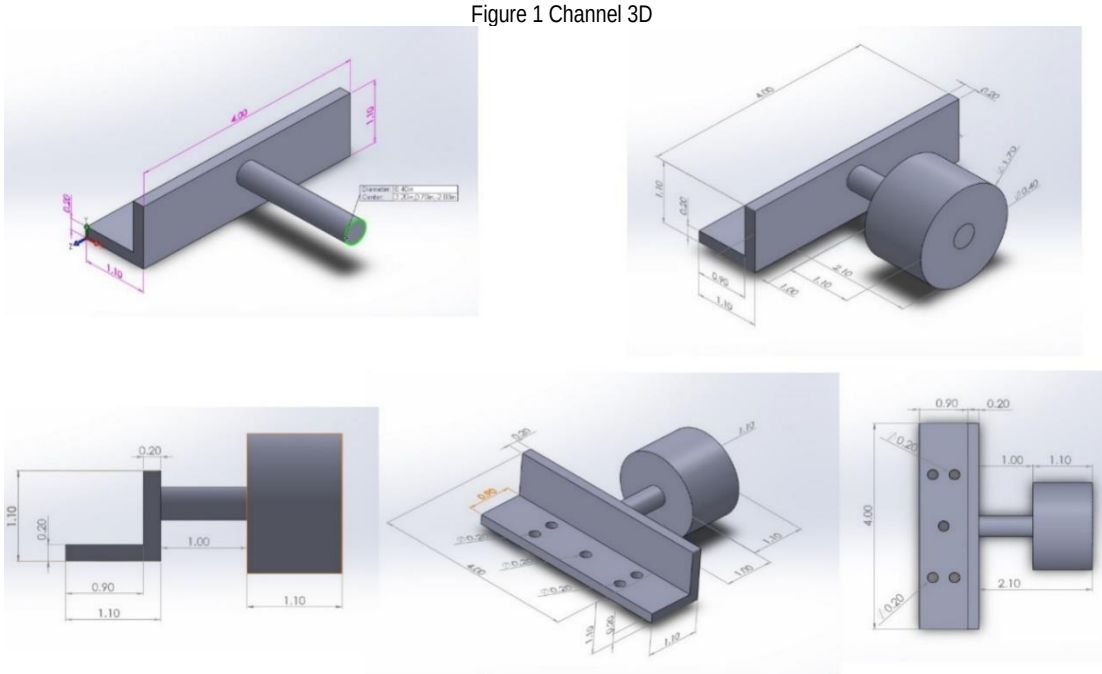


Figure 2 Slider hinge with wheel 3D

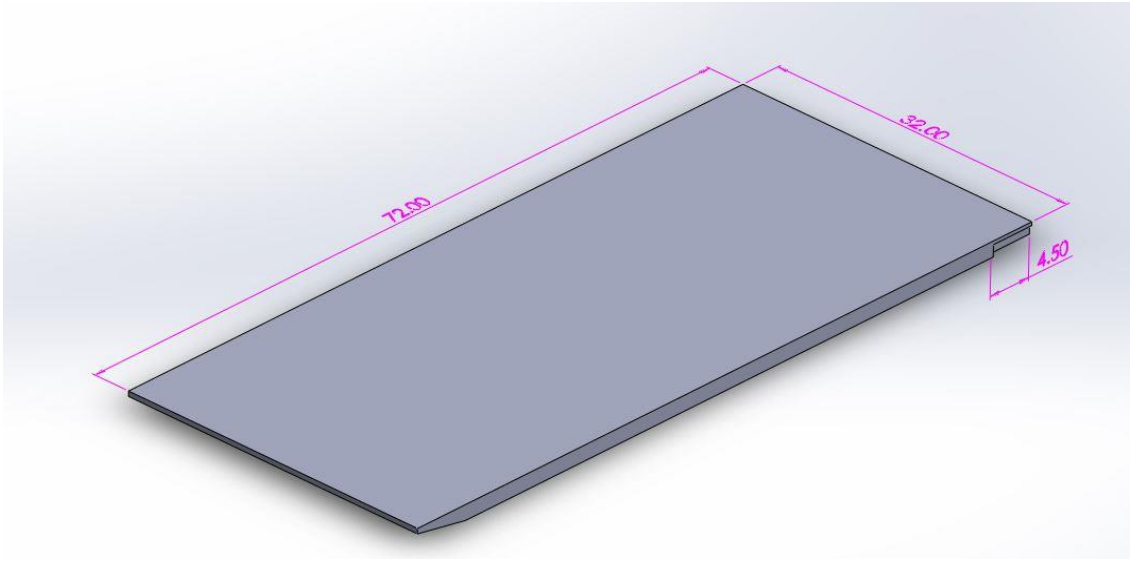


Figure 3 Ramp Body 3D

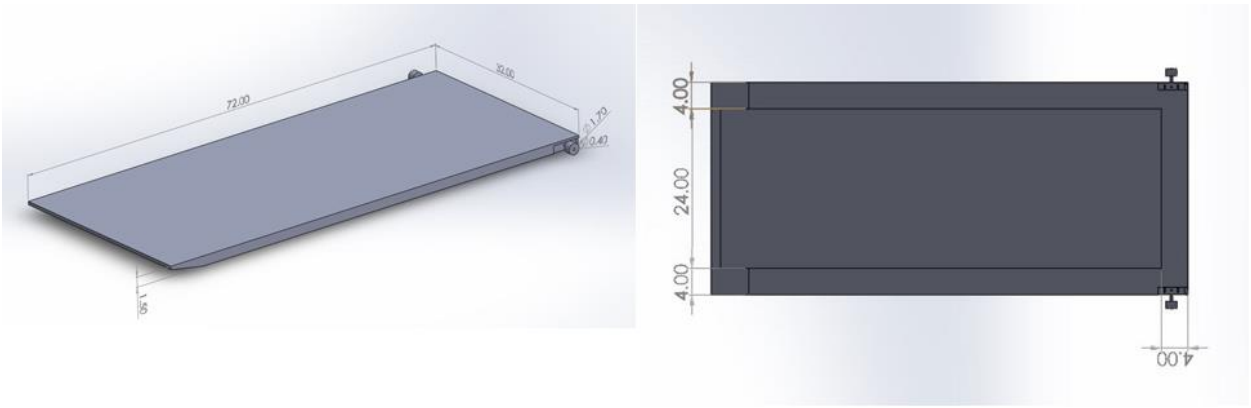


Figure 4 Ramp with Slider Wheel 3D

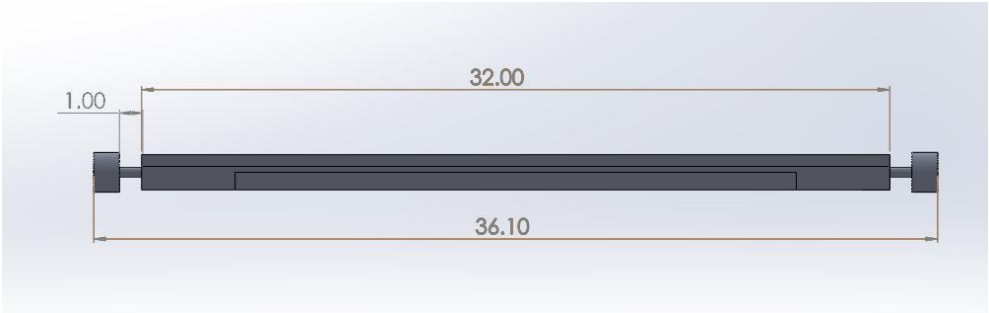


Figure 5 Ramp with Slider Wheel Back view 3D

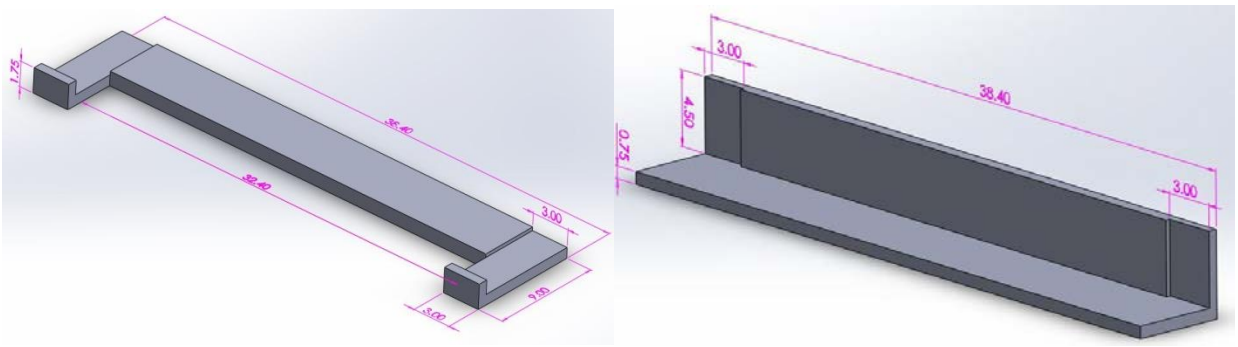


Figure 6 Front and Back Support for the assembly 3D

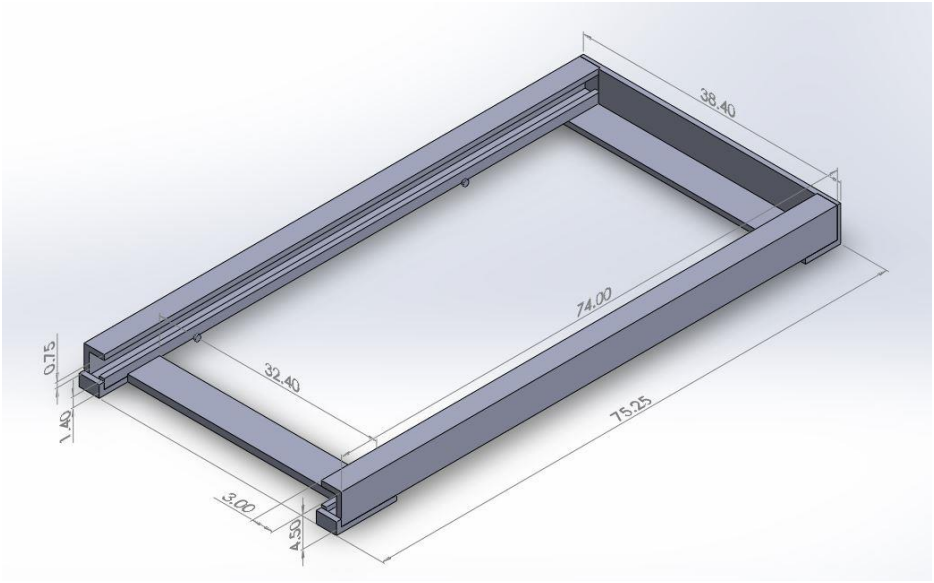
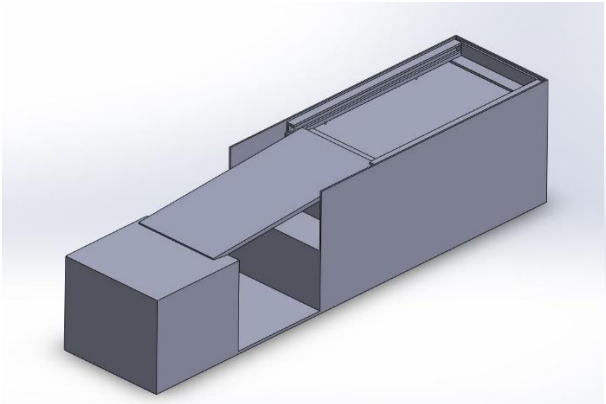


Figure 7Channel Assembly 3D



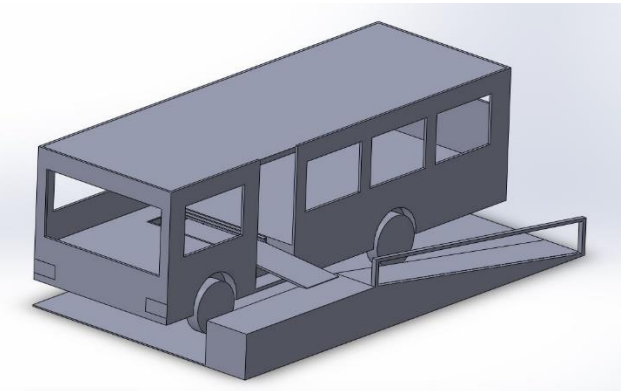


Figure 8 Ramp-Channel Assembly Installed on Stairs and Pedestrian 3DFigure 8 Ramp-Channel Assembly Installed on Bus 3D

3.2 Drawing of the parts

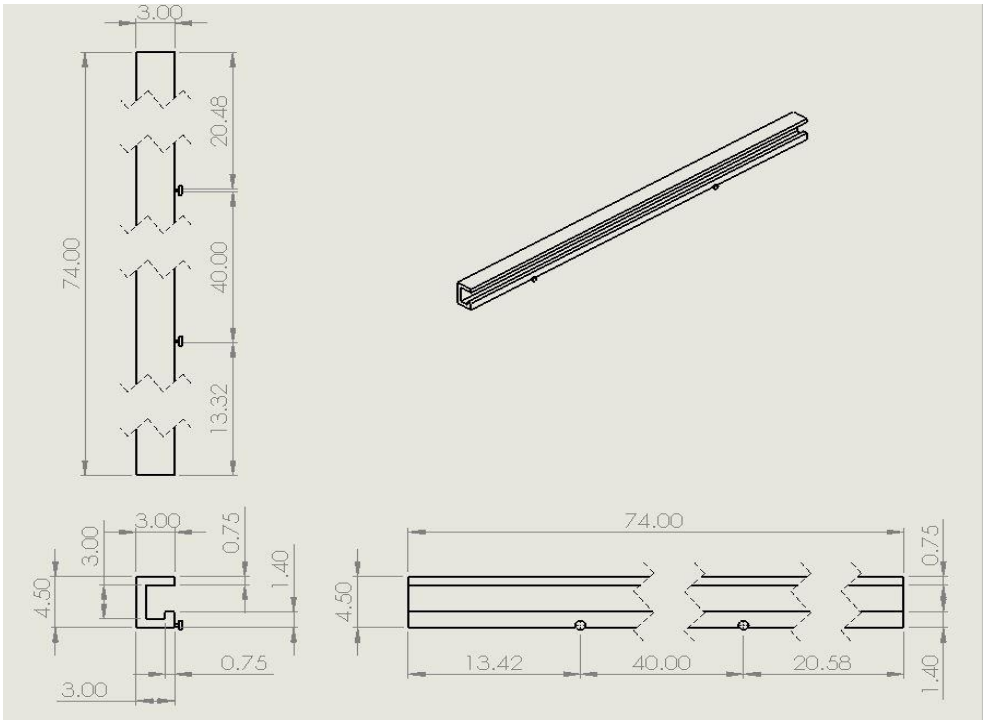


Figure 9 Channel Drawing

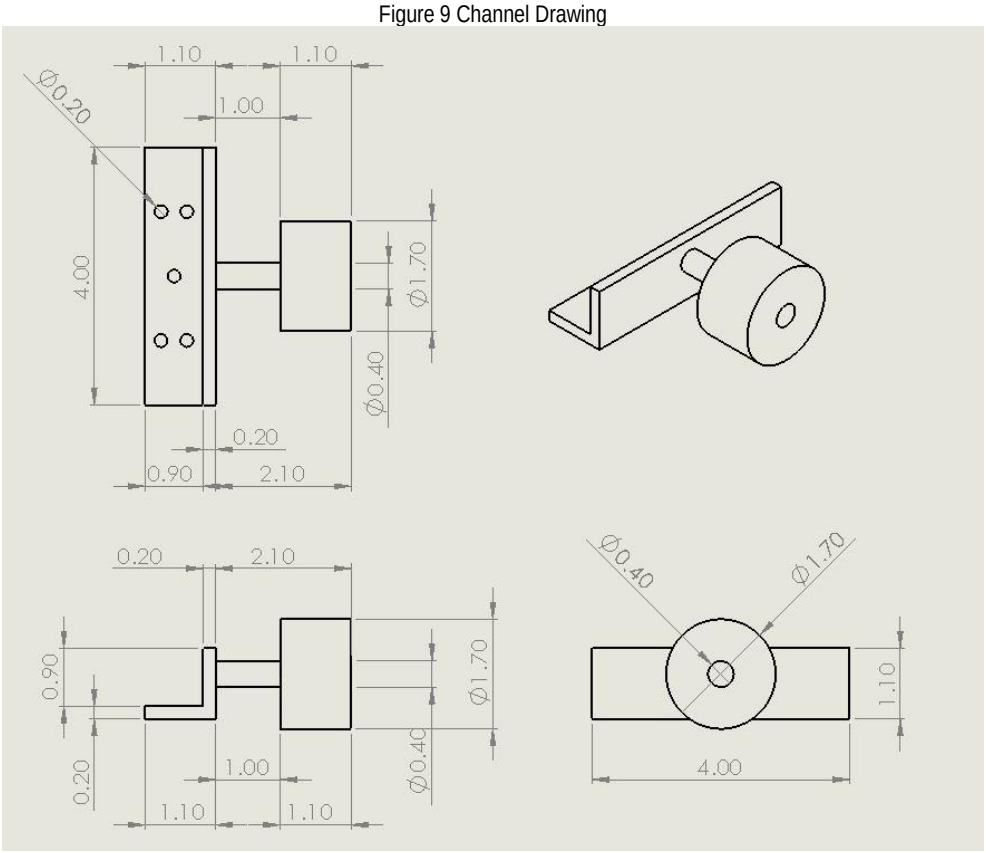


Figure 10 Slider hinge with wheel Drawing

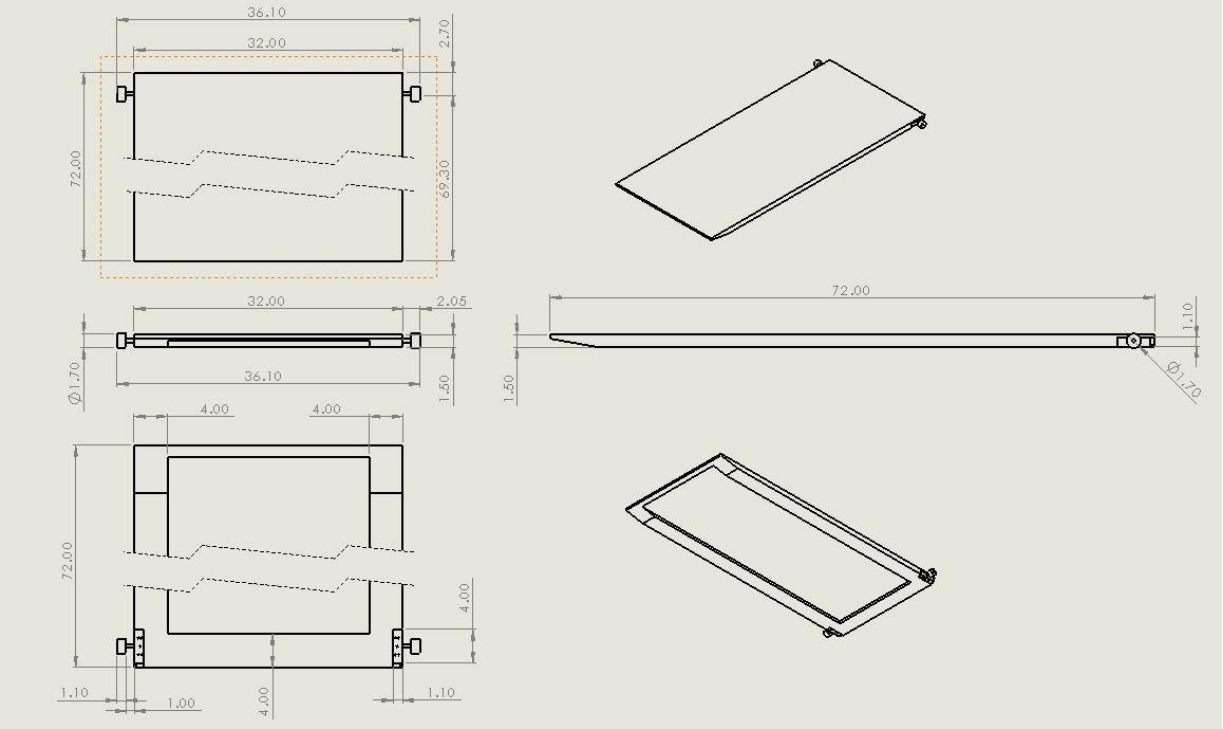


Figure 11 Ramp Board Drawing

4 Conclusion

The model can be installed on public buses around Dhaka city with a simple modification of bus door and sitting arrangement. This design is based on manual mechanism because it was focused on low-cost installation on local public buses. However, there is provision for modification for converting this design into an automatic mechanism. A further modification of the ramp for the reduction of the ramp's weight is under consideration. A further study such as Factor of safety, Displacement, Stress analysis is under consideration for the selection of materials for the ramp.

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Biographies

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Optimization of logistic concepts in Bangladesh by using Automated Guided Vehicle (AGV) to enhance efficiency, productivity and security in Warehouse Management System (WMS)

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Abstract

In the recent time, the automated guided vehicles (AGV) are becoming more common sights in the manufacturing industries and the large warehouses for the purposes of logistic supports and in many other aspects. But in case of third world developing countries like Bangladesh, the idea of implementing of the automation technologies like Automated Guided Vehicle (AGV) is not so much popular among the investors due to high initial setup cost, low human labor cost and some other facts. In this paper, we are trying to build up a model i.e. a line follower robot (LFR) with a carrier at its top which is following both straight and curly paths having some obstacles, carrying specific amount of loads and unloading them in specified position in the laboratory. Hence by performing this experiment for several times we are trying to prove to enhance the efficiency, productivity and security in the warehouse management system. We are trying to use local raw materials and available technologies to construct an automated guided vehicle (AGV) locally and hence are trying to reduce the initial setup cost to encourage the investors for setting up the automated guided vehicle system for improved productivity, security and efficiency in the manufacturing industries especially in warehouse management system (WMS) in Bangladesh.

Keywords

AGV, WMS, Efficiency, Productivity, Security, Bangladesh, Logistics.

1. Introduction

1.1. Productivity

A measure of the efficiency of a man, machine, manufacturing plant, framework, and so forth is changing input to useful output. Productivity can be computed by dividing mean output per time by the total costs incurred or resources (capital, energy, material, personnel) consumed in that time. Productivity is a critical determinant of cost proficiency.

1.2. Efficiency

The correlation of what is really delivered or performed with what can be accomplished with a similar utilization of assets (cash, time, work, and so forth.). It is an important factor in determination of productivity.

1.3. Safety

The quality or state of being secure from danger.

1.4. Warehouse Management System (WMS)

It is a software or application that controls or monitors the day-to-day operations in a warehouse. WMS programs allows centralized management of tasks such as keeping track of inventory levels and locations of stock. WMS systems can be standalone applications or part of an Enterprise Resource Planning (ERP) system.

This is modern technique of managing the warehouse operations and this is how the process of logistics handling escalates:

1) Maximization of Functionality
2) Ease of Use
3) Flexibility
4) Complete Transaction Management
5) Useful, Easy-to-read Metrics

6) Proven Track Record
7) Seamless ERP Integration
8) Value for ROI
9) Commitment to Warehousing and Logistics

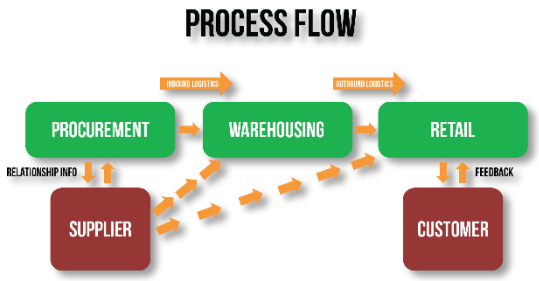

Figure 1 : Position of warehouse in the process of logistics operation

1.5. Automated Guided Vehicle

A mobile robot that follows markers or wires in the floor, or uses vision, magnets, or lasers for navigation. This uses an energy neutral system with low carbon emission, as it can operate without air conditioning and lighting.

The AGV can tow objects behind them in trailers to which they can autonomously attach. The trailers can be used to move raw materials or finished product. The AGV can also store objects on a bed. The objects can be placed on a set of motorized rollers (conveyor) and then pushed off by reversing them. AGVs are employed in nearly every industry, including pulp, paper, metals, newspaper, and general manufacturing. Transporting materials such as food, linen or medicine in hospitals is also done.

Barrett Electronics of Northbrook brought first AGV to market in the 1950s, Illinois, and at the time it was simply a tow truck that followed a wire in the floor instead of a rail. Using this theme came a new type of AGV that followed UV marks on floor.

1.6. Background and present state of the problem

Almost the entire logistic operation in Bangladesh is carried out by human labor. This results in prolonged worktime and lack of efficiency. In the global context, integration of automation has reached the warehouse management system far back, but Bangladesh is lagged behind in this very sector. The reputation of Bangladesh is coined as “Time-lagger” when it comes to delivery of commodities and the prime reason behind this being- lack of automation and skilled methodology of operation in the fullest extent.

This study will show the various aspects of automated guided vehicles and their scope of implementation in the context of Bangladesh.

1.7. Objectives with specific aims:

Evaluate current warehousing facilities in Warehouse Management System.
Identifying how AGVs can enhance key performance in terms of overall

- **Productivity**
- **Efficiency**
- **Security**

Evaluate the scopes of implementation in Bangladesh

1.8. Methodology

The entire industry of logistics operation and warehousing was properly screened and by analyzing, we developed the scope of AGV implementation in Bangladesh. This was done keeping live monitoring of the existing

conditions of the respective warehouses. Related literature review were then Sought-after to the selected area of research to obtain a theoretical base for the research and help determine the nature of the research. The research design was then formulated keeping the implementation scopes open in the local arena as mentioned earlier. The decision mentality of the industry key players was also taken into account. The research design put forwarded the data accumulated from case study helped to reach some findings and upon analyzing them, the limitations and future scopes were provided.

2. Literature review

2.1. Hospital management industry

2.1.1. The Augusta-Kranken-Anstalt (AKA) Hospital in Bochum, Germany

The company began to implement AGV in their operations with 10 vehicles and 46 stations covering an approximate of 1100 meters and they have found that, their cost for internal logistics processing have reduced drastically. Not only that, they were able to introduce transparency and control of their delivery status which insures just in time delivery of material. Using Automated Guided Vehicles for product handling increased their storage capacity by 20% and staff productivity by 60%.

2.1.2. University Medical Center Hamburg-Eppendorf (UKE)

They consist of 14 centers and brings together more than 80 clinics, hospitals, and medical institutes and benefiting from the interdisciplinary cooperation within the UKE. With a number of 1248 beds and 165 beds in the University Heart Center Hamburg GmbH, the University Medical Center Hamburg-Eppendorf is one of the largest hospitals in Hamburg.

The Automated Guided Vehicle system consists of 33 vehicles which covers a track length of 2100 meters having 91 stations taking over the automated transportation of meal, laundry, waste, pharmaceutical, and sterile containers at UKE in Hamburg-Eppendorf, safely transporting goods to their respective destinations – 16 hours a day, seven days a week.

Thanks to the resulting flexibility, they are able to run their operations smoothly even in the peak hours. Moreover, changes in routes and schedules can be realized at any time via the software control using the laser technology, therefore providing an ever-increasing flexibility of the system. There are no transport delays thanks to the separate logistic infrastructure, as the routes for the transport of goods do not cross with the routes for patients and patients' transports, visitors, or employees. The vehicles are guided by a laser scanner along so-called points of references of the buildings.

2.2. Warehouse management of E-commerce platforms

2.2.1. Alibaba's Smart Warehouse

The name of the world's largest and most valuable retailer as of April 2016 is Alibaba. They have a warehouse that occupies 3,000 square meters (0.7 acres) of space and it is situated in Huiyang, south China's Guangdong Province, and is owned by T-mall. The automated delivery system started working at the warehouse from July, and have helped the warehouse by increasing its output by three times, according to Quicktron, the manufacturer of the robots. They named the machine Zhu Que.

The instructions are given to be robots via Wifi signals. They would then find the product and take them to the designated drop-off points for human workers to pick up. Each of the robots is fitted with laser detection for preventing them from bumping into each other.

Normally, an average worker could sort a number of 1,500 products during a 7.5-hour shift by taking 27,924 steps; with the help of the AGV, that same worker could sort a number of 3,000 products during the same period of time by using only 2,563 steps.

2.2.2. Warehouse of Flipkart

Flipkart is India's largest online marketplace with more than 60% market share of mobile commerce. Flipkart has 75 million registered customer, Flipkart offers more than 40 million products across 80 categories including Books, Consumer Electronics, Media, Smart Phones, Furniture, Fashion and Lifestyle. It was launched in October 2007.

Flipkart partnered with GreyOrange to attain next-gen robotic solutions for automating their fulfilment center and transport centers and to resolve the challenges it faced with manually order sorting, routing and inaccurate billing for shipments by vendors.GreyOrange introduced two double decks and five single deck sorters of capacity 6000 sorts/hour and four sorters of 3000 sorts/hour across 8 transport centers and the Hyderabad fulfilment center of flipkart. It resulted into the following advantages:

- Sorting output increased to 48000 sorts/hour across operations and across all of their facilities
- Reduced sorting processing time by half using the automation.
- Dimensioning and weighing accuracy was improved by 16-18%,which resulted in increased revenue recognition by around 10%
- Optimized warehouse space utilization with savings up to 2.5 times.

3. Research Design

3.1. Basic Flowchart

The process of research initiated through field work analyzing the status quo. This involved visiting the warehouse of various organizations of varied interests. Some of them are: FMCG, CNF, Electrical components, Pharmaceuticals etc. All the operations of the warehouse of these companies were observed carefully along with interrogation of the responsible officials.

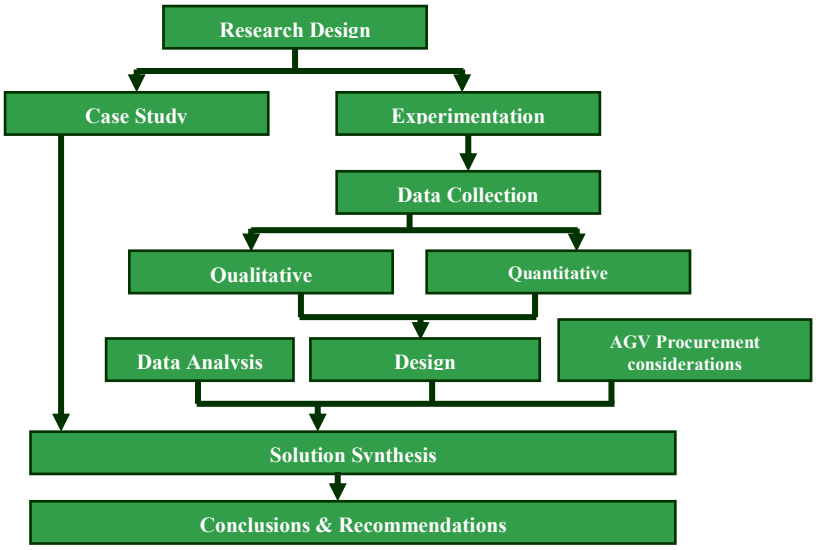

Figure 2: Research Design flowchart

Furthermore, we also constructed a prototype of the proposed AGV in a small scale and performed various experiments. This gave us the pool of data and information which were then sorted qualitatively and quantitively and reserved for analysis.Alongside, we also gathered information on the design consideration and AGV selection considerations which were also analyzed. This analysis process gave rise to the empirical situations helping us to reach a solution synthesis. The solution synthesis contains the brief segmentations of the advantages and the limitation of the area of the study. Understanding these and taking them into consideration, the future scopes and recommendations were laid out.

3.2. Status Quo Analysis and Case Study

We visited three different type of warehouse in Bangladesh and also consulted with the warehouse specialist of a few well-known company who are currently handling Logistics in Bangladesh**.** These companies include British American Tobacco, Fedex, Unilever, ACI Limited.

3.2.1. PRAN Warehouse

PRAN takes a comprehensive approach to all kinds of agro-processed food products, considering all of the ways their lives can be enriched through ensuring hygienic and quality food products. With HACCP compliance to ensure best quality products reaching to the consumers, PRAN places great importance on hygienic manufacturing processes. This encompasses everything from choosing quality materials to the use of storage facilities and careful monitoring of products using electronic sorting. Furthermore, company's computer systems offer continuous monitoring of all manufacturing process to ensure the highest level of quality.

It has a warehouse situated in Rupgonj, Narayengonj. They chose this location for their warehouse because it is near to Dhaka and for availability of large space. The warehouse had a floor space of about 60,000 square feet. It mostly deals with the consumable product that PRAN manufactures. Currently they are using Human labor, regular trolley, forklift and some other conventional warehouse tools. This particular warehouse handles approximately 60 trucks per day including loading and unloading. Warehouse in charge of that warehouse admitted that they are thinking of modernizing the warehouse to increase efficiency and they are willing to consider AGVs for product handling. They might start using AGVs in the near future, which is approximately within the next 10 years.

3.2.2. Hellmann Worldwide Logistics

Founded in 1871, Hellmann Worldwide Logistics started with one man, Carl Heinrich Hellmann, using a horse-drawn cart to deliver parcels in and around the town of Osnabrueck, northern Germany. Four generations later, Hellmann is a company with a worldwide network of 19,500 people in 437 branches in 162 countries.

They have one of their warehouses located in Station Road, Tongi. They have selected this located because of its proximity to the international airport of the city. It was a medium sized warehouse with floor space of 10000 square feet. This warehouse mainly deals with RMG, Medicines, Lather Products, etc and handles 10 trucks per day including loading and unloading. This particular warehouse is mainly depended upon their human labor for product handling. They also use some regular tools like trolley, fork lift etc. Hellmann admitted that using regular tools prolongs their handling time so they are also wiling to embrace AGV system within the next 30 years.

3.2.3. CISCO and TnT Express Warehouse

Since the company's inception, Cisco engineers have been leaders in the development of Internet Protocol (IP)-based networking technologies. In addition to its products, Cisco provides a broad range of service offerings, including technical support and advanced services.

They have installed a new warehouse in Mohakhali, Dhaka, considered as one of the busiest commercial hubs of Dhaka. It is termed as Express Warehouse, meaning that products are kept for a very short period of time in this warehouse. Most of the product they deal with are environment sensitive.

They suffer of prolonged handling time due to inefficiency of human labor. Plans on adopting digitalized and automated techniques of handling. This particular warehouse is comparatively small one but as it handles delicate products including electronic devices they are very keen to embrace AGV system but labor cost in Bangladesh is really cheap and AGV System has a pretty hefty intial cost they are thinking of using AGVs within next 40 years down the line.

3.3. Experimentation

3.3.1. Initial CAD design

The following design was prepared initially using a CAD software. However, it was modified in order to ensure proper balance of the center of gravity and weight distribution.

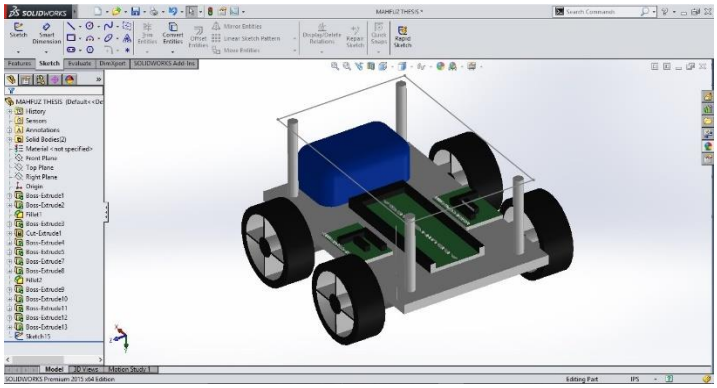

Figure 3: Perspective View of the initial design of the bot.

3.3.2. Functioning prototype construction

A functioning prototype was developed with the vision of imitating an actual AGV. It could follow line to perform locomotion.

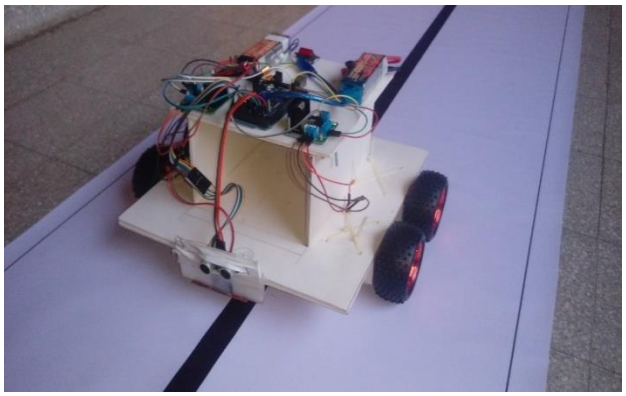

Figure 4: Perspective view of the AGV Prototype

3.3.3. Features of the AGV prototype:

- DC powered robot
- Plastic Wood Body
- Can follow black line over white background and vice versa
- It had a maximum weight carrying capacity of 2000 grams.
- It had a velocity of 0.5m/sec
- The total construction cost was approximately 17000 BDT.

4. Analytics and Core Findings

4.1. Financial Analysis:

One of the most compelling reasons to switch from a manual operation to an automated one is to save money. An AGV system will run 24 hours a day, seven days a week and are designed to operate without supervision. If your business runs three shifts a day, five days per week the annual cost per forklift is $240,000. This cost includes; three driver's wages, capital expenditure or leasing for the vehicle and running costs. Over ten years with equates to $2.4 million per forklift in your operation. In most cases you will replace one forklift with one AGV. An AGV will cost the same in the first year for outright purchase and less if using a leasing option. However, the costs for the AGV drop dramatically in the following years, averaging only $4000 to $6000 per year. Over the ten-year period you will save nearly $2.1 million per forklift by investing in an AGV system. The more shifts you run the more money you will save as our AGVs will run on a 24-hour rotation without any additional staffing costs or penalty rates. Any company that works its factory floor for more than 8 hours a day will recognize instant cost savings by switching to an AGV system.

Furthermore, AGVs reduce costs by eliminating all the Human resource management costs such as recreational break, sick leave, vacation, bonuses and increments AGV operations will ensure better Return on Investment in comparison to human labor. It will reduce utility costs as the AGVs can operate in lights-out environment. It can work at a steady consistent speed leading to lower maintenance.

4.1.1. Examples of typical leasing costs

- 1 vehicle pallet-forklift type AGV system with up to 20 load and unload positions and a travel distance of up to 100 meters. Monthly cost for 5 years, with no residual: A$ 5,400/month (comparable cost for 1 forklift and 3 drivers in a 3-shift operation ~A$20,000/month)

- 3 vehicles pallet-forklift type AGV system with up to 50 load and unload positions and a travel distance of up to 200 meters. Monthly cost for 5 years, with no residual: A$ 12,100/month (comparable cost for 3 forklifts and 9 drivers in a 3-shift operation ~A$60,000/month)

- 5 vehicles pallet-forklift type AGV system with up to 100 load and unload positions and a travel distance of up to 300 meters. Monthly cost for 5 years, with no residual: A$ 19,200/month (comparable cost for 5 forklifts and 15 drivers in a 3-shift operation ~A$100,000/month)

- 10 vehicles pallet-forklift type AGV system with up to 1000 load and unload positions and a travel distance of up to 500 meters and a small Warehouse Management Solution. Monthly cost for 5 years, with no residual: A$ 36,500/month (comparable cost for 10 forklifts and 30 drivers in a 3-shift operation ~A$200,000/month) *.

4.2. Productivity Analysis

- **Optimization of warehouse functions:**
  Implementing AGV in warehouse operations ensures proper tracking of the palette handling, material transfer, and exchange of goods to and from the warehouse. Thus, it ensures smooth integration of the data into Enterprise Resource Planning (ERP) & Material Requirements Planning (MRP) systems.

- **Complete working shifts:**
  Unlike human labor, the AGVs is capable of working complete eight hours per shift. This eventually decreases the time lags caused due to downtime, recreational leave, rest time etc.

- **Rapid Charging mechanism:**
  The AGVs are equipped with high configuration battery system in which quick charge of 5 minutes ensures up to 5 hours of continuous operations.

- **Proper control of WIP:**
  AGV operations are completely controlled by computerized commands and thus the entire work in progress remain in the control. As a result, any unexpected changes in the demand or delivery time can be addressed properly by adjusting the operation of the AGVs.

- **Smooth feedback insurance:**
  The working progress of the AGVs can be traced transparently and thus it gives proper insurance of the feedback. These feedbacks can be used to bring any desired changes in order to obtain maximum output.

- **Easy expandability:**
  AGV operations can be initiated with limited number of bots and can be expanded with the necessity of the operation. On the contrary, a fixed automation system, once implemented, is difficult and costly to move; AGVs on the other hand can be easily reprogrammed to follow new paths.

4.3. Efficiency Analysis

- **Weight loading capacity**
  A typical AGV can carry up to 2000 kg of weight at a time facilitating the option to bring about changes in the plant layout, process layout etc. This is impossible on the part of a human being to carry weight of such limit.

- **Highly optimized throughput**
  Insurance of highly optimized throughput can be made possible by the proper utilization of the plant space. Furthermore, the AGVs can reach such heights and passages which are impossible for the human labor to accomplish.

- **Steady speed**
  A typical AGV can move at an average speed of 20m/min (carrying 500kg). This speed is maintained to be steady without any turbulence. This makes it easy to predict delivery time and handling time precisely.

- **Disciplined handling system**
  AGV follows order fulfillment policies such as pick-by-time/after-time or pick-by-FIFO, expiry or manufacturing date. This ensures proper discipline of the operations inside the plant and reduces the scopes of error to the utmost extent.

- **Adaptive handling system**
  AGV intelligently adapts in real-time to changing inventory profiles and order fulfillment patterns and thus opens up the opportunity of staying intact to the committed delivery time.

- **Increased Inventory Accuracy**
  This is another area where human error reigns supreme. A simple miscount can throw off figures and create issues, but automated inventory systems can easily solve that issue. And it's another area where costs can be cut.

4.4. Security Analysis

- **Improving workplace safety**
  Utilizing automatic guided vehicle systems enhances workplace safety in a variety of ways. First, they can perform tasks that would normally be considered dangerous for humans. Second, they operate in a smooth, controlled manner, which means fewer risks of human-operated vehicles injuring other employees. And enhanced workplace safety can also decrease costs, including insurance rates and OSHA penalties.

- **Diminishes the scope of damages**
  AGVs handles the products in a comparatively safer way and thus the amount of accumulated damage decreases. This further results in decreasing the loss incurred due these damages.

- **Handling hazardous items**
  AGVs are dependable to carry hazardous items which might impose threats to human labor. This also facilitates the continuation of the work under extreme operations.

- **Insurance of machine safety**
  AGVs are equipped with overload sensors, and makes sure that it won't move if it is overloaded. This ensures both the AGV & PRODUCT SAFETY.

4.5. Conclusion

4.5.1. Limitations In the context of Bangladesh

- **Low labour costs**
  Bangladesh is reputed in the global context for its low labour cost, and thus the industrialists give less emphasis on the digitalization and depends on the human to get the job done.

- **Not suitable for Non-repetitive tasks**
  AGVs are not suitable for non-repetitive task as the cost of AGVs depends on the stations they visit, is the number of the stations they need to visit is different in every cycle it won't be cost efficient. Then again customization of AGV is possible.

- **Lack of investment in automation**
  Logistics operators not interested to invest in such automation project as Bangladesh have a pretty cheap labour cost. So, investing a great sum of money up front is not acceptable for them. This is the major problem why Bangladesh is lagging behind in the field of warehousing.

- **Flexible lead time**
  Enjoy comparatively flexible lead time in logistics handling, so, automation not in first priority as a part of technical integration, this flexible lead time is offered because Bangladesh has a bad reputation in this sector. All the multinational logistics companies know that Bangladesh needs more lead time as the warehouses here are not automated. So, they allow up comparatively long lead time but this is in the long run bad for us.

4.5.2. Future Scopes and recommendations

- **Global competitiveness**
  International heavy logistics handlers operating in Bangladesh should adopt AGV because it will raise the bar for local logistics handler and make the local industry more competitive. In Bangladesh the main problem is that logistics handlers are happy with the current scenario so they don't find the urge to modernize and this is why they are neglecting the bigger future.

- **Focus on the air and seaport**
  All the Major ports and export zones are semi-automated in our country, making them automated can drastically increase the efficiency and effectiveness of the whole process.

- **Development of local engineering sector**
  Making AGVs is pretty common for Bangladeshi engineering students, the problem is, they are simple line followers or obstacle avoider they need to step up the game and big shot companies should work alongside them to produce industry grade AGV systems which can be used and imported.

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Application of modern Supply Chain Management Tools to the Power Plants of Bangladesh: A Case Study

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Abstract

Power generation sector of a country plays a pivotal role in her overall development and progress. In modern world, as days goes by people are getting depended on technology even more. Bangladesh is the ninth most populous country in the world. In order to turn this overpopulation from a burden to a blessing we need to equip them with necessary technology. To provide technology for this huge amount of people we need a lot of electric power. If we take a look at the most developed countries in the world. They are also the country which are leading in electricity production. It clearly proves how much impact energy production has on any country's development. This is where Bangladesh lacks the most. Our country currently ranks 46th in overall electricity production whereas its population ranking is 9th. Modern supply chain tools are currently being used in pretty much every managing sector due to its radical effect. Utilizing it in our power sector can also help in increasing the overall efficiency. Our thesis is a case study about the prospect and goals that can be achieved if modern supply chain tools are applied in power plants of Bangladesh.

Keywords:

Supply Chain Management, Power Plant, Energy

1. Introduction

Bangladesh being one of the fastest growing economy and a promising developing country in the world, its power demand is ever increasing. In this modern age, a country's power producing capacity is an index of its development. We can see it by the high power producing rate of the developed countries.
Even though we have increased our capacity in recent years like even in 90's our only power producing options were KARNAPHULI POWERPLANT only producing 200 MW which increased to 7000 MW (approx.) up to today. But with the increase use of modern gadgets, machineries and everything it is still not sufficient.
To increase power capacity we need to establish new power plants and increase the efficiency of the existing one. Since establishing a new power plants is a really tough job considering its expenses, environmental hazards, raw material transport problems, we need to concentrate more on increasing the efficiency on the existing one.

1.1. Background

BPDB is the power generation and supplying authority of Bangladesh run by the Government of People's Republic of Bangladesh. It has been working diligently to serve the people of Bangladesh since its inception.
But with the passage of time and improvement of socio-economic condition of the country the scope of work also increased. This boom in power demand came with a lots of challenges for BPDB, not only in generation but also in infrastructure realignment. The power plants operate at their peak efficiency i.e. there is almost no scope to increase the rated capacities of the units. But developing and streamlining the infrastructure and plant management can reduce lead times and result in cutting down overall per unit generation cost. Focusing on reducing various system losses in the process by applying modern Supply Chain Management Tools can have positive impact on the power sector.

1.2. Status quo

Total power generation capacity in Bangladesh up to May 2017
Source: BPDB (Bangladesh Power Development Board)

Fuel Type	Installed Capacity (MW)	Total (%)	Rated Capacity (MW)	Total (%)
Coal	250.00	1.9	200.00	1.59
Gas	8267.00	62.73	7844.00	62.36
HFO	2800.00	21.25	2743.00	21.81
HSD	1032.00	7.83	961.00	7.64
Hydro	230.00	1.75	230.00	1.83
Imported	600.00	4.55	600.00	4.77

1.3. Challenges

Our electricity demand is going to increase each day progresses. This is an estimate according to BPDB about the increasing demand in upcoming years.

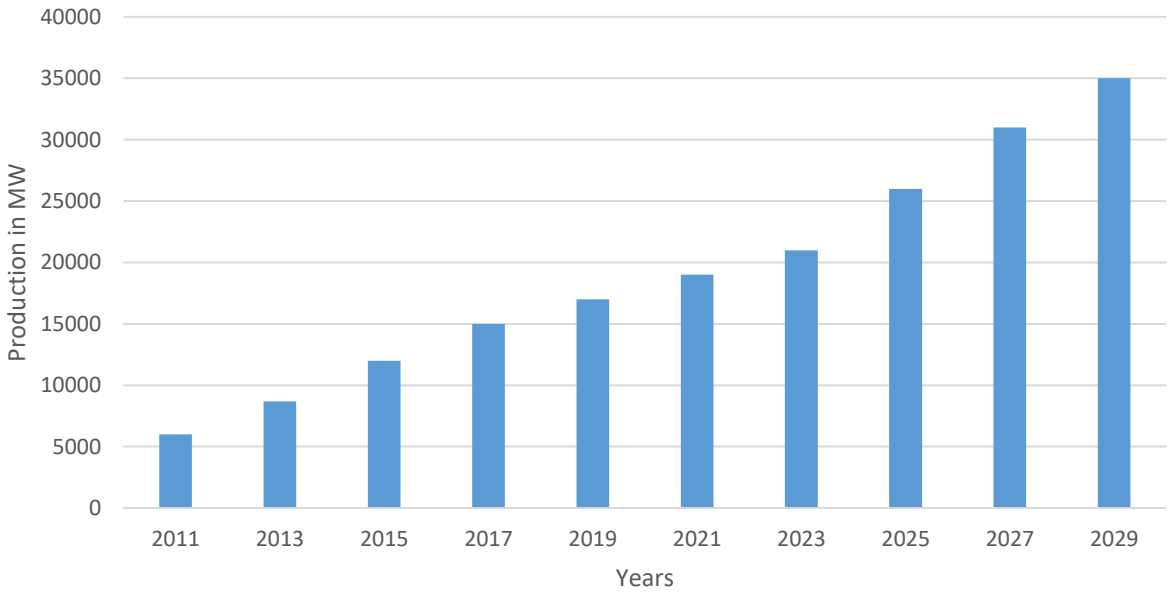

Figure 1: Estimated Electricity Demand in coming years done by BPDB

If we closely take a look at the graph we can see that, while the demand was only 10000 MW in the year 2015 it will approximately increase up to 30000 MW within 2028. We can see the exponential increase of electricity demand in our country with time. But unfortunately our energy resources will not increase with the same rate.

1.4. Objectives

We have conduct our study keeping some targets ahead. We wanted to achieve these goals through our study. Some of the primary objectives of our study is given below –

- To show the current and upcoming challenges our power sector will face in future.
- To show the impacts of Supply chain management in any managerial sector.
- To assess the scopes of application of Supply Chain Management (SCM) to power plants in Bangladesh.
- We aim to look at the managerial sector and understand what application of proper supply chain management system can be improved.
- To find out the prospective advantages of applying SCM to this sector.
- We also target to establish a comparative study about this method.

2. Fieldwork

2.1. Power Plant Visits

We were fortunate to visit 5 Power Plants in total to collect and observe data and day to day operations. All of these plants were operated by BPDB and its personnel. As most of these site are designated as KPI's we had to go through a number of security measures and verifications in order to gain access.

- **Karnaphuli Hydro Power Stations**
  - Location : Kaptai, Rangamati
  - Total Units : 5
  - Maximum Capacity : 242 MW
  - Turbine : Kaplan Turbine (Reaction Type)
  - Efficiency : 99 %
  - SCM : Absent

- **Shikalbaha Power Station**
  - It has two power plants. One is driven by Steam (60 MW), another by Gas (150 MW).
  - Location : Shikalbaha, Chittagong
  - Manufacturer : Siemens, Germany.
  - Fuel : Natural gas
  - Rated Power : 181 MVA / 144.846 MW
  - Efficiency : 33 %
  - SCM : Absent

- **Chittagong Power Station**
  - Location : Raozan, Chittagong
  - Number of Units : 02
  - Installation Capacity : 2X 210 MW per Unit
  - Total : 420 MW
  - Raw Materials : Water, Natural Gas, Air
  - SCM : Absent

- **Hathazri Peaking Power Plant**
  - Location : Hathazari, Chittagong
  - Rated capacity : 100 MW
  - Fuel : HFO (Heavy Fuel Oil)
  - No. of Diesel Engine : 11
  - Operation Time : After 5 PM
  - SCM : Absent

- **Tongi 80 MW Gas Turbine Power Station**
  - Location : Tongi, Dhaka
  - Rated capacity : 105 MW
  - Fuel : Natural Gas
  - RPM : 3000
  - Efficiency : 34%
  - SCM : Absent

3. Supply chain management (SCM)

3.1. Definition

The entire oversight of the processes that include procurement, production, distribution and feedback is called Supply Chain Management. In a nutshell. Everything related to the product fall under the purview of Supply Chain. It encompasses planning and management of all stages that are involved directly or indirectly in accomplishing the customer needs. More importantly, it includes collaboration and co-ordination with partners, intermediaries, suppliers, customers and service providers.

3.2. Supply Chain Management Tools

SCM, as an invigorating part of enterprise resource planning, offers a number of tools at one's disposal. Utilizing these tools and factors properly optimizes and makes the entire process more efficient. Which in turn makes the company cost effective and profitable. Following are some such tools:

- Internal Realignment
- Category Management
- Supplier Integration
- Risk Management
- Inventory Optimization
- Improved Metrics

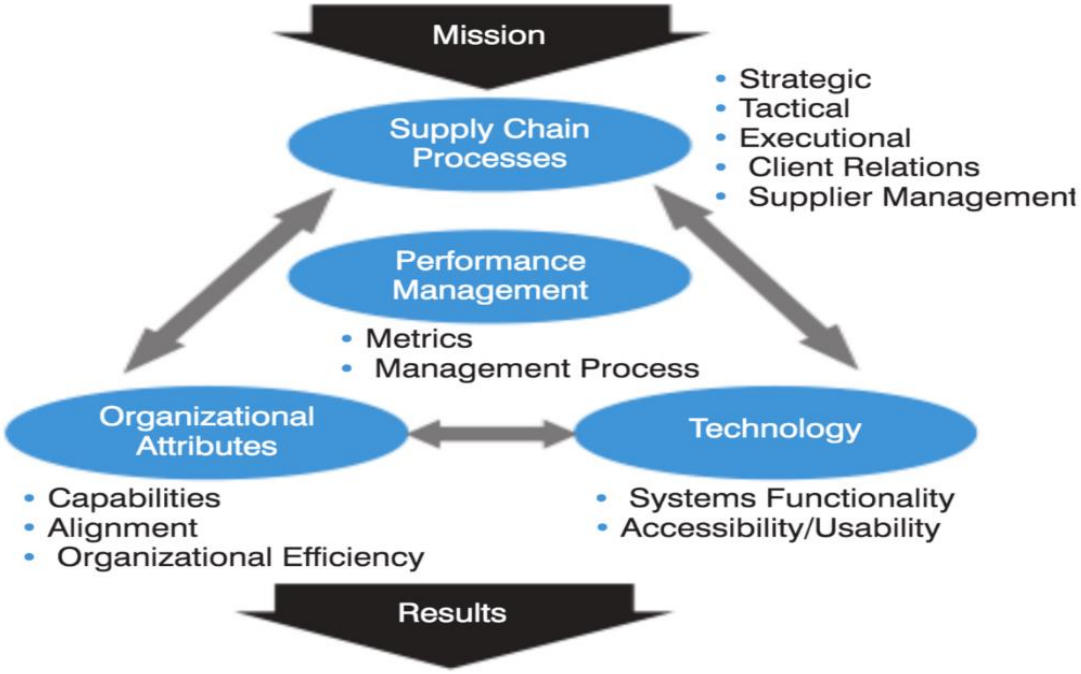

Figure 2: Typical SCM Process

4. Utilities Supply Chain Management

According to the Author of 'Optimal Supply Chain Management in Oil, Gas and Power Generation',

"Supply Chain Management in oil, gas and power generation closely resembles the process industry just more complex and dynamic in nature. Technology, even chemistry can affect every component and every decision due to vulnerable nature of its demand"

As the utilities sector entered the last decade of 21st century, impending deregulation and increased scrutiny from regulators raised utilities' focus on cost management. This change brought a proliferation of strategic sourcing schemes made to reduce the costs of procured materials and services. Utilities coordinated cross-functional commodity groups to pursue more effective supplier strategies, reducing the number of suppliers on many commodities so that companies could grow stronger relationships with fewer, more essential suppliers. Utilities signed long-term corporate contracts for many spending groups, which redesigned the competitive landscape as weaker suppliers lost business and consolidated.

Figure 3: Utilities SCM Flow Diagram

5. Distinguishing SCM in Power

Majority of people understand SCM from the consumer product industry's perception, where thousands of SKUs of FMCG flow through distribution centers. SCM in power sector resembles more to the process industry. Even so, it is much more complex than in low value process industries like paper and cement. Technology, chemistry etc. affect every steps, decision, starting from procurement to designing network, installation and logistics. This complexity shows itself in most segments of the business as such in power sector, advances in materials sciences are allowing the turbine temperatures to surpass 2200F, delivering more power.
The prohibitive cost of downtime makes reliability and field responsiveness critical. Long investment cycle should consider risk and uncertainty factors.

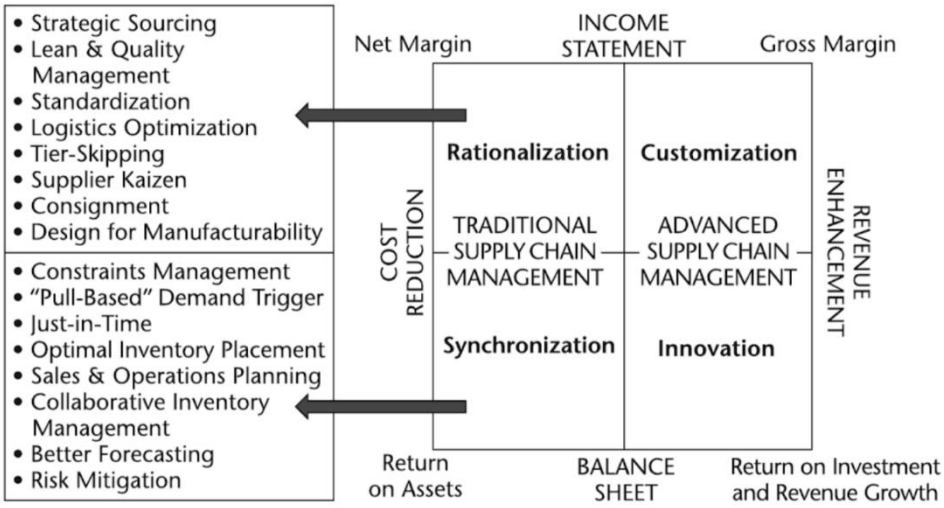

Figure 4: SCM Strategies for Power Sector

The above figure depicts how SCM can impact the power sector. It shows the schemes for increasing profit margin or in other words cost reduction. Optimization requires all the factors to be in sync and proper application.

6. Key Supply Chain Processes

Usual cross industry SCM processes include manufacturing and distribution site, location, strategic sourcing, demand forecasting, inbound logistics, transportation etc. Mapping most typical SCM techniques to the business processes that are more relevant to power sector. Dismembering this integrated framework gives us three important topic areas:

- Capex project supply chain risk mitigation
- Engineering and procurement of equipment and services at minimum cost and risk
- Operating cost minimization

Among these the circled components are key leverage areas for power sector. So utilizing these we can optimize the cost and efficiency. It includes inventory management, purchasing, production and strategic sourcing.

7. S.W.O.T Analysis

Strengths

- Field visit gave us a firsthand knowledge about the power plants.
- Less costly solution to the upcoming challenges to face.
- Successful proven SCM tools have been used.

Weakness

- Not applied in any power plants in Bangladesh.
- Changing age old process might cause some temporary disturbance.

Opportunities

- Could be the biggest weapon in upcoming hurdles to overcome in power generation
- Environmental safety can also be achieved by maintaining the supply chain rules

Threats

- Applying this might not be enough to overcome the upcoming power deficiency.
- Lack of trained people in SCM might hinders the proper application of the whole process.

8. Conclusion

With the amount of challenges to overcome in upcoming days, it's high time for the power generation authority of the country to take a step. This effort is a one step forward for solving these problem. Our approach was mainly from the managerial sector. It is a relatively new approach in power sector.
To have a concrete evidence of improvement after applying SCM to power plants, we need to apply it in a real working power plant. Since power plants have National security issues, it's not flexible on changing it process without the permission from higher authority. But based on the success of applying SCM to power plants in other countries and also based on our research, BPDB should consider applying the proper SCM tools we mentioned in any power plant and compare its efficiency with others.

9. Acronyms

SCM: Supply Chain Management

BPDB: Bangladesh Power Development Board

SKU: Stock Keeping Unit

O&M: Operation and Maintenance

FMCG: Fast Moving Consumer Goods

HFO: Heavy Fuel Oil

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29th August,2017

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Design Optimizations of Vortex Tube to Ensure Higher Temperature Difference for Cooling and Heating

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Abstract

A cooling system is significant for both human and machine. There are two types of system used for refrigeration purpose – Vapor Compression and Vapor Absorption. But, vortex tube is an unorthodox type of cooling system. We do not use this commonly for cooling purpose. Though, it has various benefits over the orthodox cooling systems. To build a counter flow vortex tube this project was attempted. The performance of counter flow vortex tube was determined to be experimented on this project. To measure the performance an experimental setup has been considered. To increase the performance of vortex tube, we changed different types of geometrical parameters like – Diameter of cold end and hot end pipe, Vortex angle, Tube length, Ratio of tube length over diameter. We also changed the working parameters at inlet like as temperature and pressure to observe difference of performance and to predict some of the experimental data. By increasing the performance i.e. both heating and cooling effect can be used.

Keywords
Vortex Tube, Design Optimization, Cooling System.

1. Introduction

A vortex tube produces two different types of streams when air or any other gases are put through a single inlet tangentially. One of the two outlet produces colder stream and the other one produces warmer stream than the inlet. Different types of experiments are done with vortex tube. Georges J. Ranque invented the vortex tube in 1933. Later, Rudolf Hilsch enhanced the performance of the tube in 1947. Flow behavior and mechanism for the generation of streams at different temperature are discussed in some previous experiments. Pressure difference between inlet and outlet plays the vital role for the drop of temperature. Partial immobility and multicirculation is the cause behind rise of temperature (Xue et al., 2013). Vortex tube is an unorthodox system for refrigeration and cooling. But one of the advantages of the vortex tube is it has no moving parts. So, we have planned to increase the temperature difference to use the device for multipurpose i.e. Heating and cooling.

Previously, some experiments are done (Xue et al. 2013) on geometrical parameters of vortex tube. In this study we have made an optimized design to get the best outcome from a vortex tube, which can be later used for multiple purposes. We have optimized the design using some geometrical parameters like length, width and the vortex angle using the results described in previous studies.

2. Vortex Tube

2.1 Components

1- Compressor
2- Inlet nozzle
3- Cold air outlet
4- Hot air outlet
5- Vortex tube
6- Digital temperature indicator
7- Valve
8- Orifice.

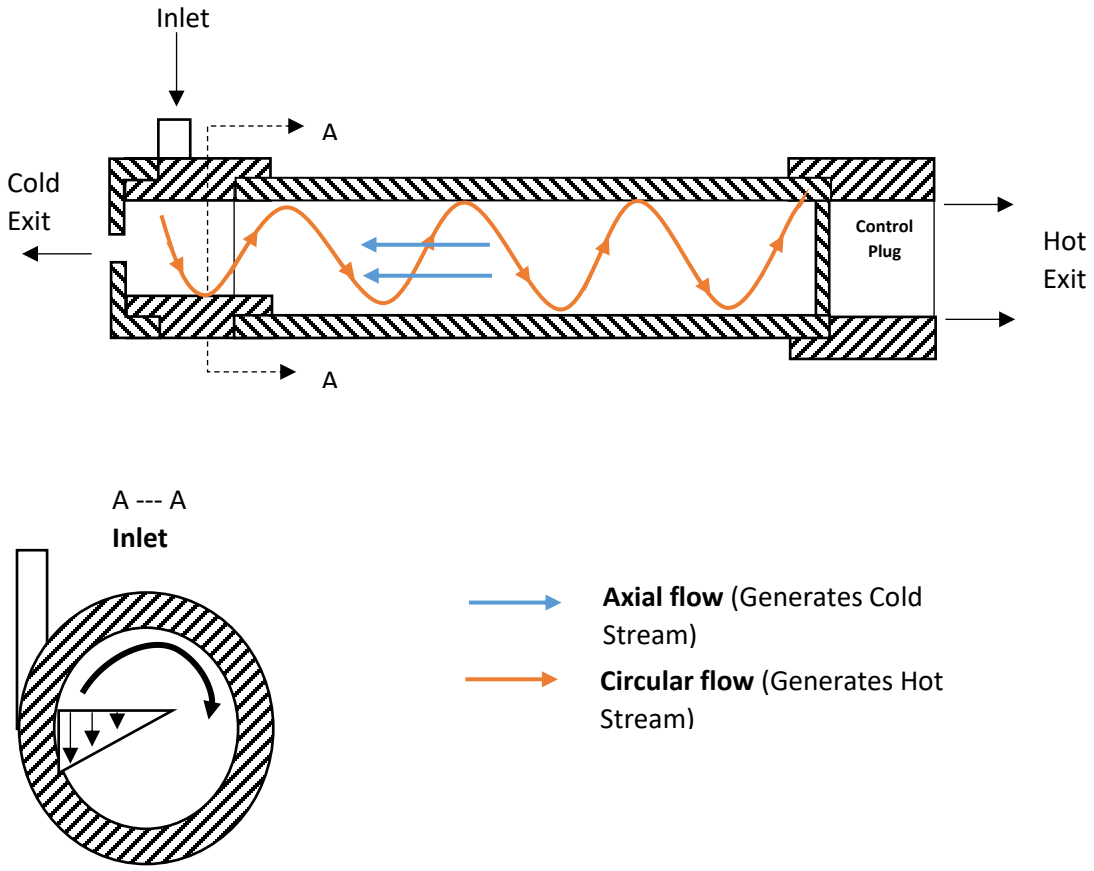

Figure 1. Components and flow structure of the Vortex tube

2.2 Working Principal of Vortex Tube

When Compressed air is passed through the nozzle as here; air expands and acquires high velocity due to the deference in diameter of the nozzle and the tube. A vortex flow is created in the chamber and air travels in a spiral motion along the periphery of the tube. This flow is restricted by the valve. When the air pressure near valve is made more than outside by partly closing the valve, a reversed axial flow through the core of the hot side starts from high-pressure region to low-pressure region. During this process, heat transfer takes place between reversed stream and forward stream. Thus, air stream through the core gets cooled below the inlet temperature of the air in the vortex tube, while air stream in forward direction gets heated up. The cold stream is escaped through the diaphragm hole into the cold

side, while hot stream is passed through the opening of the valve of the tube. Thus, by controlling the opening of the valve, the quantity of the cold air and its temperature can be varied.

3. Geometric Effect on vortex tube

Implementing both experimental and numerical methods the effects of the geometrical parameters on vortex tube performance have been investigated by many researchers. It has been reported that by selecting different geometrical parameters for testing a vortex tube, such as length and diameter of the tube, shape and size of the inlet nozzle, cold and hot exits, and structure of the tube, the temperatures of the generated cold and hot streams varied. There has not been an explanation that can be used to explain all the effects of the variable parameters on the tube performance. Based on the explanation proposed in this study, here the geometrical effects on vortex tube are discussed.

3.1 Tube Length

The effects of tube length, tube diameter and ratio of tube length over tube diameter were summarized. It was reported that the length of the tube should be longer than a critical length to achieve significant temperature separation within the vortex tube. When the vortex tube is shorter than the critical value, the separating vorticities between the cold core and multi circulation region became weaker or even disappear, and the cold flow will subsequently mix with the hot flow from the multi-circulation region. Hence, the temperature separation in a very short vortex tube will not be significant. When the length of a vortex tube approximates or is longer than the critical length, the separation of the cold region and the multi-circulation region, i.e., the hot region, is ensured by the tube length and provides a better performance of the temperature separation. The critical length is different for the vortex tube with different tube diameter.

3.2 Ratio of tube length over diameter

It has been reported that the ratio of tube length over diameter needs to be greater than 20 in order to have significant temperature separation in a vortex tube and this finding agrees with the current study. Once the ratio is greater than 45, it was reported that there is no further effect on the performance of the vortex tube. This is likely due to the fact that the cold core region and the multi-circulation region have been fully separated when the ratio of length over diameter is 45. Therefore, it does not apparent that further lengthening of the vortex tube has any influence on the tube performance.

3.3 Vortex angle

It has been reported that vortex angle had negative effects on the magnitude of the temperature differential achieved. Based on the proposed explanation, vortex angle leads to a decrease of the tangential velocity and an increase in the axial velocity. Since both the temperature drop and temperature rise are caused by the strong swirling flow, the decrease of the tangential velocity is the reason for the reduction of temperature separation in a vortex tube with a vortex angle generator installed.

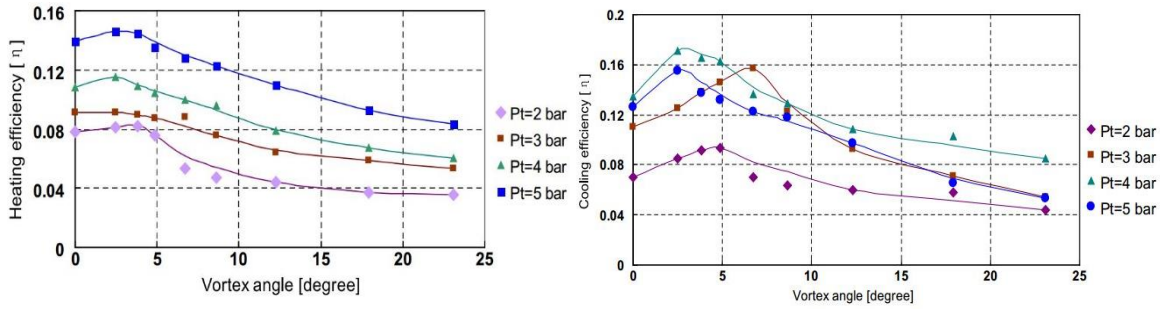

Figure 2. Heating efficiency of the vortex tube
Versus vortex angle. (Xue et al., 2008)

4. Design Optimization of Vortex Tube

In our design we optimized the length, width and the vortex angle following the rules described previously.

The length of the vortex tube was kept 560mm which is much higher than its critical length for diameter 14mm.

Here length and diameter ratio is maintained in such a way so that we can get maximum temperature difference in optimum cost.

Here, LENGTH/DIAMETER = 560/14 = 40

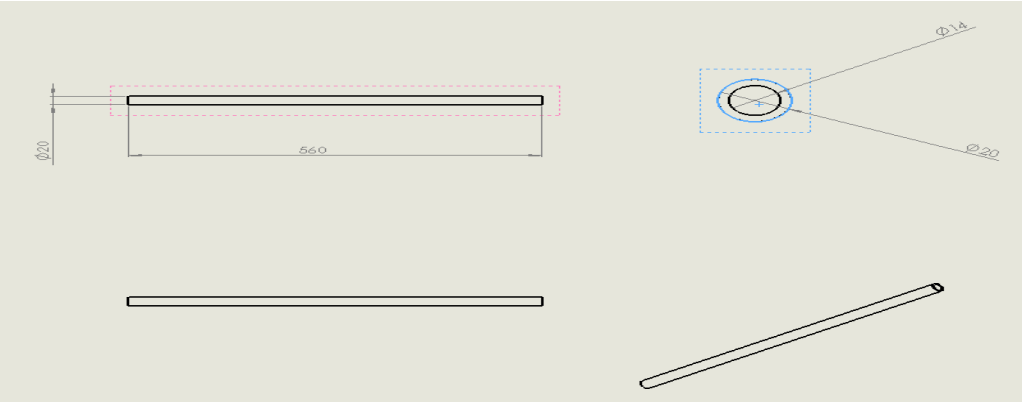

Figure 4. Dimension of tube

Here we tried to maintain the vortex angle as low as possible. Because we have seen that
For heating,
Efficiency is maximum when the the vortex angle is 3.75 degree for Pt= 2bar
Efficiency is maximum when the the vortex angle is 2.5 degree for Pt= 3bar
Efficiency is maximum when the the vortex angle is 2.5 degree for Pt= 4bar
Efficiency is maximum when the the vortex angle is 2.5 degree for Pt= 5bar

So we will get maximum efficiency for heating in Pt=2bar to Pt=5 bar if we keep the vortex angle 2.8125 degree
For cooling,
Efficiency is maximum when the the vortex angle is 5 degree for Pt= 2bar
Efficiency is maximum when the vortex angle is 7 degree for Pt= 3bar
Efficiency is maximum when the vortex angle is 2.5 degree for Pt= 4bar
Efficiency is maximum when the vortex angle is 2.5 degree for Pt= 5bar

So we will get maximum efficiency for cooling in Pt=2bar to Pt=5 bar if we keep the vortex angle 4.25 degree

So the optimum vortex angle for both heating and cooling efficiency is 3.53125 degree

5. Material Selection

Vortex tube generally using three materials for its construction namely:

- Stainless Steel
- Aluminum
- Plastic

It depends on its function to use for cooling purpose or for heating. Generally it is made up of stainless steel because of its high thermal conductivity and better corrosion resistance but because of its heavy weight it lags behind the aluminum. On the other hand aluminum is also used for constructing vortex tube because it may have good thermal conductivity and light weight. Plastic is used where the weight required is very less and the hot fluid temperature is also very less because it may not have high thermal conductivity as compared to the other two. The Design of vortex tube is not very much complicated because it may not require any moving parts. The design of vortex tube depend on its requirement just like the place where it is used either it is used in vehicles or in mines. But the design aspect is important because we may require more and more cooling so for that we may need to change the ratio of length to diameter because of changing that we may acquire cool air according to our need. We have used Stainless Steel for tubes in this project. Some small parts are made of Mild Steel.

- Cold Outlet: Material – Stainless Steel & Mild Steel
  Diameter – 10 mm
- Inlet Hub: Material – Mild Steel
  Small Diameter – 10 mm; Big Diameter – 19 mm
- Main Tube: Material – Stainless Steel
  Diameter – 16 mm; Length – 470 mm
- Hot Outlet: Material – Stainless Steel
  Diameter – 22 mm; Length – 102 mm
- Hot End Valve: Material for Head – Mild Steel
  Material for Rod – Nickel Plated Mild Steel
  Small Diameter – 10 mm; Big Diameter – 17.5 mm;
  Length – 77 mm
- Tube Thickness: 3 mm

6. The Model

6.1 Design of the vortex tube

The design are done in Solid Works 2017. All dimensions used for design are calculated and analyzed.

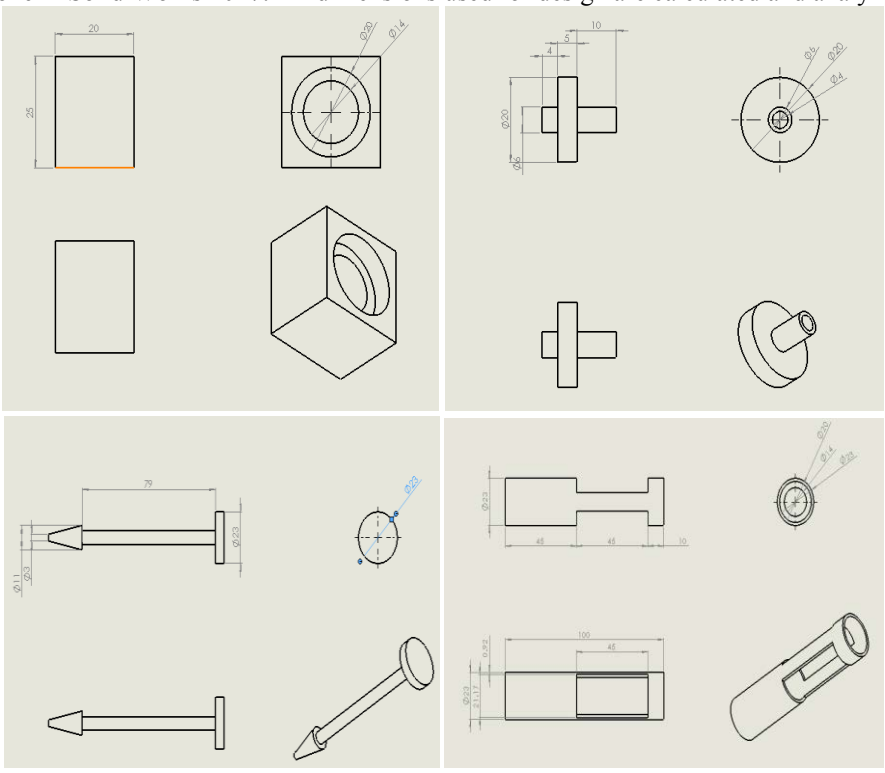

Figure 5. Design of the vortex tube in Solid Works

6.2 Vortex Tube 3D view and Sectional View

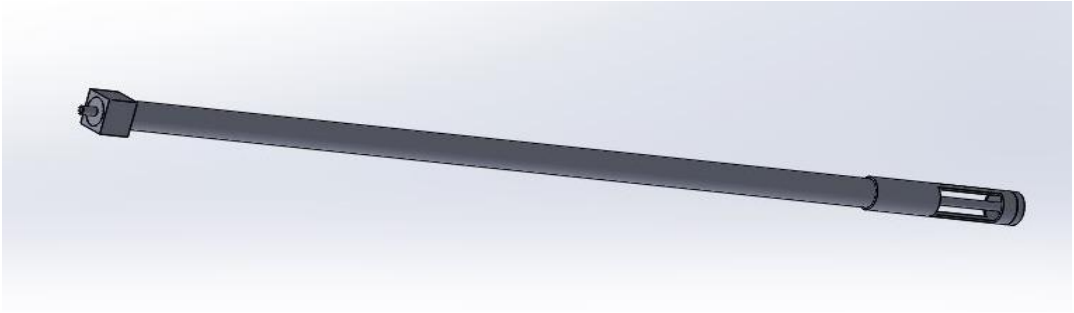

Figure6. Vortex Tube 3D view

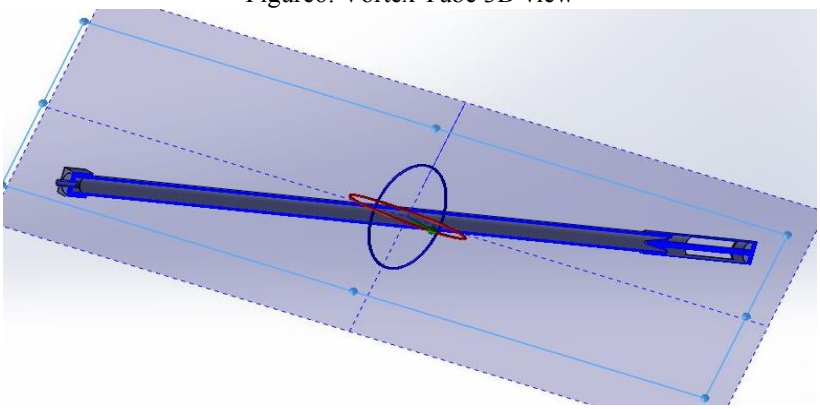

Figure 7. Vortex Tube Sectional View

6.3 The Vortex Tube

Figure 8. The Vortex Tube

7. Experimental Setup

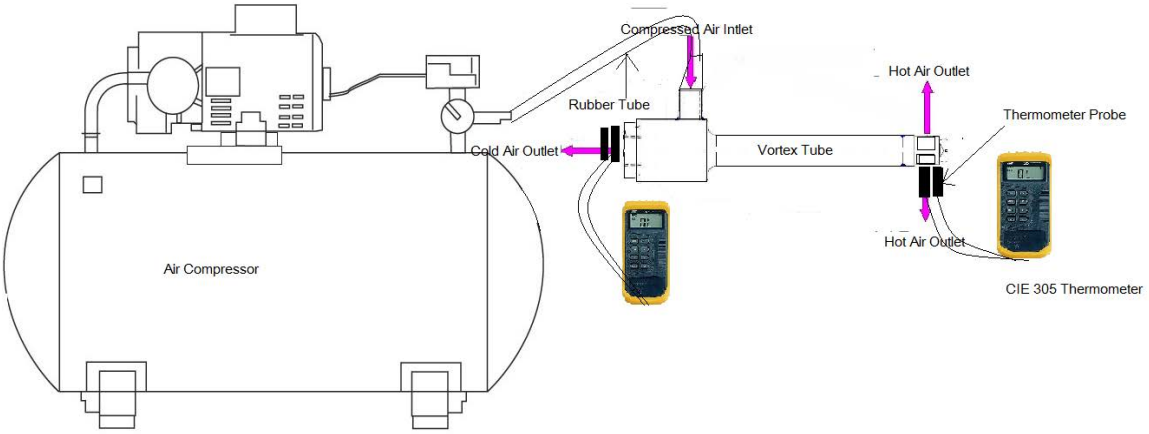

Figure 9. Schematic Diagram of the Experimental Setup

We have used several components for our experimental setup

1. Air Compressor
2. Rubber Tube
3. Vortex Tube
4. CIE 305 thermometer
5. Pressure Gauge

We placed the vortex tube over a table in front of the air compressor. A rubber pipe is connected with the air compressor outlet and its other end is attached with the inlet of the vortex tube. CIE 305 Thermometer is held on both end of the vortex tube to measure the temperature of both hot end and cold end.

At first compressed air of 2bar pressure and 25.2 degree C temperature is blown to the vortex tube. Then two different air of different temperature has come out from both of its ends. By measuring the temperature by thermometer placed on both sides, we can see the cold end temperature is 20.9 degree C and the hot end temperature is 29 degree C.

Figure 10. Experimental Setup

Figure 11. Cold Outlet Temperature

Figure 12. Hot Outlet Temperature

Figure 13. Reading from Pressure Gauge

8. Result

Pressure at inlet 1.8 bar
Temperature at inlet 25.2 degree C

Temperature at Cold Outlet 20.9 degree C
Temperature at Hot Outlet 29.0 degree C

Temperature difference between two outlets (29.0 – 20.9) = 8.1 degree C

9. Conclusion

After the optimization of different geometrical parameters, like – length, ratio of the length over diameter, vortex angle, the performance is increased. Therefore this optimized design may be used in different applications. Further study may be conducted by increasing the inlet pressure as well as controlling the number of holes in hot end, to increase the temperature difference.

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Technical and Economic Viability of A Proposed Solar Street Lighting System for SUST

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Abstract

Renewable energy is attracting both public and non-governmental investments to supply energy for the population living in Bangladesh. Financing people for installing those renewable energy systems is crucial for a sustainable energy growth. In this paper, the economic feasibility and greenhouse gas emission of a proposed solar street lighting system for Shahjalal University of Science and Technology (SUST), is analyzed by using the 'RETscreen' software. For 25 years project life time, the equity payback period for the solar project is found 13.6 years. The internal rate of return (IRR), net present value (NPV), benefit cost ratio (BCR), annual life cycle saving are found 7%, BDT 35685, 2.6 and BDT 1427 respectively which indicates its acceptability as a feasible project. The proposed solar street lighting project for SUST is estimated to reduce 100 kg of emission per year which shows the environmental benefits as well.

Keywords: Solar street lighting, Financial analysis, Emission Analysis.

1. Background of the study

The electricity generation of Bangladesh depends mostly on the natural gas reserve. Z. Wadud et al. (2011) examined the flow of gas demand in Bangladesh and forecasted that around 3000 thousand cubic feet per year gas consumption will be in the year of 2030 for per capita [Wadud et al., 2011]. So, the energy sector plays a critical role for the socio-economic development of a country and till now Bangladesh faces an acute energy shortage. For the further development of the country the availability of adequate and uninterrupted energy supply is essential component [Division F., 2011]. Fossil, solar, hydro, wind, geothermal and bio-fuels are the energy sources of Bangladesh [Kabir H., 2013]. The problem arising for the limitation of the fossil fuels which leads to the utilization of the renewable energy resources. The power generation from solar energy has great potential. The geographic location of Bangladesh is 20.30-26.38 degree and 88.04-92.44 degree of north and east latitude, respectively, which refers an excellent location for utilization of solar energy [Kabir H., 2013]. The daily solar radiation is average between 4 and 6.5 kWh/m^2. In 1980, the first solar electrification was started in Bangladesh and developed mainly in rural off-grid areas. The power capacity from renewable energy was 78MW until 2012 where 95% of the renewable electricity comes from solar energy [Biswas et al., 2014].

Solar street system can play a vital role in this issue. The component of the solar street system is photovoltaic solar panel, a storage battery, a battery charging controller, and end-use equipment like LED (Light Emitting Diode) lamps etc. S. Sowe et al. (2014) investigated on the economic viability of a c-Si module based power plant and found that the IRR, PBP, BCR are 9%, 8.35 years, 1.82 respectively [Sowe et al., 2014]. In a study of M.A.H. Mondal (2010) argued that only financial analysis is not sufficient to appreciate the energy investment and environmental factor should also be incorporated [Mondal M.A.H., 2010]. N.S.M. Aung and Z.H. Myint (2014) suggested solar LED street lighting system rather than using the normal electric bulbs [Aung and Myint, 2014]. In this research work, similar consideration of LED lamps for proposed solar street lighting system is evaluated.

2. Methodology

The methodology can be divided into two parts. First, the data were collected from the existing system and calculated the required energy of a solar electric poll for the project. After that identification of the suitable solar panel, battery, charge regulator and the LED lamps were made. The second part is the analysis of the economic viability and estimation of the greenhouse gas emission of this project. The net present value (NPV), internal rate of return (IRR), benefit cost ratio (BCR) and payback period (PBP) methods are calculated in this paper. Again, the NPV for the life cycle cost of the solar project is also calculated in the Microsoft excel software.

Net Present Value (NPV) shows the difference between the present value benefit and present value cost, which can be shown as below:

$$\sum_{n=0}^{N} \frac{P_n}{(1+i)^n} - \sum_{n=0}^{N} \frac{Q_n}{(1+i)^n} = \text{PVB} - \text{PVC}$$ [Sowe et al., 2014].

Where, P_n= expected benefit at the end of the year n, Q_n= expected cost at the end of year n, i = discount rate, n= project duration in years, N= project period, PVB = present value benefit and PVC = present value cost. If the NPV is greater than zero, it means that the project will add value to the firm or investor and create wealth for shareholders [IAAPA, 2017].

The interest rate which can be earned on the unrecovered project balance of the investment, is known as the internal rate of return (IRR). If the IRR is greater than the discount rate, the PV project is considered as the acceptable and viable project. This can be determined as below, where i=IRR :

$$\sum_{n=0}^{N} \frac{P_n}{(1+i)^n} - \sum_{n=0}^{N} \frac{Q_n}{(1+i)^n} = 0$$ [Sowe et al., 2014].

From the ratio of the total present value benefit and the total present value cost, the benefit cost ratio is determined. The BCR value greater than one indicates the profitable PV project. The formula of BCR is given as below:

$$\text{BCR} = \frac{PVB}{PVC}$$ [Sowe et al., 2014].

Payback period (PBP) is significantly showed by the payback period of the project as given below [Sowe et al., 2014]:

$$\sum_{n=1}^{N} (P_n - Q_n)$$

Life-Cycle Costing (LCC) is the determination of all significant costs of ownership of an item, system, facility or product over a specified length of time. It can be determined by the major cost incurred over the life time of the product or project [Hoekstra R.L., 2017].

3. Results and Discussions

For the solar lighting system, the existing electric polls containing the lamps are calculated in the SUST campus area as shown in the Table 1.

Table 1. Existing street lighting components

Category	Numbers	Serving capacity
Energy bulb	32	23 watt
Tube-light	111	40 watt (average)
Flash light	8	50 watt
Total	151	

It is apparent from this table that most of the existing lamps are tube lights and their service capacity is 40 watt in average. The total number of electric polls are 126 which are grid connected. For the Sylhet region, the average tilt

angle throughout the year should be 25˚ [Solar Angle Calculator, 2017]. Off-grid system is described in this research work which is performed for the stand alone system. The basic component setup is shown in the Figure 1. The off grid solar street system has mainly five component. They are the solar panel, charge regulator, battery and the LED lamps.

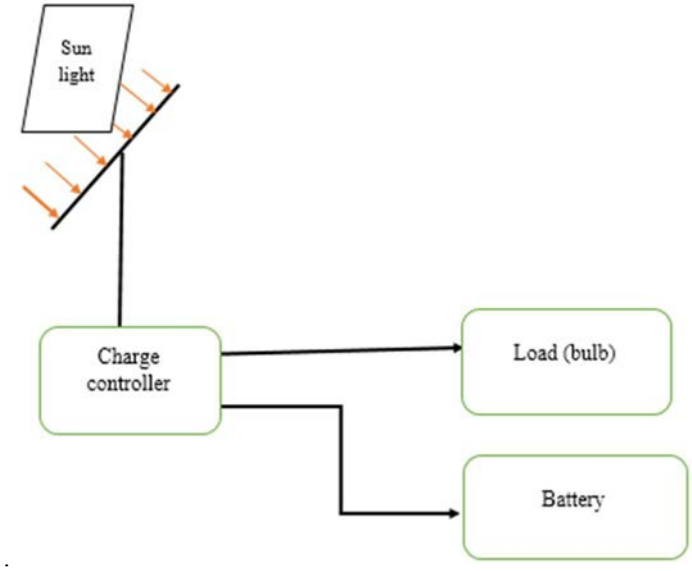

Figure 1. Component setup for solar system

3.1. Required energy

The energy consumption of one electric poll for SUST solar street lighting project is shown in Table 2.

Table 2. Daily energy consumption for SUST Solar street lighting project

Load	Quantity	Power (watt)	using hour per day	Total energy consumption per day
Bulb	2	20	11	440Wh

Required energy R_e is calculated by dividing the total average energy consumption per day by coefficient of system components

$$R_e = \frac{Daily\ avarage\ energy\ consumption}{overall\ component's\ efficiensies}$$

$$R_e = \frac{R}{\eta_{comp}} = \frac{440\ \text{Wh}}{.8} = 550Wh$$

It is essential to obtain the peak power (P_e) of the system. The peak power can be determined by the ratio of R_e and average sun hours in that location. The average sunshine hours in Sylhet region is about 6.6 hours/day [Visit 2W., 2017].

$$P_e = \frac{R_e}{average\ sun\ hours}$$

$$= \frac{550Wh}{6.6}$$

$$= 83.33 = 84\ Wp$$

The total current for the system needed can be found by ratio of P_e and the system DC voltage.

$$I_{dc} = \frac{P_e}{system\ DC\ voltage}$$

$$= \frac{84}{12} = 7 \text{ Amp}$$

3.2. Required battery size

Average total energy used for the street lighting is 550 Wh and 1 day is considered as the numbers of no sun day. By multiplication of the total power demand and the number of no sun days will be:

$$\text{Rough energy required} = 550 \times 1 = 550 \text{ Wh}$$

For the safety storage of energy in battery, depth of discharge should be considered. 80% depth of discharge is considered for the battery. It defines that 80 percent of the available energy will be delivered while 20 percent remains in reserve.

$$\text{Energy required} = \frac{Rough\ energy\ required}{Depth\ of\ discharge}$$

$$= \frac{550}{.8}$$

$$= 687.5 \text{ Wh}$$

$$\approx 688\ Wh$$

So, the capacity of the battery can be determined by the ratio of the energy required and the DC voltage of the battery. For this research work 12V battery is considered.

$$\text{Capacity of the battery} = \frac{energy\ required}{battery\ voltage}$$

$$= \frac{688}{12}$$

$$= 57.33 \text{ Amps h}$$

$$\approx 58\ Amps\ h$$

The overall system specification of SUST street light project has been selected from different company based on the required energy calculation as described in earlier. Table 3 shows the specifications of overall components including the purchasing cost.

Table 3. Selected components specification for the project [Alibaba, 2017]

Required feature	Capacity	Quantity	Model	Price (BDT)
Panels	150 W	1	GOPV150Wp 156P 36 SERIES (Polycrystalline Silicon, Efficiency 15.6%)	6478
Charge controller	10 A	1	Tracer1305LPLI	3944
Battery	72 AH	1	LI-ION KING	9467
Bulb	20 W	2	THL-20 12v dc led solar street	1704

3.3. Cost analysis

The cost of solar street lighting system includes components costs, operating and maintenance costs, installation and replacement costs. As the selected LED bulb has life hours about 50000 hrs. So, the light should be replaced after a certain period. Serving life time of LED bulb can be calculated by the ratio of total life hours of the lamp and the number of hours needed to active in night time.

$$\text{So, the LED lamp life time} = \frac{Working\ life\ time}{working\ hours\ per\ night}$$

$$= \frac{5\ 0000}{11}$$

$$= 4545.46 \text{ nights}$$

After the installation of the lamp, replacing time R_t will be

$$R_t = \frac{4545.46}{365}$$

$$= 12.45 \text{ years}$$

So, after the 12.5 years the LED lamp should be replaced. The installation cost is considered as 10% of solar panel or PV cost. The maintenance cost is assumed about 3% of PV cost. Cost for the SUST solar street lighting project has been illustrated in Table 4.

Table 4. Cost for the SUST solar street lighting project

Item	Required unit	Cost per unit BDT/unit	Cumulative cost (BDT)
Solar panel	1	6478	6478
Battery	1	9467	9467
Charge controller	1	3944	3944
LED lamp	2	852	1704
Installation cost		10% of PV cost	648
Operation and maintenance cost/ year		3% of PV cost	195
Total			22436

Total development cost for the SUST street light system = Solar panel cost + Battery cost + Charge controller cost + LED bulb cost + installation cost

= BDT (6478 + 9467 + 3944 + 1704 + 648)

= BDT 22241

Battery warranty is one year where the LED bulb has 12.5 years working life time. The charge controllers has three years warranty and the solar panel has twenty five years warranty. Considering the warranty and their price, it is assumed that about 25% of the cost of battery, panel and charge controller as replacement cost after each four years. So, the replacement cost is BDT 3000 after each eight years.

3.4. Financial analysis

Financial analysis is the process of determining the finance related activities for a certain purposes whether it is stable or not. The concerning areas are the income statement, balance sheet and the cash flow statement. RETscreen which is a renowned renewable energy technology software has been selected for the financial analysis. In this section financial analysis of the developed solar model has been analyzed. Several factors are considered for this analysis. According to Bangladesh bank the inflation rate is 5.45% [Bank B., 2017]. The fuel cost escalation rate is considered about 7%. While the electricity bill rate for the street lighting system for Bangladesh is 7.17 BDT/KWh [Board, B.P.D., 2017]. The discount rate or minimum interest rate is 5% in Bangladesh [Bank B., 2017]. In Microsoft excel the net present value of LCC is estimated BDT 52847. The NPV for the LCC of proposed solar street lighting system is much more than zero. It indicates, the project creates wealth for the shareholders.

After considering all types of costs, required energy and present energy prices, the RETscreen software provided the project costs or saving income summary. On the basis of the fuel cost, the annual life cycle savings per year is about BDT 1427. From the financial viability, the equity payback period is found 13.6 years. The IRR is found 7% which is more than the discount rate 5% as considered. For verifying the result in Microsoft excel the IRR and PBP are also calculated and found the same result. The benefit cost ratio is also found 2.6 which indicates the project viability. The factors of financial viability are shown in the Table 5.

Table 5**.** Financial viability of SUST solar street lighting project

	Financial viability	
Pre-tax IRR – equity		7%
Pre-tax IRR – assets		7%
After-tax IRR – equity		7%
After-tax IRR – assets		7%
Equity payback	Year	13.6
Annual life cycle savings	BDT/year	1427
Benefit-Cost (B-C) ratio		2.60
Net present value	BDT	35685

RETscreen software is also provided the yearly cash flow. When the income is higher than the expenses, the cash flow is positive. Again, when the income is lower than the expenses, the cash flow is negative. In the break-even point, the income and expenses is equal. The cumulative cash flow is shown in Figure 2. As shown in the Figure 2, the users can get benefit after 13.6 years in a project life span of 25 years.

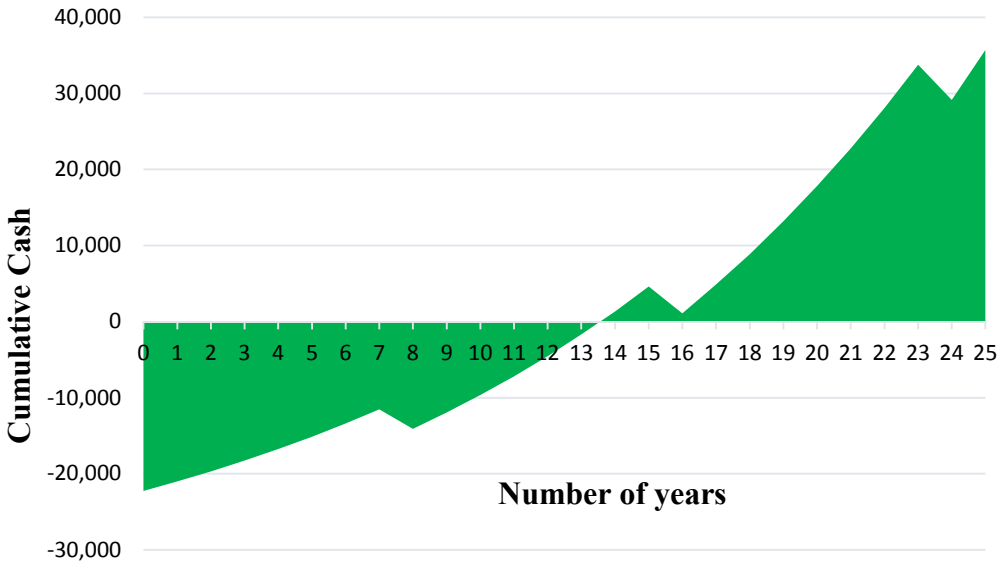

Figure 2. Cumulative cash flow graph for the project of SUST street lighting system.

3.5. Emission analysis

The emission analysis is calculated for the proposed PV system. The grid electricity mostly produced by the natural gas in Bangladesh. For this research work, natural gas is replaced by the dc solar electric system. For each MWh

electricity, 0.578 tone CO_2 is decreased. The proposed system, each solar street light system can reduce 100kg of CO_2 emission in a year.

4. Conclusion

There is a shortage of energy everywhere in the world. More and more energy sources is searched to fulfill the demand. In this point of view renewable energy like the solar energy can play a vital role. The solar radiation and long-term average sunshine of Bangladesh is sufficient enough to use it. In this paper, through some technical and financial analysis is made to prove it. From the analysis, it is found that the proposed project is found cost effective. But in case of large scale, it can be more cost effective. Moreover, the financial analysis, does not take the social and environmental factors for the investors. The project is also estimated to reduce the greenhouse gas emission in the air which is important for the environment.

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Determination of Different Body Dimensions from Stature in Bangladeshi Female

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Abstract

The purpose of this study was to investigate the correlation between different human body dimensions, and to determine different body dimensions from stature. This study involved 52 female volunteers in Bangladesh with age ranging between 19 and 25 years. Fourteen anthropometric measurements such as stature, standing elbow height, forward elbow reach, sitting height, sitting shoulder height, subscapular height, popliteal height, knee height, buttock-knee depth, buttock-calf length, buttock-popliteal length, thigh thickness, sitting elbow height and hip width have been measured to conduct this study. The result showed that there was a meaningful corelation between the stature and other body dimensions ($p < 0.05$) except sitting elbow height ($p = 0.20$). Pearson correlation (R) values of anthropometric data with stature were ranged from +0.18 to +0.86. Regression equations derived in this paper can be used to determine various body dimensions from stature for Bangladeshi female population. The result provided lower values of standard errors of estimation (SSE) ranged from ±1.253 to ±3.688. This study finally concluded that stature can be used to estimate different body dimensions of female except sitting elbow height.

Keywords
Anthropometry, Stature, Regression analysis, Body dimension estimation

1. Introduction

Anthropometry, comes from the Greek words *anthropos* (human) and *metron* (measure), means the measurement of the human body [1]. Determination of different human body dimensions from stature is an area of interest in the field of human factors engineering and forensic science [2]. Anthropometric techniques have been used for stature and bone length estimation from unknown body parts and skeletal remains by anthropologists, medical scientists, and anatomists for over a hundred years [3-4]. This has been important in recent times due to natural disasters like cyclones, tsunamis, earthquakes, floods and man-made disasters such as terror attacks, bomb blasts, mass accidents, wars, plane crashes, etc. In such cases, the forensic pathologists have often opined about the identity of the deceased.

A number of studies have been published on the estimation of stature from different body parts such as feet [5], hand [6-7], lower limb [8], upper limb [9], radials and ulnas [10] etc. Human height is the major predictor of the other body parts [11]. Since, human body measurements are biologically correlated to each other [11-17]; therefore, it is possible to estimate different body measurements from the stature.

However, not all anthrometric measurements are can be determined from stature [18]. A study on on twenty nine anthropometric parameters in Turkey population revealed that, among them only seventeen parameters can be estimated from human height. Therefore, further research is needed to investigate which body measurements can be determined from stature and which can't.

Anthropometic measurement varies among nations, even within a nation [19]. For this reason, the correlation coefficient between different anthropometric measurements and regression equations must vary by regions. The objective of this study was to investigate the biological correlation between anthropometric measurements, and to develop specific regression models to estimate different human body measurements from stature for Bangladeshi female people.

The rest of the paper is organized as follows. Section 2 represents materials and methods of this study. In section 3, we describe the result and the findings of this research. Section 4 provides conclusions, and section 5 ends with limitations and future work.

2. Materials and Methods

In this study, participants with on physical disabilities that included 52 female Bangladeshi were of age ranging from 19 to 25 years. Data were collected from three different Universities of Bangladesh: Rajshahi University of Engineering & Technology (RUET), Rajshahi University (RU), and Varendra University. Fourteen anthropometric measurements, including stature, standing elbow height, forward elbow reach, sitting height, sitting shoulder height, subscapular height, popliteal height, knee height, buttock-knee depth, buttock-calf length, buttock-popliteal length, thigh thickness, elbow height (sitting) and hip width was obtained from each participant. A steel ruler and a standard measuring tape were used to measure the body dimensions from the participants. Data were analyzed using Microsoft Excel 2013. To conduct this study the following anthropometric measurements were taken from each participant (Table 1).

Table 1. Anthropometric dimensions and their description

Anthropometric Dimensions	Description
Stature (S)	The vertical distance from floor to top of the head, when standing.
Standing elbow height (SEH)	The vertical distance from the floor to the lowest point of the right elbow, when standing.
Forward elbow reach (FER)	The distance from the back of the right elbow to the tip of the middle finger, with the elbow flexed at 90°.
Sitting height (SH)	The vertical distance from the sitting surface to the top of the head, when sitting.
Sitting shoulder height (SSH)	The vertical distance from the sitting surface to the tip (acromion) of the shoulder, when sitting.
Subscapular height (SUH)	The vertical distance from the lowest point (inferior angle) of the scapula to the subject's seated surface.
Popliteal height (PH)	Vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps femurs muscle inserts into the lower leg.
Knee height (KH)	The vertical distance from the sitting surface to the right knee cap, when sitting with knees flexed at 90°.
Buttock-knee depth (BKD)	The horizontal distance from the back of the buttocks to the back of right knee, when sitting with the knees flexed at 90°.
Buttock calf-length (BCL)	The horizontal distance from the back of the buttocks to the calf, when sitting with the knees flexed at 90°.

Buttock-popliteal length (BPL)	The horizontal distance from the back of the buttocks to the right knee just below the thigh, when sitting with the knees flexed at 90°.
Thigh thickness (TT)	Vertical distance from the seat surface to the top of the uncompressed soft tissue of the thigh as its thickest point, generally where it meets the abdomen.
Elbow height (sitting) (EHS)	The vertical distance from the sitting surface to the lowest point of the right elbow, when sitting.
Hip width (HW)	The maximal horizontal breath across the hips or thighs, whatever is greater, sitting position.

3. Results and Discussion

The summary of statistical analysis, including arithmetic mean, standard deviation (SD) and range of different body dimensions is shown in Table 2. The mean values of stature, standing elbow height, forward elbow reach, sitting height, sitting shoulder height, subscapular height, popliteal height, knee height, buttock-knee depth, buttock-calf length, buttock-popliteal length, thigh thickness, elbow height (sitting) and hip width were 157.5 cm, 97.7 cm, 41.3 cm, 80.4 cm, 52.5 cm, 43.4 cm, 42.4 cm, 48.4 cm, 54.4 cm, 42.9 cm, 44.7 cm, 12.3 cm, 20.2 cm and 35.5 cm respectively. Camparimg this result with male Bangladeshi population [2], the mean values of anthropometric parameters in case of female were lower than male.

Table 2. Summary of measured body dimensions (cm)

Anthropometric Parameters	Female	
	Mean ± SD	Range
Stature	157.5 ± 5.3	168.9 − 147.3
Standing elbow height	97.7 ± 5.1	108.0 − 86.4
Forward elbow reach	41.3 ± 1.5	44.2 − 38.1
Sitting height	80.4 ± 3.1	85.5 − 74.5
Sitting shoulder height	52.5 ± 3.9	61.0 − 44.2
Subscapular height	43.4 ± 3.3	50.8 − 36.8
Popliteal height	42.4 ± 2.0	46.5 − 39.1
Knee height	48.4 ± 3.5	58.4 − 40.6
Buttock-knee depth	54.4 ± 2.6	61.0 − 49.0
Buttock-calf length	42.9 ± 2.6	49.5 − 38.1
Buttock-popliteal length	44.7 ± 3.1	52.0 − 38.1
Thigh thickness	12.3 ± 1.9	17.8 − 9.7
Elbow height (sitting)	20.2 ± 3.4	28.4 − 12.7
Hip width	35.3 ± 2.4	40.3 − 30.5

Table 3 represents the correlation coefficient matrix between anthropometric parameters. The result revealed that, negative correlation existed between buttock knee depth with elbow height seating, and buttock knee depth with hip width, and other amthropometric parameters were positively correlated. This is also reasonable as if hip width increases, then calf thickness will increase and buttock knee depth may decrease.

Table 4 shows the linear regression equations for the determination of different human body measurements from stature. The present data showed that stature was statistically significant with all parameters except for sitting elbow height of women ($p > 0.5$). It means that the estimation of sitting elbow height for the female was not reliable with the help of stature dimension.

Table 4 also exhibits determination coefficient (R^2), standard error of estimation (SEE), and p-value. The value of the coefficient of determinations (R^2) varied from 0.031 to 0.746. The SSE values varied from ±1.253 to ±3.688. The values of SSE were very low which means higher accuracy in the estimation.

Table 3. Correlation coefficient matrix

Sl. No	Anthropometric parameters	S	SEH	FER	SH	SSH	SUH	PH	KH	BKD	BCL	BPL	TT	SEH	HW
1	S	1.00													
2	SEH	0.69	1.00												
3	FER	0.46	0.41	1.00											
4	SH	0.86	0.57	0.50	1.00										
5	SSH	0.49	0.41	0.19	0.57	1.00									
6	SUH	0.51	0.59	0.29	0.52	0.57	1.00								
7	PH	0.79	0.55	0.37	0.67	0.29	0.26	1.00							
8	KH	0.59	0.57	0.36	0.55	0.35	0.37	0.53	1.00						
9	BKD	0.28	0.08	0.10	0.25	0.07	0.09	0.30	0.29	1.00					
10	BCL	0.46	0.33	0.26	0.38	0.23	0.28	0.42	0.34	0.56	1.00				
11	BPL	0.47	0.38	0.11	0.49	0.17	0.25	0.47	0.32	0.41	0.38	1.00			
12	TT	0.29	0.16	0.06	0.35	0.04	0.12	0.18	0.26	0.11	0.25	0.28	1.00		
13	EHS	0.18	0.38	0.30	0.27	0.22	0.49	0.13	0.20	-0.18	0.02	0.17	0.14	1.00	
14	HW	0.35	0.40	0.03	0.31	0.18	0.37	0.21	0.36	-0.01	0.07	0.28	0.62	0.22	1.00

Table 4. Linear regression equations for the estimation of different body measurements (in cm) from stature

Equations	R^2	SEE	*p*-value
SEH = - 6.9 + 0.664 (S)	0.480	3.688	0.000*
FER = 21.254 + 0.127 (S)	0.208	1.325	0.001*
SH = 0.586 + 0.507 (S)	0.746	1.578	0.000*
SSH = - 4.898 + 0.364 (S)	0.244	3.426	0.000*
SUH = - 7.584 + 0.324 (S)	0.263	2.891	0.000*
PH = - 4.714 + 0.3 (S)	0.619	1.253	0.000*
KH = - 13.823 + 0.395 (S)	0.347	2.895	0.000*
BKD = 32.097 + 0.142 (S)	0.080	2.558	0.042**
BCL = 7.187 + 0.227 (S)	0.216	2.305	0.001*
BPL = 0.707 + 0.279 (S)	0.223	2.779	0.000*
TT = - 3.573 + 0.101 (S)	0.081	1.802	0.040**
EHS = 2.072 + 0.115 (S)	0.031	3.430	0.212***
HW = 10.417 + 0.158 (S)	0.123	2.245	0.011**

*Significant ($p \leq 0.001$)
**Significant ($p < 0.05$)
***Not significant ($p > 0.05$)

The present study notified that, linear regression equations determined the statistically significant correlation between body dimensions and stature except women's sitting elbow height. This result is somewhat contradictory with the result obtained from the Bangladeshi male population. In a study on same parameters on Banglsdeshi male adults [2], it was seen that estimation of all anthropometric parameters from stature were statistically significant. Therefore, more research is needed to generalize and to validate the findings. However, the present research is very helpful from the forensic, anthropometric and human factors point of view in Bangladesh.

4. Conclusion

The present study finally concludes that, stature is a very useful tool to estimate different body dimensions of women except sitting elbow height. The linear regression formula derived in this study can be used not only for forensic researchers, but also for the anatomist, product designers, anthropologists, and industrial engineers.

5. Limitations and Future Work

1. For further validation of the present findings large sample size should be investigated.
2. The present study was carried out with participants aged range 19 to 25 years. Therefore, this result may not be useful for all adult people as human height is decreased after a certain period in both sexes with the increase of age [20].
3. Consequently, further research is needed to determine relevant regression equations for all age's Bangladeshi people.
4. In the future, similar studies must be conducted to compare it with other populations.

Acknowledgement
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Sustainable manufacturing : road forward to green

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Abstract

Sustainable manufacturing is the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources. Sustainable manufacturing also enhances employee, community, and product safety . Sustainable manufacturing focuses on both how the product is made as well as the product's attributes. This includes the inputs, the manufacturing processes, and the product's design. Our paper mainly focuses on 4 sectors .Such as apparel ,agriculture ,fuel, leather and their impact on environment . The main environmental focus with regards to manufacturing was pollution abatement—preventing the pollution that has been created from getting into the environment.

Keywords
Sustainable manufacturing
Environmental impact
Manufactured product quality
Pollution abatement

Indroduction

Sustainability is the driver for innovation .Sustainable manufacturing is about finding innovative ways to minimize the impact of industrial operations on the environment through using state-of-the-art technology. To meet the increasing demand, domestic and foreign enterprises have been actively investing in building a lot of factories and production workshops to supply for businesses in the factories .This poster is focusing on the four main manufacturing sectors of Bangladesh including leather ,apparel ,agricultural, fuel sector and their impacts in environment. The poster will also focus on why sustainable manufacturing is important in those sectors ,as the amount of waste from the industry is increasing and badly affecting the environment and if not handled in a timely and reasonable manner it will harm human existence. Ultimately, sustainability isn't just about being greener for the environment's sake alone. Great sustainability initiatives not only benefit the environment, but the people who work and do business with the company engaging in the "green" practice as well. The poster highlights on not only the development needed for these synthesis and changes in design that will pose new challenges to the manufacturing related industries, but it also describes recent and probable future developments i that should assist in different sectors.

Methodology:

7 action steps to sustainable manufacturing:

1. Map the impacts and set priorities
2. Choose indicators and understand data needs
3. Measure inputs used in production
4. Assess the operations of your facility
5. Measure inputs used in production
6. Measure inputs used in production
7. Take action to improve your performance

Leather sector:

- Traceability issue of leather
- Sustainable chemical material management

1. ETP(Effluent Treatment Plants)

- Clean and green leather making process

1.Vagitable tanning
2.Using FeCl3 in waste managemant

- Economic sustainability of the leather business
  1.using alternatives of leather like faux leather,microfiber,textiles,vinyl or PVC.

Apparel sector:

- By recycling the waste fabrics
- Reclying food waste into yarn
- Using polyester eating microbes
- Using "Airdye" to minimize water loss
- Recycled PET,nylon from carpets
- Using digital printing process

- Using organic and Natural Fibers
- Using natural and Low Impact Dyes and Chemicals

Agricultural sector:

- Use of renewable energy sources
- Polycultures and Crop rotation
- By avoiding soil erosion
- Crop diversity
- Better water management
- Bio intensive integrated pest management
- Natural pest management

Fuel sector:

- Electricity as the alternatives of fuel in transportation system
- Usage of biodiesel
- Hydrogen and steam as the alternative of fossil fuel in combustion engine
- Using brake energy regeneration system
- Converting heat into electricity
- Liquid nitrogen as an alternative of fossil fuel

Feasibility and impact analysis:

- Reducing hazardous impact on the environment.
- Designers are creating products that are sustainable for environment.

- Tax incentives can be leveraged to invest into new technologies and increase a company's size.

- Cloud-based technologies reduce energy costs.
- Using recycled products for raw materials.

- Creating supply chains with bi-directional flow.
- Reducing waste in transporting goods.
- Preventing ecological imbalance and the spreading of different kinds of fatal and contagious disease among the tannery workers and other individuals.
- Measuring performance of apparel products will spotlight priorities for action and opportunities for technological innovation
- Increasing the transparency of a product and offering more information about a product's development, the more this product will represent eco-friendliness and will be superior in terms of sustainability.

- Evaluating the Potential of Value-Added Agriculture Ideas
- Identifying Alternatives, Decision Making, Financial Feasibility
- Using alternative Sources of Power

Results:

Over the last century, most developed and developing countries prospered by basing their economies on a linear design. Sadly, this approach leads to wastage of natural resources and it is not sustainable given the growing global population. Luckily, recycling can remedy this situation.This poster is all about enhancing productivity through diversification,intensification, sustainable management of natural resources, use of quality inputs and mechanization.

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UTILIZATION OF HIGHWAY IMPACT WIND ENERGY PRODUCED BY PASSING VEHICLES AND TECHNO-ECONOMIC ANALYSIS”

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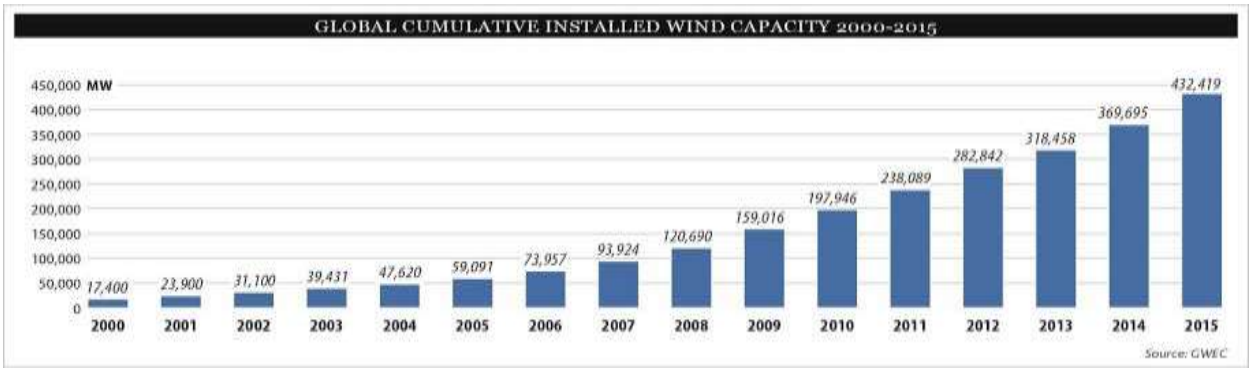
Abstract
In this period of global energy crisis and the striving for zero carbon emission, efforts are being made to search for efficient alternative sources of renewable energy. In order to contribute to this search, the objective of this project is to design an optimized wind turbine to utilize the unused highway wind energy produced by the moving vehicles. Wind energy is considered one of the fastest growing renewable energy sources. Highways can provide a considerable amount of wind energy to drive a turbine as a result of the velocity of the vehicle, size of the vehicle and intensity of the traffic. Extensive research on the fluid flow dynamics is required to determine the wind distribution pattern and average velocity created by the passing vehicles. This wind energy can be utilized for the generation of electrical energy with the use of vertical axis wind turbines. A decision is made to use a vertical axis wind turbine due to its capability of capturing wind in all directions as compared to a horizontal axis wind turbine which needs to be pointed towards the direction of the oncoming wind. For this reason the wind turbine can be placed on the median of the road so that wind generated from both sides of the road can be captured. In order to achieve these optimization performances an extensive study of the blade profile is conducted using different simulation software in order to arrive at a conclusion on the profile for a better aerodynamic efficiency. Other design consideration such as mechanical efficiency, electrical efficiency, and environmental hazards are also taken into consideration.

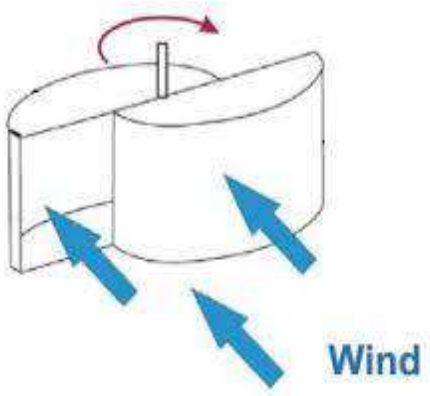
Keywords: Vertical axis wind turbine (VAWT), Horizontal axis wind turbine (HAWT), Power coefficient (Cp), Angle of attack (AoA), Efficiency.

Introduction
The world’s energy crisis and the need for zero carbon emission call for efficient alternative sources of renewable energy. Wind energy is considered one of the fastest growing renewable energy sources. Highways can provide a considerable amount of wind energy which could be utilized to reduce the cost of energy. This depends on the *speed* of the vehicle, *size* of the vehicle and *intensity* of the traffic. The main objective of this project is to contribute to this energy search.
The world is facing a great energy challenge. With increasing population and increasing wealth, the demand for energy is increasing fast. The diminishing supplies of fossil fuels and the threat of global warming call for sustainable solutions. These solutions are found in a new sustainable energy mix consisting of hydro, solar and wind power. Wind energy, especially in Europe, South-east Asia and North America, is a fast growing industry and will play a significant role in the solution of the energy challenge the world is facing. (Kemp) With increasing interest in wind power harvest, minds are now being diverted to offshore wind energy potential especially with the revitalization of research interest in the Vertical Axis Wind Turbine (VAWT) which has a promising feature for offshore platforms.



Wind energy industry

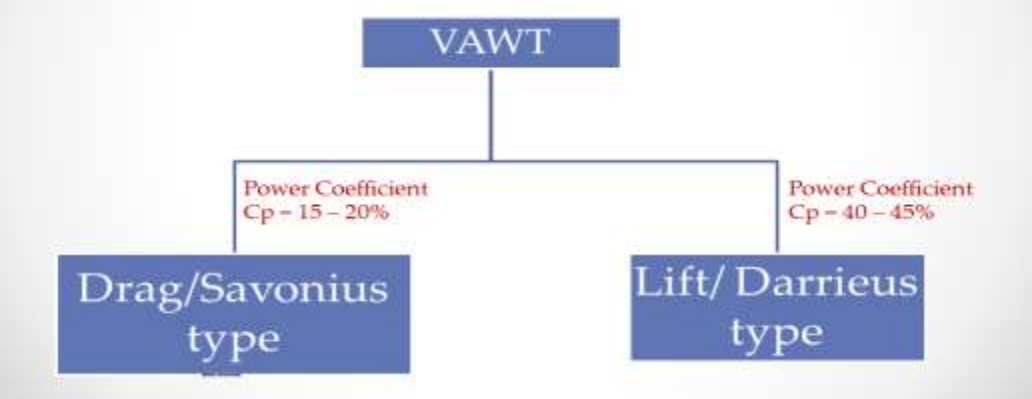
In the field of wind energy, the most well-known and widely used turbines are the horizontal axis wind turbines (HAWT). This turbine is being used onshore as well as offshore and is available in all sorts of sizes ranging from 1 kW up to 10 MW, with plans of even larger scales. VAWT are not well-known and not widely used yet, only small turbines in the order of 10 kW are commercially available, and bigger turbines are still in development. But, this has not always been the case and might not be the case anymore for very long. (Kemp) Practically, wind turbines can be classified in two ways, according to the Driving force and according to axis of rotation. Classification according to driving force can be in two forms, Drag driven type and Lift driven type. Most of the modern and commercial wind turbines are based on the lift driven type, mainly due to their higher aerodynamic efficiencies.



Drag driven VAWT

Lift driven VAWT

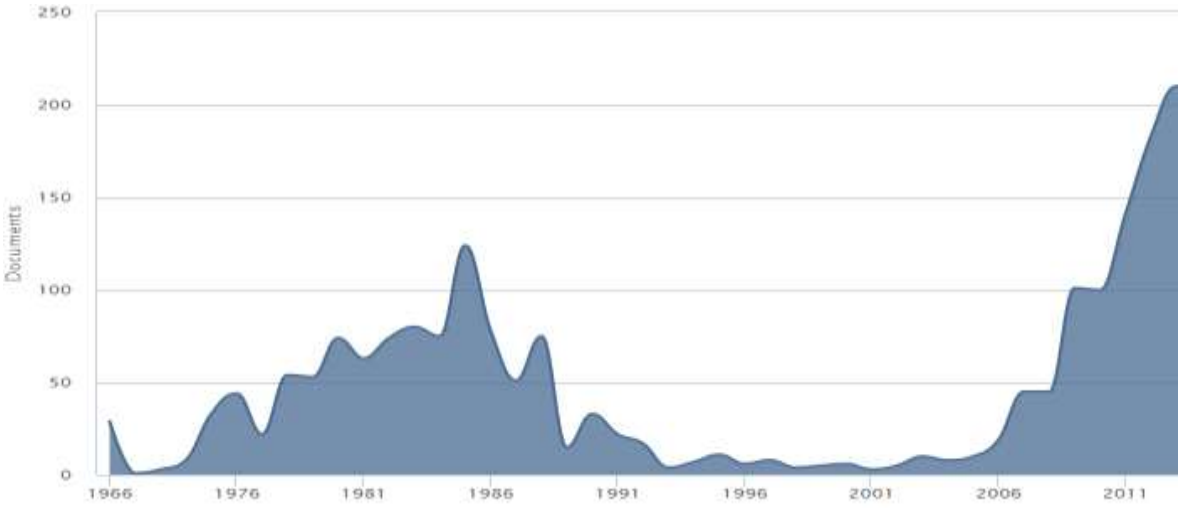
Wind energy is considered one of the fastest growing renewable energy sources. Highways can provide a considerable amount of wind energy which goes wasted if not properly harnessed. The magnitude of this impact wind energy depends on the ***speed*** of the vehicle, ***size*** of the vehicle and ***intensity*** of the traffic.
This project made use of the VAWT because of its suitability for the application and therefore this review focused on the Vertical Axis Wind Turbine VAWT. And more specifically the high performing type or lift driven type also known as the *Darrieus Type* VAWT.
We attempted to study the Darrieus type of VAWT because of the higher power coefficient as compared to the Savonius or Drag type.



Cp range for drag and lift VAWT

Researches on VAWT since in the 1970's are given below in chronological order. However the most relevant papers to this work are discussed. The format of this literature review is adopted from the work of a Master thesis dated march 13, 2015, by Rody Kemp of Delf University of Technology, in his thesis titled, "Airfoil optimization for Vertical Axis Wind Turbines". His detailed literature review was used as reference to search the internet for the different research works through the time. The format adopted here is to divide the researches based on earlier works and the current works. Notably that much research has been conducted in the early 70's to 80's before fading out and again taking momentum in around 2005 to date as discussed below.

Earlier, much research has been done on VAWT in the 1970's and 1980's
Recent research which has been done on VAWT begun around 2005 (Kemp)



Research on VAWT since 70's (Kemp)

No	Air foil	Author	Institution	Year	Subject
1	WSU 0015	T. Fukuda	WSU	1977	Relationship between airfoil thickness and Cp. (document not available cited by others)
2	NACA 0012 WSU 0021	Melvin H. Snyner & Naoki Furukawa	WSU	1979	NACA 00xx & NASA 0012H
3	NACA 00xx Series	Emil G. Kadlec	SNL	1978	First SNL report on VAWT for both aerodynamic and structural performances
4		Dale E. Berg	SNL	1985	Structural Design of Sandia 34-Meter VAWT
5	NACA0009 NACA 0012 NACA 0015 NACA 0018		Queen's University of Balfast		Effect of airfoil thickness and camber on power output
6	T.W.T 11215-1		Tokai University	1973	Improvement of NACA 0012 to TWT 11215-1

Summary of earlier literature review

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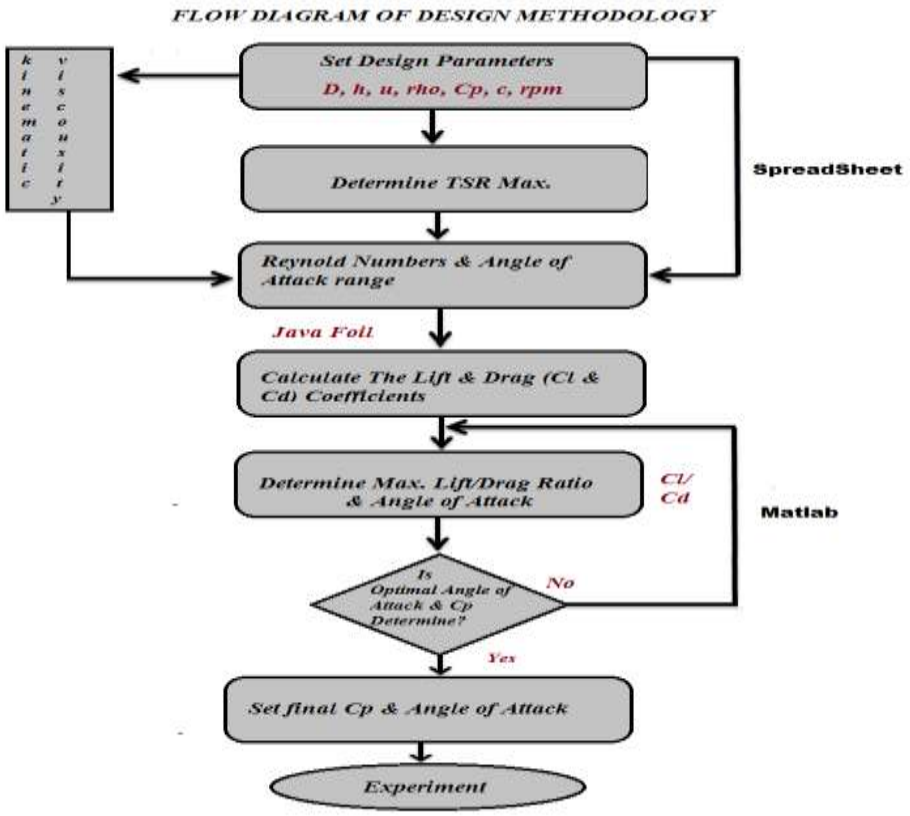
No	Air foil	Author	Institution	Year	Subject
1	NACA 4 series NACA 6 series NFL airfoils SNLA 0018 S824 airfoil	Claessens	Delf University	2006	Optimation of airfoil for use in small scale VAWT intended for use in urban areas
2	AIR family DU12W262	SIMÃO FERREIRA ET AL.	Delf University	2014	Generalized objective function for optimization of VAWT airfoils
3	MI-VAWT1		Winsor University	2007	Design of an improved version of the NASA LS-0417
4		Rody Kemp	Delf university	2015	AIRFOIL OPTIMIZATION FOR VERTICAL AXIS WIND TURBINES

Summary of recent literature review

This review shows an excerpt of a summary of the research and design efforts into the airfoils for VAWT. In the early periods the main method on which airfoil design was based is analytically derive principles which served as a basis for the design. In the present period mostly existing airfoils were used and then tailor-made to get the desired performance. A clear shift is shown in design methods with the arrival of more and more computational power.

Methodology

In this methodology a combination of techniques were used. The design calculations were done using excel spread sheet to determine the Tip Speed Ratio TSR, range of Reynolds Numbers and Angle of attacks. These results are then fed into the Java applet (JavaFoil) software to obtain the Coefficients of Lift and Drag Forces which are further used as bases for calculation in the model using Matlab Software.



Design Flow Diagram

Design calculations

The design calculations were done using Microsoft Excel Spread Sheet to obtain the TSR and which was also used calculate the range of angle of attacks and Reynolds. The design calculation was segmented into three parts.

Power calculation

The cells of the spread sheet were embedded with power density formula, Tip speed Ratio and Reynolds and Angle of attack range. The results are shown in the tables below.

Inputs parameters

Rotor Diameter	1.5	m	59.06	in
Blade Length	1.25	m	49.21	in
Wind Velocity	10	m/s	22.4	mph
Cp	0.59			
Air Density (p)	1.22	kg/m^3	59.0	%

**Chosen for various reasons *Typical rating wind speed *Estimated Coefficient of performance (Max 59.3%), 0.59 is a guess.*

Outputs Parameters

Turbine area:	1.88	m^2
Power available in wind:	1143.8	Watt
Power produced by turbine:	674.8	Watt

**Power from turbine, not power delivered to load.*

Tip Speed Ratio Calculation

The TSR was calculated based on acceptable acceleration relative to the gravity of the turbine during rotation. This helps in determining the maximum rotational speed for safer operations.

Input parameters

Rotor Diameter	1.5	m	59.06	in
Limits (RPM at given air velocity)				
Wind Velocity	16	m/s	35.8	mph
Rotation Limit	500	rpm	52.35	rad/s

*Max wind before cutoff *Max desirable RPM

Output Parameters

TSR	2.45	
Acceleration	2056.70	m/s^2
G's	210	G's kg-m/ s^2

*Max desirable TSR

	G's	Acceleration	Speed	Speed	TSR
	kg-m/ s^2	m/s^2	rad/s	RPM	
100%	210	2057	52.35	500	2.45
90%	189	1851	47.12	450	2.21
80%	168	1645	41.88	400	1.96
70%	147	1440	36.65	350	1.72
60%	126	1234	31.41	300	1.47
50%	105	1028	26.18	250	1.23

Aerodynamic Force Coefficients (Lift and Drag)

α [°]	**Cl** [-]	**Cd** [-]		**Cl / Cd** [-]
12.5	1.4	0.03756		37.27
9.5	1.14	0.02513		45.36
6.5	0.824	0.01767	Optimal character	46.63
3.5	0.447	0.01566		28.54
0.5	0.064	0.016		4.00
-2.5	-0.317	0.01659		-19.11
-5.5	-0.693	0.01848		-37.50
-8.5	-1.036	0.02278		-45.48
-11.5	-1.324	0.03201		-41.36

Range of Angle of Attack & Reynolds

Inputs parameter

Diameter	1.5	M	59.06	In
Chord	0.2	M	7.87	in
No. of Blades	3			
TSR	2.5			
Interference factor	0.6			
Wind Velocity Max	16.00			
Wind Velocity Min	3.00			
Kinematic Viscosity	1.617E-05	m^2/s		

*Selected based on acceptable acceleration 100% *Upwind interference factor (Betz flow a = 0.67) *Cut out speed for maximum Re *Cut in speed for minimum Re *Kinematic viscosity of air at 32.33°C

Outputs Parameter

Solidity	0.80	80	%
Induction down	60.00		

*Downwind induction factor approx. 10% less

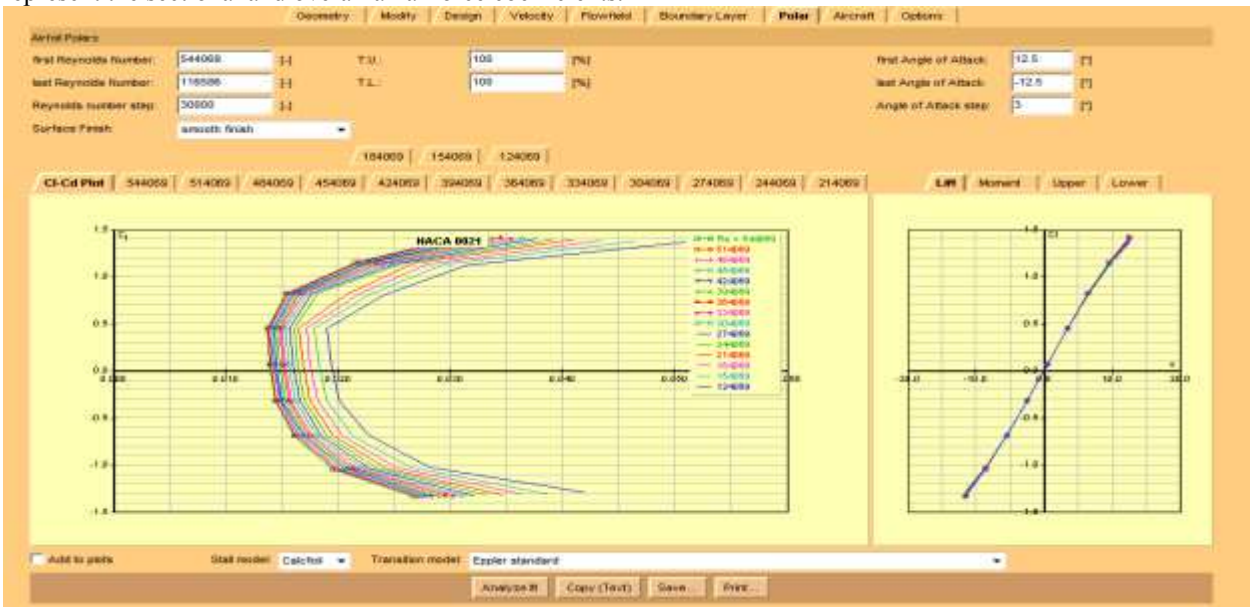
Initial estimates for initial airfoil select ion& analysis

Max upwind angle of attack	12.5	deg	Max Re:	485776
Max downwind angle of attack	-12.5	deg	Min Re:	91083
			Avg Re:	288430

The result obtained from the above calculations was then used for performance analysis of the airfoil.

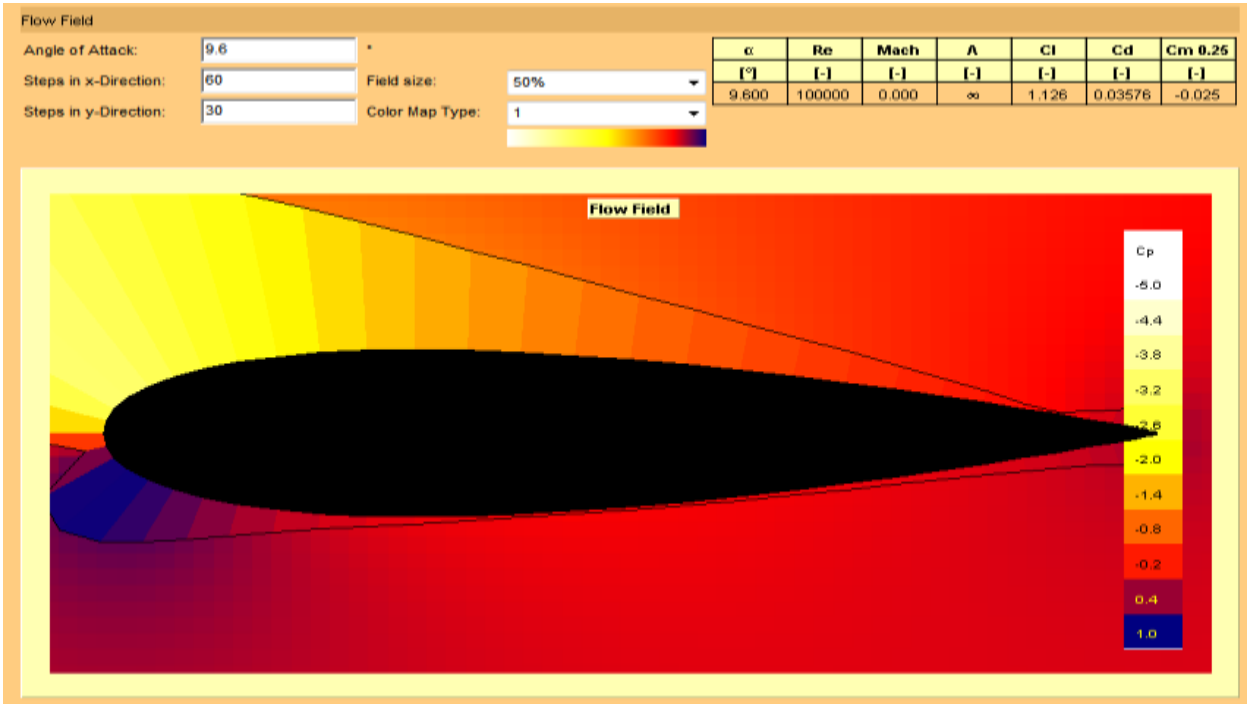
Performance analysis

Each blade generates lift and drag (Cl and Cd) relative to the incoming flow. For the purpose of performance analysis it is convenient to transform Cl and Cd into cylindrical form with Cn and Ct as the sectional force coefficients normal and tangential to the direction of rotation or CN and CT for the entire blade. Ca and CA represent the sectional and overall axial force coefficients.



JavaFoil Polar Card

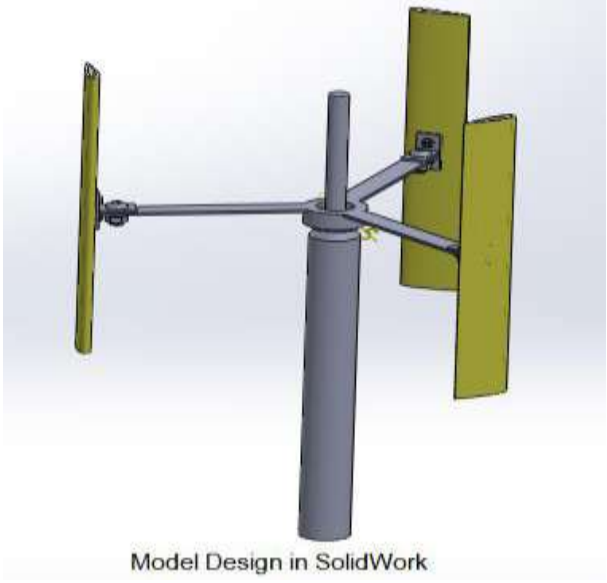
The flow field card enables flow analysis at a specific angle of attack and a color map show a visual indication of pressure gradient along the surface of the airfoil.



JavaFoil Flow Field Card

Prototype design

Based on the design parameters and calculations, a prototype was designed using Solid Works software and the blades were printed using Poly Lactic Acid Plastic in a 3D printer. The pole structure and the bearing housing with the couplings were fabricated and assembled in the workshop.



Model Design in Solid Works

Fabricated Model Assembly

Blade model design

Model Blade in Solid Works

3D Printed Blade

Techno-economic analysis

The demand for energy is increasing and the reserve of our heavily dependent fossil fuel is running out. As a result the cost of energy is expected to project up. Alternatives of sustainable sources of energy are the only option. The wind energy industry seeks to solve this problem. As envisaged in the global energy pathways to achieve this solution, chunks of installed capacities around the world from individual to national and private Commercials is the option. The contribution of this project to the Cost of Energy is summarized in this part.

Load factor

It is defined as the ratio of the average load to the peak load during a certain prescribed period of time. The load factor of a power plant should be high so that the total capacity of the plant is utilized for the maximum period that will result in lower cost of the electricity being generated. It is always less than unity. High load factor is a desirable quality. Higher load factor means greater average load, resulting in greater number of power units generated for a given maximum demand. Thus, the fixed cost, which is proportional to the maximum demand, can be distributed over a greater number of units (kWh) supplied. This will lower the overall cost of the supply of electric energy. [P.K Nag]

Assumptions

- A 0.95 load factor is assumed, since a peak load equal to capacity of the machine is chosen, bearing in mind that the generated electricity in fed to the grid (higher load).
- A 5% less of the load factor was assumed for times when there is no load on the grid (during maintenances)
- An operating period of a year 8760 hours was used in the calculation.
- Other factors such as taxes and insurances were neglected.
- The labor cost was based on 3 persons at a rate of 50BDT per hour.
- A work hour of 36hours of manufacturing and 5hours of installation was used.
- For components which are not available in the local market, shipping cost is neglected.

Fixed cost of the plant

NAME	DESCRIPTION	VALUE in BDT
Manufacturing cost	**Labor cost** **Material Cost (Full Scale)** **Overheads (10% of L&M)**	**5440** **13890** **1556**
Installation Cost	**Labor Cost** **Transportation Cost**	**750** **500**
Miscellaneous Cost		**2000**
TOTAL		**24,136 BDT**

Fixed Cost

Cost of energy produced

DESCRIPTION	Model Design	Full Scale Design Potential
Load Factor	**0.95**	**0.95**
Average Load	**9.5w**	**950kw**
Peak Load	**10w**	**1kw**
Annual Power Generation	**83.22kwh**	**8.322 X10$_3$ KWh**
Cost of power in BD (Tk) Dhaka Region	**7.03Tk**	**7.03Tk**
Annual Cost Of Energy Production	**585Tk**	**58,503Tk**

Conclusion

Highway wind energy has a lot potential in it and if properly harnessed then it can help in resolving the problem of energy crisis in the world. The design of an optimized wind turbine and the study of the distribution pattern & average velocity of Impact wind energy, the harnessing of highway wind energy can reduce the cost of energy (COE) globally.

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Free Convection Flow of Nanofluid through anExponentially Accelerated Vertical Platewith Variable Viscosity in the Presence of Radiation and Chemical Reaction

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Abstract

Free convection flow of nanofluid through an exponentially accelerated porous plate with variable viscosity in the presence of radiation and chemical reaction has been discussed in this paper. Here we have considered variable viscosity in the effects of radiation and chemical reaction in both the cases. The governing equations are transformed into non-dimensional form by the as usual mathematical technique of transformation. Then the obtainednon-dimensional nonlinear partial differential equations are solved by using explicit finite difference technique. Also, the numerical results has been calculated by computer programming languageCOMPAQ VISUAL FORTRAN 6.6a. Then the numerical solutions for velocity, temperature and concentration profiles are obtained graphically for various dimensionless parameters and discussed after stability test by using graphics software tecplot-9. The skin friction coefficient, Nusselt number and Sherwood number are also investigated by tabular form.

Keywords: Nanofluid, free convection, MHD, porous medium.

Introduction

The concept of nanofluids was introduced by Choi in 1995. Nanofluids are the suspension of nanaparticles in a base fluid such as, oil, water and ethylene glycol etc. whose size are 1 to 100 nm. Nanofluids are engineered colloidal suspensions of nanoparticles in a base fluid. Also, nanoparticle which are commonly used in nanofluids are made from numerous materials such as oxide ceramics, carbide ceramics, metals, semiconductors, carbon nanotubes and composite materials such as ethylene glycol (*EG*), engine oil (*EO*) and pump oil. There are many applications of Nano fluids are in cancer therapeutics, smart fluid, biological science, biomedical, industrial cooling, car engine, solar industry, nuclear reactors, electronic industry etc. Application of nanoparticle coatings to carrier particles using an integrated fluidized bed supercritical fluid precipitation process introduced by Leekea *et al.* (2016). Fundamentals of Nanofluids have scrutinized by Uddin *et al.*(2016). They have discussed the basic concept of nanofluids and showed many applications of nanofluids in different fields. Effect logs of double diffusion on MHD Prandtl nanofluid adjacent to 4 stretching surface by way of numerical approach has been studied by Bilal *et al*. (2015). Also, Oyelakin *et al*. (2016) have discussed the unsteady Casson nanofluid flow over a stretching sheet with thermal radiation, convective and slip boundary conditions.

The study of a continuous, electrically conducting fluid under the influence of electromagnetic fields is consisted by the field of magnetohydrodynamics. The study of incompressible fluid is included the MHD but nowadays the terminology is applied to studies of partially ionized gases as well as the other names have been recommended, such as magneto-fluid-mechanics or magneto-aero-dynamics, but unique nomenclature has

persisted. For the quandary to be analyzed the essential requirement is that the continuum approach be applicable. MHD analysis deals with many ordinary phenomena and engineering problems. The cosmos is filled with extensively spaced charged particles and permeated by magnetic fields so MHD is useful in astrophysics. Thus the gamut postulation becomes applicable. In the interactions of conducting fluids and magnetic fields, geophysicists run into MHD phenomena that are present inand around blissful bodies. MHD principles are employed by engineers in the design of heat exchangers, pumps and flow meters, in space vehicle propulsion, control and re-entry problem, in designing communications and radar system, in creating novel power generating systems and in developing confinement schemes for controlled fusion. Electrical power produced by the flow of an electrically conducting fluid through a slanting magnetic field which is the important application of MHD. Experiments with ionized gases recently have been performed on a huge level in immobile plants with expect of producing power with large magnetic fields. Das *et al.*(2016) performed Hall effects on an unsteady magneto-convection and radiative heat transfer past a porous plate. MHD free convection and mass transfer flow through a vertical oscillatory porous plate with Hall, ion-slip currents and heat source in a rotating system have reported by Hossain *et al.*(2016). Effects of radiation and chemical reaction on MHD unsteady heat and mass transfer of Casson fluid flow past a vertical plate have discussed by Biswas *et al.*(2017). Hall effects on unsteady MHD free convective flow past an accelerated moving vertical plate with viscous and joule dissipations has been capitalized by Sarkar *et al.*(2015).

Mass transfer problems are of importance in many processes and have therefore received a considerable amount of attention. Mass can be transferred by diffusion of one component of a fluid mixture from a region of high concentration to one of low concentration. This is analogous to the transfer of heat from a high-temperature region to a low temperature region. In many mass transfer processes, heat transfer considerations arise owing to chemical reaction and are often due to the nature of the process. In processes such as drying, evaporation at the surface water body, energy transfer in a wet cooling tower and the flow in a desert cooler, heat and mass transfer occur simultaneously. In many of these processes, the interest lies in the determination of the total energy transfer, although in processes such as drying, the interest lies mainly in the overall mass transfer for moisture removal. Natural convection processes involving the combined mechanism are also encountered in many natural processes, such as evaporation, condensation and agricultural drying, in many industrial applications involving solutions and mixtures in the absence of an externally induced flow and in many chemical processing systems. In many processes such as the curing of plastics, cleaning and chemical processing of materials relevant to the manufacture of printed circuitry, manufacture of pulp-insulated cables etc., the combined buoyancy mechanism arise and the total energy and material transfer resulting from the combined mechanisms, has to be determined. Ali *et al.*(2017) presented Cattaneo-Christov model for radiative heat transfer of magnetohydrodynamic Casson-ferrofluid. Optimal solution of nonlinear heat and mass transfer in a two-layer flow with nano-Eyring–Powell fluid has been elaborated by Khan *et al.*(2015). Raju *et al.*(2015) have scrutinized the heat transfer effects on a viscous dissipative fluid flow past a vertical plate in the presence of induced magnetic field and The effect of induced magnetic field and convective boundary condition on MHD stagnation point flow and heat transfer of upper-convected Maxwell fluid in the presence of nanoparticle past a stretching sheet has been focaused by Ibrahim *et al.*(2016).

Apurpose has been carried out by the above studies that free convection flow of nanofluid through an exponentially accelerated porous plate with variable viscosity in the presence of radiation and chemical reaction. We have used a usual transformation to transform into non-dimensional form in our experiment and solve our problem numerically by using explicit finite different method. Our results are computed for various physical parameters such as magnetic parameter, Schmidt number, Grashof number, Prandtl number, chemical reaction, thermophoresis parameter, Brownian motion parameter, radiation parameter etc. and the obtained results are plotted after stability test.

Mathematical Analysis of the Problem

An unsteady free convection flow of nanofluid through an exponentially accelerated porous plate in the presence of radiation and chemical reaction has been carried out. In this paper, *x*-axis is taken along the plate in the vertically upward direction and *y*-axis is chosen normal to the plate which are shown in **Figure 1**.A uniform magnetic field of strength $B_0$is applied transversely to the y-direction which is occupied to be electrically non-conducting. This assumption is justified when the Reynolds number is taken very small so that induced magnetic field strength is neglected and is of the form $B=(0, B_0, 0)$ where magnetic lines of force are fixed relative to the fluid. Also, it is considered that the temperature of the plate is $T_w$and concentration at the plate is $C_w$but at time $t>0$, the plate is accelerated exponentially with a velocity $u=U_0exp(b't)$ in its own plane and the temperature and concentrationlevel of the plate are raised exponentially to $T_\infty$and C_∞ with time *t*.

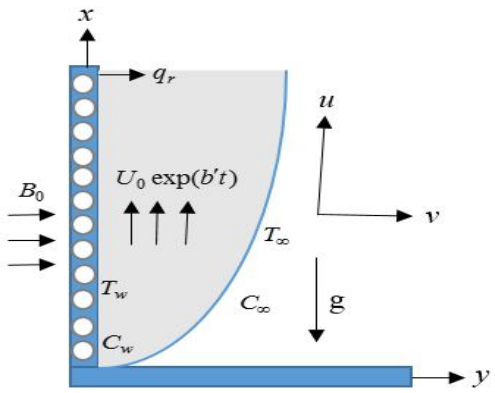

Figure 1. Physical model and coordinate system

Under these assumptions the dimensional continuity, momentum, energy and concentration equations of the present problemare given by

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\frac{1}{\rho}\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right)+g\beta_T\left(T-T_\infty\right)+g\beta_C\left(C-C_\infty\right)-\frac{\upsilon}{k^*}u-\frac{\sigma B_0^2 u}{\rho} \tag{2}$$

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2}-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial y}+\tau'\left\{D_B\left(\frac{\partial C}{\partial y}\frac{\partial T}{\partial y}\right)+\frac{D_T}{T_\infty}\left(\frac{\partial T}{\partial y}\right)^2\right\}+\frac{Q}{\rho C_p}\left(T-T_\infty\right)$$

$$+\frac{D_m k_T}{C_S C_P}\frac{\partial^2 C}{\partial y^2} \tag{3}$$

$$\frac{\partial C}{\partial t}+u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D_B\frac{\partial^2 C}{\partial y^2}+\frac{D_T}{T_\infty}\frac{\partial^2 T}{\partial y^2}-K_1(C-C_\infty) \tag{4}$$

The associate initial and boundary conditions according to the present problem are,

$$\left.\begin{array}{ll} t\le 0,\ u=0, v=0, T=T_w, C=C_w & \text{for all } y \\ t>0,\ u=U_0 e^{(b't)}, v=0, T=T_\infty+\left(T_w-T_\infty\right)e^{\left(\frac{U_0^2}{\upsilon}t\right)}, C=C_\infty+\left(C_w-C_\infty\right)e^{\left(\frac{U_0^2}{\upsilon}t\right)} & \text{at } y=0 \\ \quad u=0, v=0,\ T\to T_\infty, C\to C_\infty & \text{as } y\to\infty \end{array}\right\} \tag{5}$$

where, u and v are the velocity components in the x and y-axis respectively, υ is the kinematic viscosity, C_p is the specific heat at constant pressure, $C_s$is concentration susceptibility, k is the thermal conductivity, ρ is the fluid density, g is the gravitational acceleration, k_T is the thermal diffusion ratio, T is the temperature and C is the concentration component of the fluid, β_T is the thermal expansion coefficient,k^* is the Darcy permeability,β_c is the concentration expansion coefficient and $q_r$is the radiated heat flux, $\tau'=(\rho c)_p/(\rho c)_f$ is the ratio of the heat capacity of the nanoparticle material and theheat capacity of the fluid,D_B is the Brownian diffusion coefficient, D_T is the thermophoretic diffusion coefficient, T_m is the mean fluid temperature.

It is assumed that the viscosity varies as a linear function of temperature (Rani and Kim, (2010)) which is taken as follows

$$\mu=\mu_0\left[1+\gamma(T-T_\infty)\right] \tag{6}$$

where μ is the viscosity of the fluid at the surface temperature , μ_0 is the viscosity far away from the plate and $\gamma$is a constant based on the viscous property of the fluid. Also, we have considered a non-dimensional viscosity variation parameter λ as

$$\lambda = \gamma(T_w - T_\infty) \tag{7}$$

From (6) and (7) we get the fluid viscosity of the following form

$$\mu = \mu_0\left(1+\gamma\overline{T}\right) \tag{8}$$

The following dimensionless variables that are used to obtained the partial differential equations in terms of dimensionless variables as

$$U = \frac{u}{U_0}; V = \frac{v}{U_0};\ Y = \frac{yU_0}{\upsilon};\ X = \frac{xU_0}{\upsilon}; \tau = \frac{tU_0^2}{\upsilon}; T = T_\infty + \overline{T}\left(T_w - T_\infty\right) \tag{9}$$

$$C = C_\infty + \overline{C}\left(C_w - C_\infty\right); P_r = \frac{\upsilon\rho C_p}{k}; G_r = \frac{\upsilon g\beta_T(T_w - T_\infty)}{U_0^3}; G_m = \frac{\upsilon g\beta_c(C_w - C_\infty)}{U_0^3} \tag{10}$$

$$S = \frac{Q\upsilon}{\rho C_p U_0^2}; M = \frac{\sigma B_0^2\upsilon}{\rho U_0^2};\ D_u = \frac{D_m K_T}{C_s C_p \upsilon}\frac{(C_w - C_\infty)}{(T_w - T_\infty)};\ L_e = \frac{\upsilon}{D_B};\ N_b = \frac{\tau' D_B(C_w - C_\infty)}{\upsilon} \tag{11}$$

$$R_a = \frac{4\sigma' T_\infty^3}{k'k}; K_p = \frac{\upsilon^2}{k^* U_0^2};\ N_t = \frac{\tau' D_T(T_w - T_\infty)}{T_\infty \upsilon};\ \lambda = \gamma(T_w - T_\infty) \tag{12}$$

By substituting the above values and the derivatives into the equations (1) to (4) and we have obtained the following nonlinear coupled partial differential equations in terms of dimensionless form as

$$\frac{\partial U}{\partial X} + \frac{\partial V}{\partial Y} = 0 \tag{13}$$

$$\frac{\partial U}{\partial \tau} + U\frac{\partial U}{\partial X} + V\frac{\partial U}{\partial Y} = \frac{\partial^2 U}{\partial Y^2} + \frac{\lambda}{1+\lambda\overline{T}}\left(\frac{\partial U}{\partial Y}\frac{\partial \overline{T}}{\partial Y}\right) + G_r\overline{T} + G_m\overline{C} - K_p U - MU \tag{14}$$

$$\frac{\partial \overline{T}}{\partial \tau} + U\frac{\partial \overline{T}}{\partial X} + V\frac{\partial \overline{T}}{\partial Y} = \frac{1}{P_r}\left\{\left(1+\frac{4}{3}R_a\right)\right\}\frac{\partial^2 \overline{T}}{\partial Y^2} + S\overline{T} + D_u\frac{\partial^2 \overline{C}}{\partial Y^2} + N_b\frac{\partial \overline{C}}{\partial Y}\frac{\partial \overline{T}}{\partial Y} + N_t\left(\frac{\partial \overline{T}}{\partial Y}\right)^2 \tag{15}$$

$$\frac{\partial \overline{C}}{\partial \tau} + U\frac{\partial \overline{C}}{\partial X} + V\frac{\partial \overline{C}}{\partial Y} = \frac{1}{L_e}\frac{\partial^2 \overline{C}}{\partial Y^2} + \frac{N_t}{N_b L_e}\frac{\partial^2 \overline{T}}{\partial Y^2} - K_1(C - C_\infty) \tag{16}$$

Also, the associate boundary conditions according to the present problem are,

$$\left.\begin{array}{ll} \tau > 0,\ \ U = \exp(b\tau), V = 0, \overline{T} = \exp(\tau), \overline{C} = \exp(\tau) & \text{at } Y = 0 \\ U = 0,\ \overline{T} \to 0, \overline{C} \to 0 & \text{as } Y \to \infty \end{array}\right\} \tag{17}$$

Where M is magnetic parameter, b is acceleration parameter, P_r is Prandlt number, $G_r$is Grashof number, $G_m$is modified Grashof number, $R_a$is radiation parameter,S is heat source parameter, $K_P$is permeability of porous medium, N_t is thermophoresis parameter,λ is viscosity variation parameter, N_b is Brownian Motion parameter, $D_u$is Dufour Number andL_e is Lewis number.

The physical non-dimensional quantitiesskin friction coefficient, Nusselt number, and Sherwood number are carried out respectively by the following expressions as:

$$C_f = -\frac{1}{2\sqrt{2}}(G_r)^{-\frac{3}{4}}\left(\frac{\partial U}{\partial Y}\right)_{Y=0}; N_u = \frac{1}{\sqrt{2}}(G_r)^{-\frac{3}{4}}\left(\frac{\partial \overline{T}}{\partial Y}\right)_{Y=0}; S_h = \frac{1}{\sqrt{2}}(G_r)^{-\frac{3}{4}}\left(\frac{\partial \overline{C}}{\partial Y}\right)_{Y=0} \tag{19}$$

Stream function $\psi(X,Y)$ satisfies the continuity equation and associated with the velocity components as:

$$U = \frac{\partial \psi}{\partial Y}, V = -\frac{\partial \psi}{\partial X} \tag{20}$$

Calculation Technique of the Problem

To obtain the difference equations, the region of the flow is divided into a grid or mesh of lines parallel to *X* and *Y* axis where *X*-axis is taken along the plate in the vertically upward direction and the *Y*-axis is chosen normal to the plate. It has been assumed that ΔX, ΔY are constant mesh sizes along *x* and *y* directions respectively and taken as follows,ΔX=0.83(0≤X≤125), ΔY=0.083(0≤Y≤25) with the smaller time-step, Δτ=0.0005. There are m=150 and n=300 grid spacing in the *X* and *Y* directions respectively as shown in Figure (A).

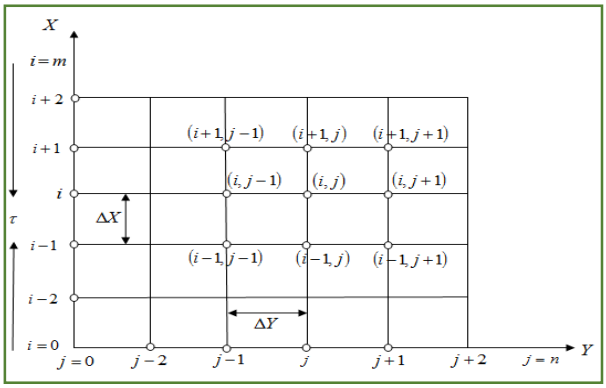

Figure (A). Explicit finite difference system grid.

Then the explicit finite difference approximation as below

$$\frac{U_{i,j}-U_{i-1,j}}{\Delta X}+\frac{V_{i,j}-V_{i,j-1}}{\Delta Y}=0 \tag{21}$$

$$\frac{U'_{i,j}-U_{i,j}}{\Delta\tau}+U_{i,j}\left(\frac{U_{i,j}-U_{i-1,j}}{\Delta X}\right)+V_{i,j}\left(\frac{U_{i,j+1}-U_{i,j}}{\Delta Y}\right)=\frac{U_{i,j+1}-2U_{i,j}+U_{i,j-1}}{(\Delta Y)^2}+G_r\overline{T}_{i,j}$$
$$+\left(\frac{\lambda}{1+\lambda\overline{T}_{i,j}}\right)\left(\frac{U_{i,j+1}-U_{i,j}}{\Delta Y}\right)\left(\frac{\overline{T}_{i,j+1}-\overline{T}_{i,j}}{\Delta Y}\right)+G_m\overline{C}_{i,j}-k_pU_{i,j}-MU_{i,j} \tag{22}$$

$$\frac{\overline{T}'_{i,j}-\overline{T}_{i,j}}{\Delta\tau}+U_{i,j}\frac{\overline{T}_{i,j}-\overline{T}_{i-1,j}}{\Delta X}+V_{i,j}\frac{\overline{T}_{i,j+1}-\overline{T}_{i,j}}{\Delta Y}=\frac{1}{P_r}\left(1+\frac{4}{3}R_a\right)\frac{\overline{T}_{i,j+1}-2\overline{T}_{i,j}+\overline{T}_{i,j-1}}{(\Delta Y)^2}+S\overline{T}_{i,j}$$
$$+N_t\left(\frac{\overline{T}_{i,j+1}-\overline{T}_{i,j}}{\Delta Y}\right)^2+N_b\left(\frac{\overline{C}_{i,j+1}-\overline{C}_{i,j}}{\Delta Y}\right)\left(\frac{\overline{T}_{i,j+1}-\overline{T}_{i,j}}{\Delta Y}\right)+D_u\frac{\overline{C}_{i,j+1}-2\overline{C}_{i,j}+\overline{C}_{i,j-1}}{(\Delta Y)^2} \tag{23}$$

$$\frac{\overline{C}'_{i,j}-C_{i,j}}{\Delta\tau}+U_{i,j}\frac{\overline{C}_{i,j}-\overline{C}_{i-1,j}}{\Delta X}+V_{i,j}\frac{\overline{C}_{i,j+1}-\overline{C}_{i,j}}{\Delta Y}=\frac{1}{L_e}\frac{\overline{C}_{i,j+1}-2\overline{C}_{i,j}+\overline{C}_{i,j-1}}{(\Delta Y)^2}$$
$$+\left(\frac{N_t}{N_bL_e}\right)\frac{\overline{T}_{i,j+1}-2\overline{T}_{i,j}+\overline{T}_{i,j-1}}{(\Delta Y)^2}-\gamma\overline{C} \tag{24}$$

In this case,the associate boundary conditions according to the present problem are,

$$\left.\begin{array}{l}\tau>0,\quad U^n_{i,0}=\exp(bn\Delta\tau),\ V^n_{i,0}=0,\overline{T}^n_{i,0}=\exp(n\Delta\tau),\ \overline{C}^n_{i,0}=\exp(n\Delta\tau)\qquad \text{at Y}=0\\ U^n_{i,L}=0,\ \overline{T}^n_{i,L}\to 0,\ \overline{C}^n_{i,L}\to 0\ \text{where}\ L\to\infty\end{array}\right\} \tag{25}$$

Here *i* and *j* designate to the mesh points with *X* and *Y* coordinate respectively and the superscripts *n* represent a value of time, $\tau=n\Delta\tau$ where, *n*=0, 1, 2 …

Stability and Convergence Analysis

The stability conditions for the present problem are,

$$\frac{2\Delta\tau}{(\Delta Y)^2}\left[1+\lambda(1-\lambda)\right]+\frac{M\Delta\tau}{2}+U\frac{\Delta\tau}{\Delta X}+\left|-V\right|\frac{\Delta\tau}{\Delta Y}+\frac{K_p\Delta\tau}{2}\le 1 \tag{26}$$

$$\frac{1}{P_r}\left(1+\frac{4}{3}R_a\right)\frac{2\Delta\tau}{(\Delta Y)^2}+U\frac{\Delta\tau}{\Delta X}+|-V|\frac{\Delta\tau}{\Delta Y}-\frac{S\Delta\tau}{2}\le 1 \quad (27)$$

$$\frac{1}{L_e}\frac{2\Delta\tau}{(\Delta Y)^2}+U\frac{\Delta\tau}{\Delta X}+|-V|\frac{\Delta\tau}{\Delta Y}+\frac{\gamma\Delta\tau}{2}\le 1 \quad (28)$$

Since the initial condition, U=V=0 at τ=0. So, the equations (26) to (28) present $P_r\geq$ 0.046 and $S_c\geq$0.035 respectively.

Therefore, the convergence criteria of the present problem are $P_r\geq$ 0.046 and $S_c\geq$0.035.

Results and Discussion

In order to investigate the results of the present problem, a finite difference solution has been used by explicit method. The numerical values of non-dimensional velocity, temperature, concentration, skin friction, Nusselt number, Sherwood number, streamlines and isotherms for vertical plate within the boundary conditions are obtained by FORTRAN program in the variations of different values of different parameters such as magnetic parameter (M), permeability of porous medium (K_p), Schmidt number (S_c), Prandtl number (P_r), viscosity variation parameter (λ), chemical reaction parameter (γ), Grashof number (G_r), modified Grashof number (G_m), heat source parameter (S), Soret number (S_r), thermophoresis parameter (N_t), Brownian motion parameter (N_b) and Radiation parameter (R_a) which are shown in **Figures 2 to 15**. In order to obtain the accuracy of the numerical results, the following values of default parameter are chosen as: M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S=0.1, N_b=0.5, N_t =0.8, L_e=2.5, S_r=2, G_m=5,λ=1.0,G_r=10, K_p=1, and γ=0.50 with time τ=1. These values are treated as same throughout the study in the respective Figs and Table 1.

The effects of different values of Grashof number, modified Grashof number, permeability of porous medium and magnetic parameter on velocity profiles are displayed in **Figures 2-5** respectively. We observed that velocity profiles are increasing respectively with the increase of the Grashof number and modified Grashof number which are shown in **Figure 2** and **Figure3**. The thermal Grashof number which signifies the relative effect of the thermal buoyancy force in the boundary layer. Due to this augmentation of thermal buoyancy force which executing on the fluid particles for gravitational force that increase of the thickness of momentum boundary layer. This is the fact that velocity are increasing due to increase of Grashof number. Also a similar effect is visible in the vicinity of modified Grashof number. Also, the velocity profiles are decreasing 44.6%, 26.6%, 23.8% and 16.2% as permeability of porous medium changes as K_p=1.00 to K_p=2.00, K_p=2.00 to K_p=3.00, K_p=3.00 to K_p=4.00 and K_p=4.00 to K_p=5.00 respectively which occurs in the **Figure 4**. Physically, the permeability of porous medium K_p which increases the resistive force. Due to this resistive force the velocity profiles are decreasing with the increasing of permeability of porous mediumK_p. In the **Figure 5,** the impact of different values of magnetic parameter M on velocity profiles are exhibited. It is shown that velocity decreased by 59.49%, 32.50%, 20.25%, and 13.95% for M=0.50 to M=1.50, M=1.50 to M=2.50, M=2.50 to M =3.50 and M=3.50 to M=4.50 respectively. The decrease in the tangential velocity as the increase of magnetic field which introduce a resistive force called Lorentz force. This force is one kind of resistive force which slows down the fluid velocity.

The impact of thermophoresis parameter, heat source parameter, radiation parameter and Prandtl number on temperature profiles are displaced in **Figures. 6-9**. It is worth mentioned that the temperature of the fluid increased with the increase of ase of thermophoresis parameter which are shown in **Figure 6**. This is due to fact that, the unrestrained motion of nanoparticles get increased with an increase in thermophoresis parameter which enhancement of fluid temperature. Also, from **Figure 7.** we observed that heat source parameter increased the temperature profiles. Here we exhibited that temperature profiles are increased by 54.49%, 35.50%, 34.25%, and 26.95% for R_a=0.50 to R_a=1.50, R_a=1.50 to R_a =2.50, R_a =2.50 to R_a =3.50 and R_a=3.50 to R_a=4.50 respectively which are shown in **Figure 8.** Physically, radiation parameter R_a provides more heat into the fluid, which leads to increases the thermal boundary layer thickness by increasing the values of radiation parameter. But on the other hand, temperature profiles decreased by Prandtl number which are shown in **Figure9.**Physically, this due to the fact that fluids with high Prandtl number have greater viscosity, which makes the fluid thick and hence move slowly.

The influence of Soret number,chemical reaction, Lewis number and thermophoresis parameter on concentration profiles are shown in **Figures. 10-13**. We have found from **Figure 10** that concentration profiles increased with the increased of Soret number. Also, concentration profiles areincreased with the increase of thermophoresis parameter where thermophoresis parameter leads the concentration profiles which are shown in **Figure 13.** Physically, it is mentioned that thermophoresis parameter enhancement the nanoparticle. But on the

other hand chemical reaction and Lewis number decreased the concentration profiles which are shown in **Figure 11** and **Figure 12** respectively. The effects of chemical reaction parameter for destructive reaction and $\gamma>0$, $\gamma=0$ without reaction and $\gamma<0$ constructive reaction. Reaction parameter shows a retarding effect on concentration distribution as the reaction proceeds from constructive to destructive state. Also, the outcome of radiation parameter R_a on streamlines and isotherms are scrutinized in **Figure 14.** and **Figure 15.**Here, we carried out that both momentum and thermal boundary layer thickness are increasing for increasing of radiation parameter from R_a=0.50 to R_a=1.50.

Table 1presents the numerical values of different parameters such as permeability of porous medium (K_p), Dufour number (D_u), radiation parameter(R_a), Schmidt number (S_c), Magnetic parameter (M), thermophoresis parameter(N_t), Brownian motion parameter(N_b) and chemical reaction parameter (γ)on skin friction coefficient(C_f), Nusselt number(N_u) and Sherwood number(S_h). It is showed that the skin friction coefficient increases with Dufour number (D_u), radiation parameter(R_a) and thermophoresis parameter (N_t), but decreases qualitatively with an increase in permeability of porous medium (K_p), Magnetic parameter (M), Brownian motion parameter(N_b) and chemical reaction parameter (γ). On the other hand the Nusselt number is an increasing functions of radiation parameter(R_a), Schmidt number (S_c), Magnetic parameter (M), Brownian motion parameter(N_b) and chemical reaction parameter (γ) whereas this tendency is quite opposite for permeability of porous medium (K_p), Dufour number (D_u)Schmidt number (S_c) and thermophoresis parameter (N_t) . Also it is noticed that the Sherwood number increases with the increasing of permeability of porous medium (K_p) and Schmidt number (S_c) but decreases qualitatively with increasing of Dufour number (D_u), radiation parameter(R_a), Magnetic parameter (M), thermophoresis parameter (N_t), Brownian motion parameter(N_b) and chemical reaction parameter (γ).

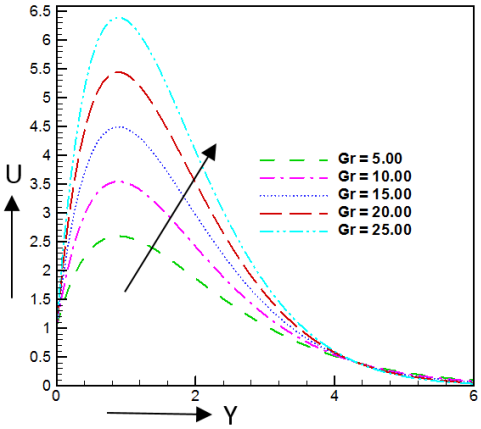

Figure 2. Velocity profiles for different values of G_r against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0, S=0.10, λ=1.0, N_t=0.8, N_b=0.5 and L_e=2.5.

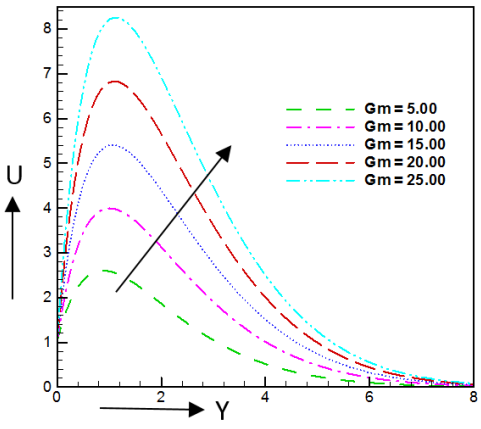

Figure 3. Velocity profiles for different values of G_m against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0, S=0.10, λ=1.0, N_t=0.8, N_b=0.5 and L_e=2.5.

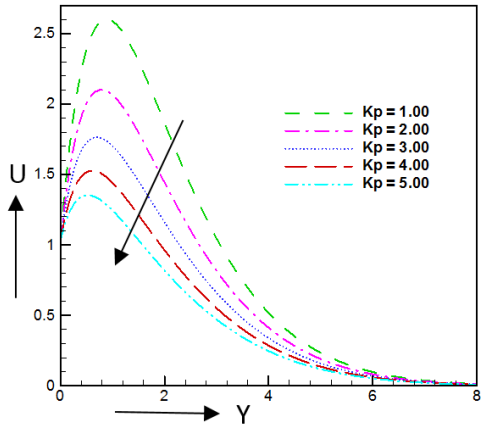

Figure 4. Velocity profiles for different values of K_p against Y when M=1.0, P_r=1.0, S_c=0.22,

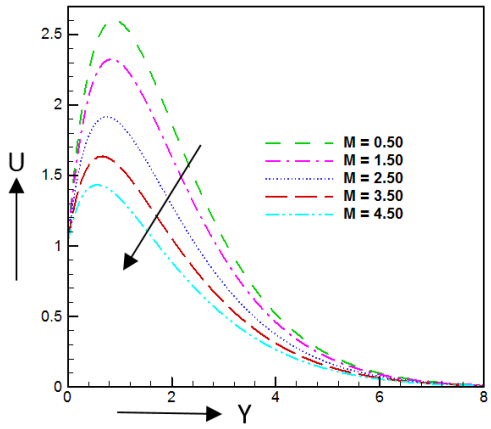

Figure 5. Velocity profiles for different values of M against Y when K_p =1.0, P_r=1.0, S_c=0.22,

R_a=0.50, S_r=2.0, S=0.10, γ=0.50, λ=1.0, N_t=0.8, N_b=0.5 and L_e=2.5.

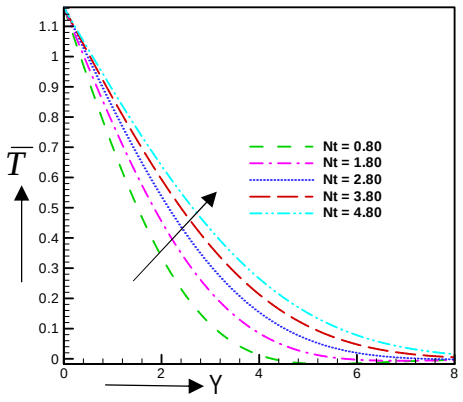

Figure 6. Temperature profiles for different values of N_t against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0, S=0.10, γ=0.50, K_p=1.0, N_b=0.5 and L_e=2.5.

R_a=0.50, S_r=2.0, S=0.10, γ=0.50,λ=1.0, N_t=0.8, N_b=0.5 and L_e=2.5.

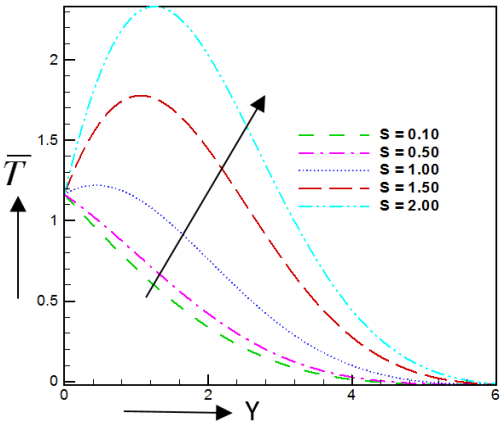

Figure 7. Temperature profiles for different values of S against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0, K_p =1.0, γ=0.50, N_t=0.8, N_b=0.5 and L_e=2.5.

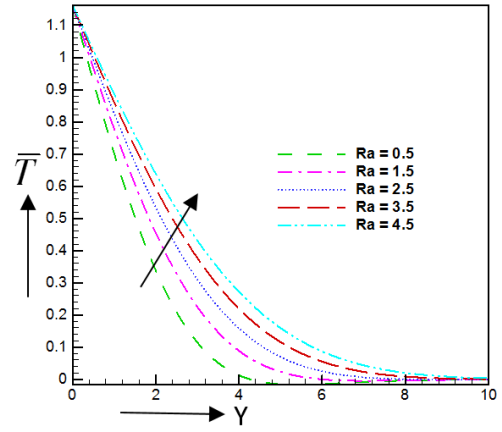

Figure 8. Temperature profiles for different values of R_a against Y when M=1.0, P_r=1.0, S_c=0.22, K_p=1.0, S_r=2.0, S=0.10, γ=0.50, N_t=0.8, N_b=0.5 and L_e=2.5.

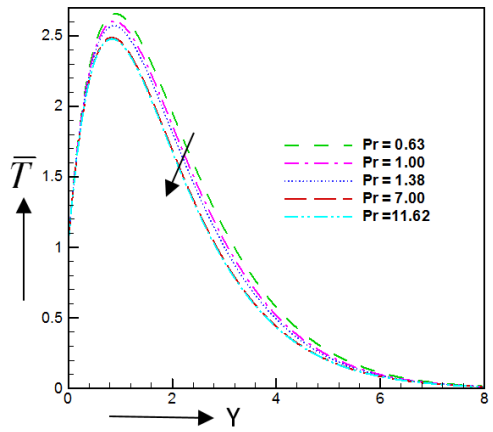

Figure 9. Temperature profiles for different values of P_r against Y when M=1.0, K_p=1.0, S_c=0.22, R_a=0.50, S_r=2.0, S=0.10, γ=0.50, N_t=0.8, N_b=0.5 and L_e=2.5.

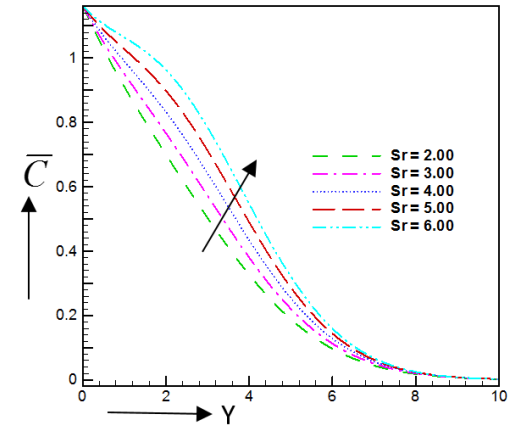

Figure 10. Concentration profiles for different values of S_r against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, K_p=1.0, λ=1.0, S=0.10, γ=0.50, N_t=0.8, N_b=0.5 and L_e=2.5.

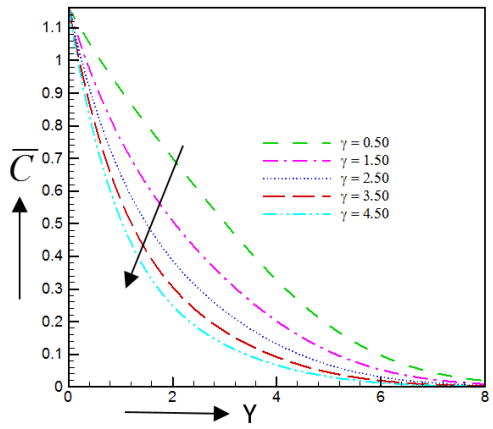

Figure 11. Concentration profiles for different values of γagainst Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0, λ=1.0, S=0.10, K_p=1.0, N_t=0.8,

N_b=0.5 and L_e=2.5.

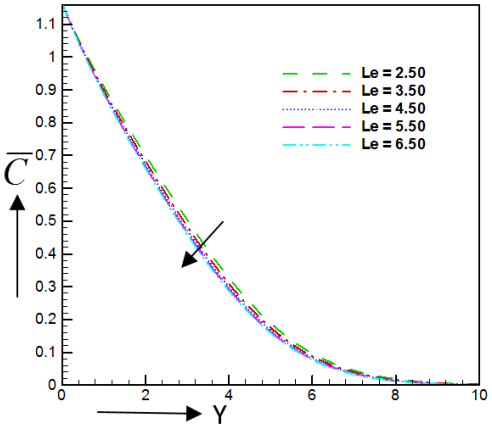

Figure 12. Concentration profiles for different values of L_e against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0,λ=1.0, S=0.10, γ=0.50, N_t=0.8, N_b=0.5 and K_p=1.0.

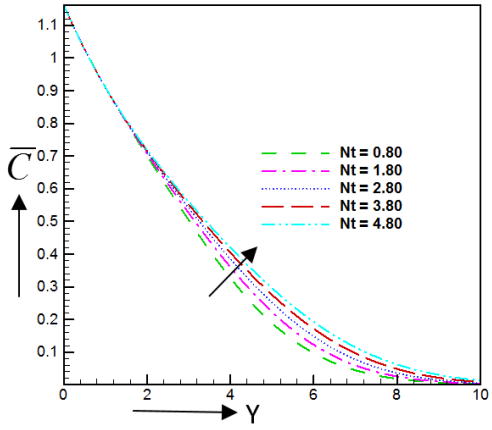

Figure 13. Concentration profiles for different values of N_t against Y when M=1.0, P_r=1.0, S_c=0.22, R_a=0.50, S_r=2.0, λ=1.0, S=0.10, γ=0.50, K_p=1.0, N_b=0.5 and L_e=2.5.

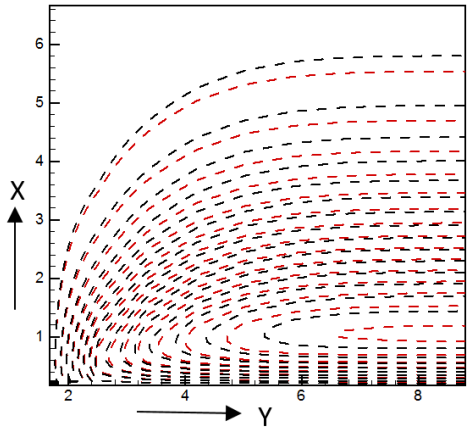

Figure 14. Streamlines for R_a=0.50 (red dashed line) and R_a =1.50 (black dashed line).

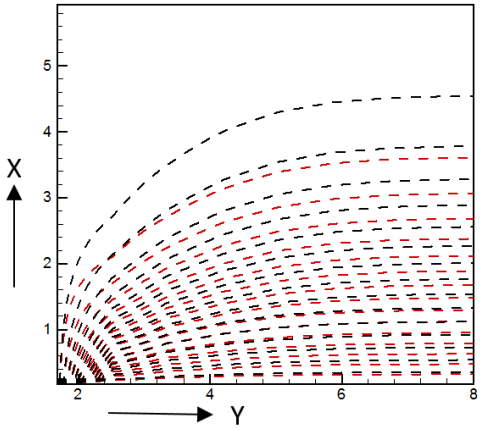

Figure 15. Isotherms for R_a=0.50 (red dashed line) and R_a =1.50 (black dashed line).

Table 1. Variation of different parameters on skin friction coefficient, Nusselt number and Sherwood number are shown in in the bellows table as:

K_p	D_u	R_a	S_c	M	N_t	N_b	γ	C_f	N_u	S_h
1.00	1.00	0.50	0.22	1.00	0.50	0.50	0.10	-0.05196	0.38531	0.34877
2.00	1.00	0.50	0.22	1.00	0.50	0.50	0.10	-0.10316	0.38527	0.34880
3.00	1.00	0.50	0.22	1.00	0.50	0.50	0.10	-0.15180	0.38522	0.34884
1.00	**1.00**	0.50	0.22	1.00	0.50	0.50	0.10	-0.03790	0.37521	0.33884
1.00	**2.00**	0.50	0.22	1.00	0.50	0.50	0.10	-0.03558	0.37521	0.33884
1.00	**3.00**	0.50	0.22	1.00	0.50	0.50	0.10	-0.03481	0.37521	0.33884
1.00	1.00	**0.50**	0.22	1.00	0.50	0.50	0.10	-0.00129	0.34972	0.31383
1.00	1.00	**1.50**	0.22	1.00	0.50	0.50	0.10	0.01095	0.27778	0.34437
1.00	1.00	**1.70**	0.22	1.00	0.50	0.50	0.10	0.01276	0.26800	0.34832
1.00	1.00	0.50	**0.22**	1.00	0.50	0.50	0.10	0.20701	0.22556	0.19423
1.00	1.00	0.50	**0.66**	1.00	0.50	0.50	0.10	0.20624	0.22540	0.19963
1.00	1.00	0.50	**0.78**	1.00	0.50	0.50	0.10	0.20497	0.22506	0.20906
1.00	1.00	0.50	0.22	**1.00**	0.50	0.50	0.10	0.17239	0.24405	0.21162
1.00	1.00	0.50	0.22	**1.50**	0.50	0.50	0.10	0.14077	0.24407	0.21161
1.00	1.00	0.50	0.22	**2.00**	0.50	0.50	0.10	0.11055	0.24408	0.21161
1.00	1.00	0.50	0.22	1.00	**0.50**	0.50	0.10	0.23425	0.21143	0.18114

1.00	1.00	0.50	0.22	1.00	**1.00**	0.50	0.10	0.23807	0.20564	0.17781
1.00	1.00	0.50	0.22	1.00	**1.80**	0.50	0.10	0.25117	0.18623	0.16678
1.00	1.00	0.50	0.22	1.00	0.50	**0.50**	0.10	0.18948	0.23484	0.20293
1.00	1.00	0.50	0.22	1.00	0.50	**1.00**	0.10	0.17926	0.27147	0.20199
1.00	1.00	0.50	0.22	1.00	0.50	**1.50**	0.10	0.17026	0.30758	0.19653
1.00	1.00	0.50	0.22	1.00	0.50	0.50	**0.10**	0.19095	0.23405	0.20219
1.00	1.00	0.50	0.22	1.00	0.50	0.50	**0.50**	0.15222	0.23409	0.20217
1.00	1.00	0.50	0.22	1.00	0.50	0.50	**1.00**	0.10832	0.23412	0.20216

Conclusions

From the present numerical investigation, following conclusions have been drawn:

1) Skin friction coefficient increases with Dufour number, radiation parameter and thermophoresis parameter.
2) It is noticed that Grashof number and modified Grashof number increases the velocity profiles.
3) The Nusselt number is an increasing functions of radiation parameter, Schmidt number, magnetic parameter
4) It is observed that Permeability of porous medium and magnetic parameter decreases the velocity.
5) Temperature profiles decreases with the increase of Prandlt number.
6) The Sheewood number decreases qualitatively with increasing of Dufour number, radiation parameter, Magnetic parameter, thermophoresis parameter, Brownian motion parameter.

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Prioritizing Suppliers by using AHP tool for managing risk factors in Logistics (A case study: Epyllion Group)

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Abstract

Risk management in logistics involves a variety of issues like selecting suppliers, the performance of suppliers, third-party logistics, and outsourcing and so forth. Selecting the best supplier is one of the most crucial tasks for any production system as there are many external or internal vulnerabilities. This paper considers a renowned company's operational risk factors which are involved with its downstream partners and develops a simple model by using Analytic Hierarchy Process (AHP) toolbox which prioritizes the suppliers by considering various selection criteria for managing risk. AHP is a practical and useful Multi-Criteria Decision Making (MCDM) tool which provides the foundation for making such evaluations in decision making. In this paper, the main purpose is getting a prioritized list of alternative suppliers so that if one supplier is suddenly unavailable to supply raw materials for unavoidable reasons, the company will get to choose another supplier quickly. Thus it will not halt the whole production system and minimize the risk factors in logistics management.

Keywords: Analytic Hierarchy Process (AHP), Logistics Risk Factor, Prioritizing, Supplier Selection, Uncertainty

1. Introduction

Success in today's highly competitive manufacturing environment depends on the effective selection of suppliers. Nowadays, strategic sourcing is one of the fastest growing areas of supply chain management. For example, raw materials and components are purchased from external suppliers. Appropriate supplier selection is important for any organization because it helps to achieve high-quality products at relatively lower costs with greater customer satisfaction and ultimately assists in increasing profitability.

Supplier selection (SS) has considered so important for its significant effect toward successful Logistic and supply chain management (LSCM). One of the key problems in SCM finds the best supplier among several alternatives according to various criteria, such as cost, service, risk, and others. This is a complicated multi-criteria decision-making problem [1]. Akarte et al. [2] developed a web-based AHP system to evaluate the casting suppliers with respect to 18 criteria. In the system, suppliers had to register, and then input their casting specifications. To evaluate the suppliers, buyers had to determine the relative importance weightings for the criteria based on the casting specifications and then assigned the performance rating for each criterion using a pairwise comparison. Muralidharan et al. [3] proposed a five-step AHP-based model to aid decision makers in rating and selecting suppliers with respect to nine evaluating criteria. People from different functions of the company, such as purchasing, stores, and quality control, were involved in the selection process. Yueh and ru-jen proposed a procedure for supplier selection that utilizes the structure of criteria in analytic hierarchy process (AHP) model and employs consistent fuzzy preference relations

(CFPR) to construct the decision matrices [4]. Fuzzy analytic hierarchy process and AHP based methodology are used to select the best supplier providing the most customer satisfaction for the criteria determined [5, 6]. Nilay Yücenur et al. proposed a model for selecting the global supplier by analytical hierarchy process (AHP) and suggested AHP can be a good tool for solving multiple-criteria decision-making problem [7].

The aim of this paper is to identify and discuss some of the important and critical decision criteria including risk factors for the development of an efficient system for global supplier selection.

2. Company Background

Epyllion Group started its journey as a house of Readymade Garments (RMG) engaged in manufacturing and exporting of Knit Apparels since 1994 and has been considered today as one of the biggest conglomerates with the substantial establishment of its backward linkage of all kinds of knit garments, textile, wet processing & garments accessories.

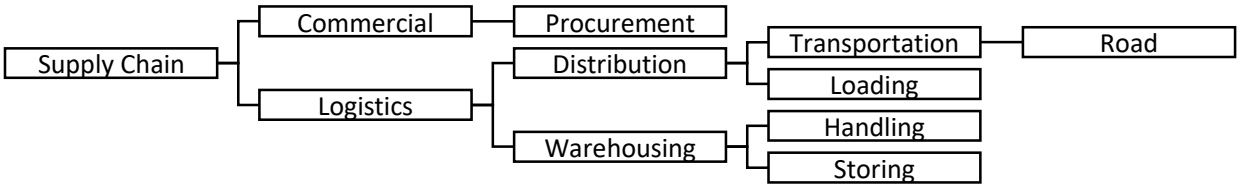

Figure 1. Hierarchy of supplier chain department

3. Problem Statement

Epyllion garments Industries in Bangladesh produces various types of garments like a t-shirt, pant, jacket etc. For its smooth production, the company has many suppliers in different countries of the world. Here, one particular item has considered for example. The item is a jacket which is made of 20 types of raw materials. Sewing materials such as thread, lining, seam tape, buttons, snaps, and zippers are generally purchased from outside vendors and stored in the garment factory. Specifically, for zippers multiple numbers of suppliers are available. The suppliers are situated in different countries such as Singapore, Sri Lanka, Malaysia, and Japan. To identify the best supplier among them is very challenging. Suppose best supplier has been selected by using various mathematical models. But if any uncertainties like fire explosion, earthquake, strikes etc. will occur in supplier's place what will happen. So, we have formulated the following general research questions for the study:

(1) What will happen if the best supplier becomes unavailable?

(2) Does the second supplier of the prioritizing list suitable in that circumstance?

4. AHP methodology for research work

The initial step for performing AHP tool is to determine the decision hierarchy with Attributes (criteria) and Alternatives (suppliers) which clearly shown in Figure 1. The pairwise comparison is used to determine the relative importance of attributes and alternatives and also compared how well the options perform on the different attributes. The pairwise comparison judgment obtains from experts or specialist in the relevant area (Epyllion Company).

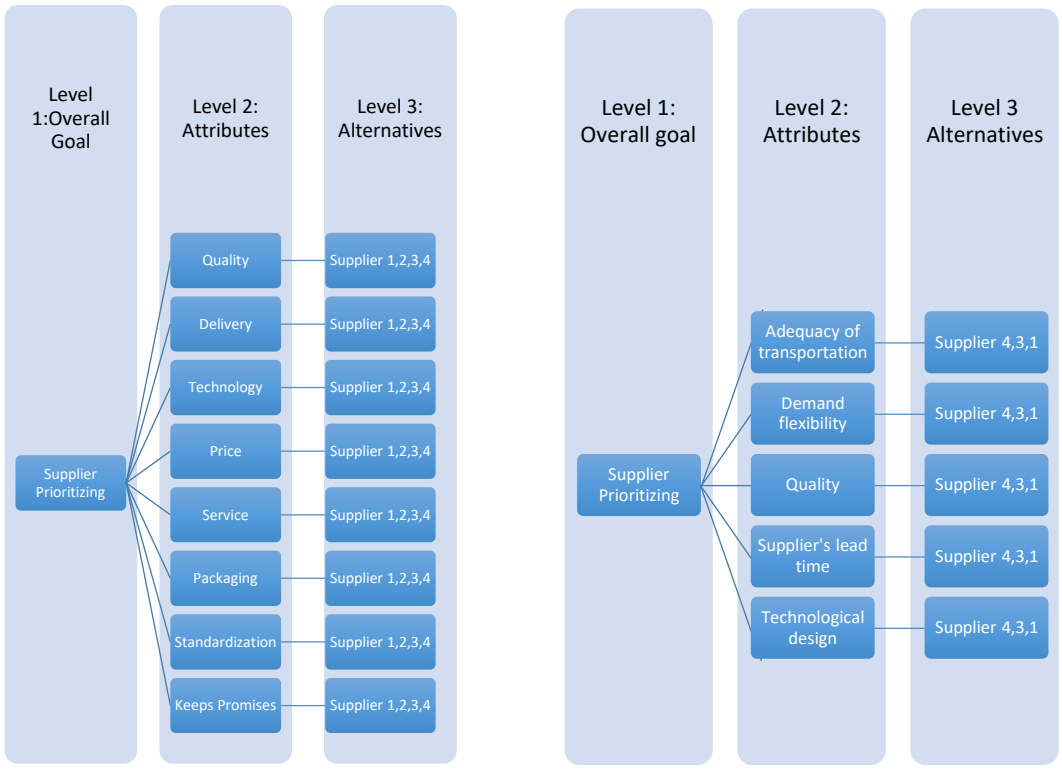

Figure 2. A hierarchy for selecting best supplier and best alternative supplier

Then the weights, Maximum Eigen value (λ max) and C.I (Consistency Index) of attributes and alternatives have been calculated. The value of C.R (Consistency Ratio) = C.I/ R.I where R.I is taken from Randomly Generated Consistency Index for different size of the matrix. When finding out all the weights, normalize the weights and find out the best supplier. From Table 1, it is observed that "Supplier 2" is ranked 1 among 4 suppliers. Thus, the decision is to select supplier 2.

Table 1. Final Evaluation for best supplier

Alternatives	Attributes and their weight								Composite Weights	Overall Ranking
	Quality 0.089967	Delivery 0.157298	Technology 0.0982985	Price 0.130005	Service 0.145443	Keeps Promise 0.123368	Standardization 0.123637	Packaging 0.131982		
Supplier 1	0.2367	0.2448	0.3373	0.1556	0.1981	0.3404	0.1768	0.2377	0.2372	2
Supplier 2	0.1796	0.2536	0.1260	0.6588	0.5709	0.2791	0.4335	0.2919	0.3637	1
Supplier 3	0.2367	0.1671	0.2631	0.0859	0.1025	0.1920	0.1947	0.2997	0.18687	4
Supplier 4	0.3467	0.3343	0.2734	0.0995	0.1284	0.1883	0.1947	0.1705	0.2121	3

After finding the best supplier put it aside and consider the remaining ones to find the best alternative supplier. For this purpose use some criteria which are risk-related criteria. Repeating the same process, find out another suitable alternative which is best when any uncertainty occurs with the selected supplier.

Table 2. Final Evaluation for best alternative

Alternatives	Attributes and their Weights					Composite weights	Overall ranking
	Quality 0.09591	Demand flexibility 0.295098	Adequacy of transportation 0.13815	Supplier's lead time 0.295098	Technologi -cal change 0.175744		
Supplier 4	0.6	0.4	0.547216	0.47423	0.549809	0.487753048	1
Supplier 3	0.2	0.2	0.263074	0.149373	0.0821306	0.173058907	3
Supplier 1	0.2	0.4	0.189709	0.376397	0.36806	0.339187837	2

Table 2 reveals that "Supplier 4" is ranked 1 among supplier 1, 4 & 3. Thus, the decision is to select Supplier 4 when the risk occurs with Supplier 2.

5. Discussion

Prioritization of the supplier is undoubtedly crucial for any company and it becomes harder when selected supplier becomes unobtainable. In Bangladesh, many companies use thumb rule and their past experiences to decide about such complex situation and the decision might be wrong that's why the company didn't achieve their profit properly. Also, it costs a lot of time, mental pressure and there is no scientific and logical method to make decisions on it. Also, keeping relation with multiple suppliers helps to minimize dependency and logistics risks. But managing the multiple suppliers is not an easy task. It can make the situation more complex like performance tracking, design collaboration, and synchronization becomes complicated.

The main objective of this paper is to develop a simple and straightforward supplier selection model by considering relevant criteria for managing logistics risks. An AHP was applied to obtain aggregated optimized results based on some developed rules. From results, it can be shown that rank of suppliers' changes with the importance of considered factors. This study reveals that when selected supplier suddenly stops their delivery, the company cannot manage to run the production of the company smoothly. There remains no sufficient time to get another supplier immediately. To prevent this problem, proactive strategies should be taken. The company needs to find the best alternative while selecting a supplier. Thus, it will save time to get immediate supplier when selected supplier stops cooperating.

6. Conclusion

Uncertainty is a common thing which brings changes in the normal situation and to deal with all these changes proactive strategies must be followed. It can be concluded that uncertain characteristic affiliated with the prioritization of the suppliers leads to the utilization of developed AHP model, which facilitates the prioritization process by making it credible and accurate.

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Distribution Network Design and Optimization of a FMCG MNC of Bangladesh

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Abstract

Supply chain network design is a powerful modeling approach proven to deliver significant reduction in costs and improvements in service levels by better aligning supply chain strategies. There are many literatures available on supply chain network optimization, and numerous studies exist on supply chain functions of location, production, inventory, and transportation including integrated network. This research is focused on the cost optimization technique to optimize the network. This study has determined the optimization of the distribution network to increase the overall profitability of the company based on the total service time and total distribution cost. By the coordination of three different methods and using three different tools, a suitable and significant model has been developed which is consistent with the real life application. In this research work, a structured and optimum network for distribution has been generated where the performance has been increased to supply the product on time to fulfill the growing demand. Moreover, environmental issues have also been considered as a part of corporate social responsibility that makes the developed network as a sustainable supply chain network. The developed network shows 15.5 times better performance with a performance rate of 3.5953×10^5. Cost optimization solution has been done by both significance and performance evaluation methods to make a robust ground for the optimized network.

Keywords
Distribution Network, Sustainability, Network Design, Network Optimization, Manufacturer, Distributor, Retailer.

Introduction

Supply chain management has become a strategic issue for any company looking to meet targets in terms of economic competitiveness, time and quality of service especially in an economic environment characterized by the globalization of trade and the acceleration of industrial cycles. The trade press is replete with examples of logistics network configuration, re-configuration, re-organization, mergers, outsourcing, and so on. These developments have been influenced by successive trends in the economy and society resulting from computerization, increased complexity of trade flows, increased competition and certainly not least, sustainable development (Majid Eskandarpour, Pierre Dejax, Joe Miemczyk, Olivier Péton, 2015). Sustainability is increasingly an essential element of companies strategies, given the recognized need to ensure the long term success in the future of people and the planet (Hay and Stavins, 2005) (Kleindorfer et al., 2005). Thus the strategic design and planning of Supply Chain networks is a topic that is becoming more important for businesses and researchers alike. Supply chain network

design is at the intersection of disciplines such as management, strategy, logistics, operations research .Supply chain networks are now more global than ever and are typically structured with five key areas: external suppliers, production centers, distribution centers (DCs), demand zones, and transportation assets (Wikipedia, the free encyclopedia, 2017). In Bangladesh, business content in FMCG business where companies like Unilever, Nestle, Reckitt Benckiser and Marico operates their business model based on the manufacturing hum and distribution center. Therefore, they connect to their end customers with this network. The authors to have a feasibility study on the present network of FMCG companies, whether this is sufficient to meet the customer demand or not in terms of numerical analysis. The numerical analysis will be based on the distribution cost, fixed cost, variable cost as well as the service time. Therefore, the rationale of this study is to understand the entire distribution pattern of FMCG Company in Bangladesh market in terms of the feasibility study of the numerical different variables.

Methodology

In order to carry out this study, steps that have been followed are mentioned below:

1. Identification of multiple criteria, which influence the design and optimization of distribution centers across the country.
2. Defining the rules by some basic logic and common conceptions for relating the inputs with the output.
3. Selecting several function and their values for each criteria.
4. Evaluating service time and distribution cost for effective and valid development of the network generated during the research.
5. Determination of statistical significance using regression analysis in Minitab.
6. Evaluation of performance of network using Neural Network(NN)analysis in MATLAB.
7. Developing the data and finding the output decision to design and optimize the distribution network.

Literature Review

In this section, several research streams are reviewed in order to highlight existing research gaps. While there is growing interest in the benefits of Supply Chain Network Design (SCND), management is often unsure of how to achieve it. Furthermore, some new research exists specifically in the area of integrated supply chain network optimization.

Supply Chain Management

The concept of SCM started receiving increasing attention from researcher and practitioners since late 1990s in response to the competitive pressure in terms of improved quality, reduced cost, increased responsiveness and shorter lead time. SCM has a critical role in the companies strategic decision-making process due to dynamic changes and opportunities in the global supply chain network (Su and Gargeya, 2012). Council of Supply Chain Management Professionals (CSCMP) has defined SCM as the planning and management of all activities involved in sourcing, procurement, conversion and all logistics management activities. It also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers and customers (CSCMP, 2017).

Sustainable Supply Chain Management

The cross fertilization between SCM and Sustainable Development (SD) research discipline began in the past decade due to a number of factors that pushed companies in various industries to strive for a more sustainable supply chain performance (Seuring and Muller, 2008; Linton et al., 2007). On one hand, these factors can be related to external pressure from govermnent policies and customers or stakeholders requirements (Hassini ei al., 2012). On the other hand, drivers for change can sometimes be incentives such as gaining competitive advantage, maintaining company reputation or economic challenges (Gold et al., 2013; Wu and Pagell, 2011; Seuring and Muller, 2008). Taking into consideration the impact of the above-mentioned drivers, it is not surprising that there exists a strong research stream as well as practical applications in industry related to sustainability in supply chain management (SCM) or in other words Sustainable supply chain management (SSCM).

Supply Chain Collaboration

Supply Chain Collaboration (SCC) is a state where individual parties work together to achieve mutually beneficial outcomes (Davis and Spekman, 2004). (Cohen and Roussel, 2005) and (Ramanathan and Gunasekaran, 2014)

suggested that SCC is the means by which various partners work together toward mutual objectives through sharing ideas, information, knowledge, risks and rewards. (Hansen, 2009) Submitted that SCC takes place when people from different units help each other to achieve a common goal that goes beyond shipping data back and forth between parties.

Supply Chain Network Design

Pishvaee,Rabbani and Seyed (2011), studied the responsive, multi-stage SCND problem and proposed two mixed integer programming (MIP) models for two conditions: (a) to allow direct shipment and (b) to prohibit direct shipment. They studied the structure of SCND problems by means of graph theoretic approach; in this way, they eliminated the complexity of the MIP models. The ability of modeling SCND problems by a bipartite graph was also proved. Finally, by means of graph theoretic view to the structure of problem understudied, they developed a novel heuristic solution method. Erenguc,Simpson and Vakharia (1999), provide a review of the important decision elements in each of the three stages of the supply chain network – supplier, plant, and distribution. The supplier stage analysis deals with issues like supplier selection, number of suppliers, and the volumes of shipments from each of them. A multi-product, multi-stage inventory model is then formulated for the plant stage considering linear inventory holding costs, fixed costs for replenishment, and no capacity constraints. The distribution stage reviews in detail the important factors for issues such as distribution network design, location/allocation decisions, and inventory decisions

.

Environmental Supply Chain Network Design:

Network design mathematical models traditionally aimed at minimizing cost or maximizing profit, with very little consideration of environmental objectives and constraints. The increasing importance of environmental issues has prompted decision-makers to incorporate environmental factors fully into the decision process (Ilgin and Gupta., 2010), giving birth to Environmental Supply Chain Network Design(ESCND). In other words, ESCND generalizes SCND by incorporating environmental factors, which may concern facilities, transportation modes, processes, product design, technological choices, etc. As shown for example in the case study in (D. Yue, F. You, and S. W. Snyder., 2014), the optimal solutions of pure economic, environmental or intermediate models differ a lot. This raises several questions that should be clarified when designing supply chains. Which environmental factors should be considered? How can they be quantified? How can they be integrated into mathematical models and optimization methods?

Research Gap

The problem of simultaneous analysis of different supply chain functions has attracted many researchers and has produced a considerable amount of literature in this area. As noted, a majority of the models presented so far have been concentrated mostly on the integration of two supply chain functions: location-production and production-distribution. Hence, the aim here is to develop an integrated network model along with optimal capacitated facility location, also includes service time and optimization of the distribution functions as well as inventory flow in the supply chain network.

Background

The Why and When of Supply Chain Network Design

Companies have realized the importance of supply chain network design exercises but are still unable to make the best use of it. The challenge typically lies in selecting the right approach. Internal factors driving supply chain network design are focused on driving service delivery and working capital optimization across existing networks. On the other hand, external factors also drive significant structural changes (L.N. Balaji, Sandeep Kumar, 2013). Often in case of internal factors, individual (function-specific) objectives and company objectives are not well defined or aligned. As a result the costs associated with certain service levels could become a concern. Conflicting optimization objectives by functions lead to sub-optimal supply chain performance. Traditionally in case of external factors, businesses have established supply chains and different facilities across the network to gain tax benefits, trade concessions, labor arbitrage, reduced logistics cost. In many cases, the impact of these changes is large enough to drive strategic structural supply chain changes.

Distribution Network Optimization

Distribution Network Optimization enables an intimate understanding of the trade-offs between the optimal network for operating expenses versus customer service level. Distribution Network Optimization is essentially a balancing act between operating expenses and working capital as opposed to Service Level requirements or Service Level versus Costs. Cost or profit-based optimization is the most widely used method for SC distribution network design problems. Supply chain network optimization with a powerful modeling approach can deliver significant reduction in supply chain cost and improvements in service levels. It incorporates end-to-end supply chain cost: purchasing, production, warehousing, inventory and transportation. Companies can revisit their network periodically, considering changes in business scenarios.

Effectiveness of Distribution Network

The route along which goods and services travel from producer/manufacturer through marketing intermediaries (such as wholesalers, distributors, and retailers) to the final user is generally referred to as channel of distribution. Channels of distribution provide downstream value by bringing finished products to end users. This flow may involve the physical movement of the product or simply the transfer of title to it. Also known as a distribution network, a distribution chain, a distribution pipeline, a supply chain, a marketing channel, a market channel, and a trade channel (M. Sreenivas, T. Srinivas, 2008).

Conceptual Framework of The Study

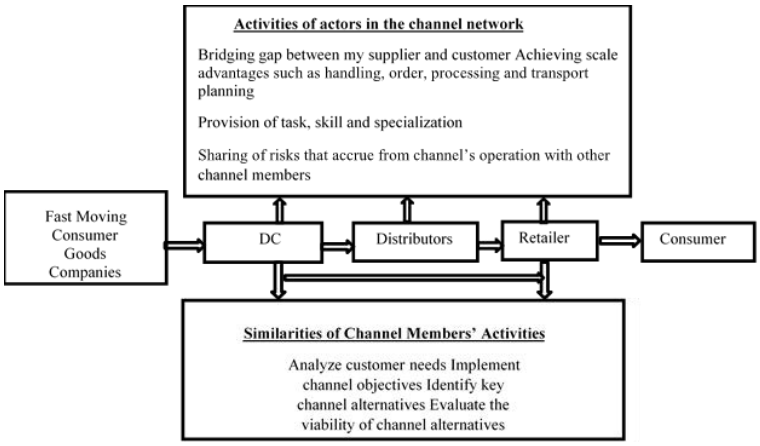

Figure 1. Conceptual Framework (Leroy Kwadwo, 2016)

The framework (Figure 1) describes the distribution channels of FMCGs companies and shows the path products pass through to the final consumer. The diagram further explains that notable similarities that occur among the channel members are analysis of customer needs, implementation of channel objectives, identification of key channel alternatives and evaluating the viability of channel objectives. Also the various activities carried out by the actors in the network are bridging the gap between supplier and customers, contributing to achieve scale advantages, provision of skills and specialization and risk sharing that accrue from the entire channel operation. All these similarities and activities are important to ensure the effectiveness of the distribution network and hence the competitiveness of the FMCGs companies.

Formulation of The Study

Assumptions

- Demand is linear
- Service time has been considered between the FMCG MNC and the distributor
- Service time does mean is basically the order placement to the goods received at the distributor end
- We did not consider the seasonal fluctuations
- We have considered the average freight rate of Bangladesh
- We have considered the average speed of vehicle across the country and considered it as constant in every case as because the vehicle speed in our highway roads raises suddenly when the road is free and drops down due to traffic

Sales Volume for DCs

$$S_d = T_v * P_s$$

Where,
S_d = Sales Per Depot(ton)
T_v = Total volume(ton)
P_s = Percentage Sales(%)

Carrying Cost for DCs

$$C_c = C_v / D$$

Where,
C_c = Carrying Cost(tk/km)
C_v = Cost Per Vehicle(tk)
D =Distance(km)

Service Time Calculation for DCs and Distributors

$$T_r = D / V_s$$

Where,
D = Distance From Warehouse(km)
V_s = Vehicle Speed(km/hr)
T_r = Time to Reach(hr)

$$T = T_r + Q_t + T_{ld\ /\ Unld}$$

Where,
T = Total Time(hr)
T_r = Time to Reach(hr)
Q_t = Waiting Time in Queue(hr)
$T_{ld/unld}$ = Loading(ld)/Unloading(unld) Time(hr)

Distribution Cost Calculation for DCs and Distributors

$$F_r = D * U_c$$

Where,
F_r = Freight Cost(tk)
D = Distance From Warehouse(km)
U_c = Unit Cost Per km(tk/km)

$$T_{dc} = F_r + F_c + V_c$$

Where,
T_{dc} = Total Distribution Cost(tk)
F_r = Freight Cost(tk)
F_c = Fixed Cost(tk)
V_c = Variable Cost(tk)

$$T_{dc} = F_r + C_{ld\ /\ unld}$$

Where,
T_{dc} = Total Distribution Cost(tk)
F_r = Freight Cost(tk)
$C_{ld/unld}$ =Loading(ld)/Unloading(unld)cost(tk)

Optimization Case

In this paper, in case of optimization, the total service time, total distribution cost, demand, carrying cost and sales volume for all the DCs have been analyzed to omit a DC from the distribution network that can be proved by both mathematically and statistically significant.

Number of Trip Calculation for Comilla DC

$$N_{tr} = S_v / T_c$$

Where,
N_{tr} = Number of Trip
S_v = Sales Volume(ton)
T_c = Truck Capacity(ton)

Regression Analysis

As regression analysis is done to check the statistical significance of a model, so regression analysis has been done to determine whether the model is statistically significant or not. Based on that, this study has been divided into two parts that includes two scenarios-

1. Scenario Before Optimization: Where the distributors of Comilla are supplied from Comilla DC.
2. Scenario After Optimization: : Where the distributors of Comilla will be supplied from Dhaka DC.

The regression equation is-

$$y = a + bx$$

Where,
y = Dependent Variable
x = Independent Variable
a & **b** are the output of regression

Neural Network Analysis

In Case of Neural Network(NN) analysis, it has been done in MATLAB by giving three inputs that includes distance, time and cost. After selecting those three inputs and putting them in MATLAB, the network required to select the target data set to train and it includes service time and distribution cost.
Basically, two sets of data have been compared from two possible conditions to figure out the suitable one with better performance. Two possible conditions are-

- Condition-1: Distributors of Comilla will be supplied from the Comilla DC.
- Condition-2: Distributors of Comilla will be supplied from the Dhaka DC.

Implementation of The Study-A Case Study

Case Description

In this research, authors have developed a model of distribution network optimization which can be used to increase the total profitability of the FMCG MNC. The mathematical model which have been developed in previous chapter is implemented in this chapter using a case study.

Sales Volume for DCs

Sales volume for the five DCs of the FMCG MNC is evaluated here using the equation for it from the previous section.

Table 1. Sales volume of DCs

DCs	Sales Percentage (%)	Total Volume (ton)	Sales Per DC (ton)
1.Dhaka	48	1600	768
2.Bogra	15		240
3.Jessore	12		192
4.Chittagong	15		240
5.Comilla	10		160

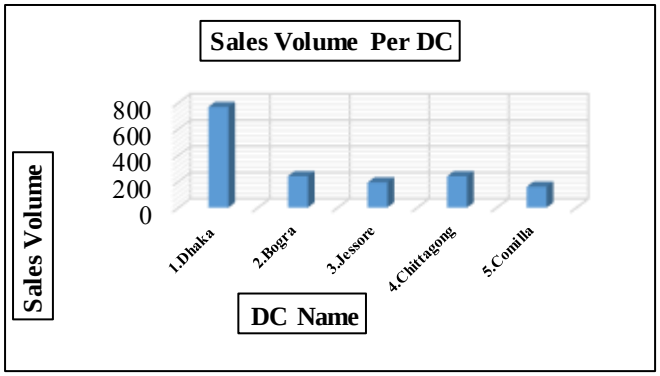

Figure 2. Sales Volume for DCs of the FMCG MNC

From Table 1 it can be seen that Dhaka DC has a large sales volume of 768 ton and Comilla with the small sales volume of 160 ton.

Carrying Cost for DCs

Table 2. Carrying Cost of DCs

DCs	Distance from Warehouse (km)	Cost Per Vehicle (tk)	Carrying Cost (tk/km)
1.Dhaka	13	5000	384.62
2.Bogra	176	8000	45.45
3.Jessore	198	15000	75.76
4.Chittagong	279	15000	53.76
5.Comilla	124	12000	96.77

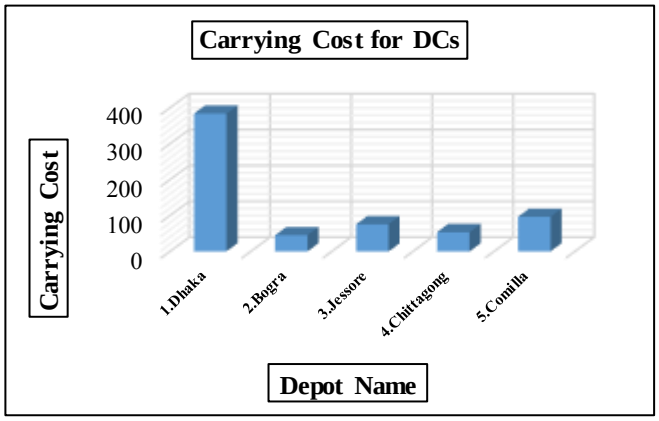

Figure 3. Carrying Cost of Goods For DCs of The FMCG MNC

After the calculation, from Table 2 it can be seen that the carrying cost is maximum for Dhaka DC which is 384.62 tk/km and carrying cost is minimum for Bogra DC which is 45.45 tk/km. We will not consider the Dhaka DC as it is our central one. Rather than we will compare the rest four to find out the one with maximum carrying cost, which is the Comilla DC. Carrying cost for the DCs are illustrated as bar chart in Figure 3.

Evaluated Total Service Time for Distributors

By analyzing data and using the equations from previous chapter total service time have been evaluated for the distributors of Dhaka and Comilla DC.

Table 3. Total Service Time for Distributors of Dhaka DC.

Distributor Location	Distance from Depot(Km)	Avg. Speed of Vehicle(Km/hr.)	Time to Reach(hr)	Time Spend in Queue(hr)	Loading & Unloading Time(hr)	Total Time (hr)
1.Faridpur	127.5	40	3.19	1.5	1.5	6.19
2.Gopalganj	200	40	5	1	1	7
3.Kishorganj	101	40	2.53	2	1	5.53
4.Madaripur	192	40	4.8	2	2	8.8
5.Mymensingh	112	40	2.8	2.5	2	7.3
6.Narayanganj	30	40	0.75	2	1	3.75
7.Tangail	87	40	2.18	2	1	5.18
8. Sylhet	246	40	6.15	2	1.5	9.65

Table 4. Total Service Time for Distributors of Comilla DC.

Distributor Location	Distance from Depot(Km)	Avg. Speed of Vehicle(Km/hr.)	Time to Reach(hr)	Time Spend in Queue(hr)	Loading & Unloading Time(hr)	Total Time (hr)
1.Bramhanbaria	63.3	40	1.5825	2.5	1	5.0825
2.Chandpur	83	40	2.075	2	2	6.075
3.Munshiganj	123.9	40	3.0975	1	1.5	5.5975
4.Chauddagram	24	40	0.6	1.5	1	3.1
5.Daudkandi	55	40	1.375	2	1	4.375
6.Laksam	30.6	40	0.765	1	2	3.765
7.Lalmai	99.3	40	2.4825	2	1	5.4825
8.Chandina	25.5	40	0.6375	2	1	3.6375

Evaluated Total Distribution Cost for Distributors

By analyzing data and using the equations, total distribution cost has been determined for distributors of Dhaka and Comilla DC. In case of the distributors, the total distribution cost has been calculated by summing the freight cost and loading-unloading cost. No fixed or variable cost is used in this case as both fixed cost and variable cost remains only with the DCs. The distributors are the third party and the FMCG MNC select those distributors by tendering.

Table 5. Total distribution cost for the distributors of Dhaka DC

Distributor Location	Distance from Depot(Km)	Unit Cost Per Km(tk/km)	Freight(tk)	Loading-Unloading Cost(tk)	Total Cost(tk)
1.Faridpur	127.5	30	3825	1900	5625
2.Gopalganj	200	30	6000	1800	7800
3.Kishorganj	101	30	3030	1600	4830
4.Madaripur	192	30	5760	1800	7560
5.Mymensingh	112	30	3360	1800	5160
6.Narayanganj	30	30	900	1800	2700
7.Tangail	87	30	2610	1900	4410
8.Sylhet	246	30	7380	2000	9410

Table 6. Total distribution cost for the distributors of Comilla DC

Distributor Location	Distance from Depot(Km)	Unit Cost Per Km(tk/km)	Freight(tk)	Loading-Unloading Cost(tk)	Total Cost(tk)
1.Bramhanbaria	63.3	30	1899	1600	3499
2.Chandpur	83	30	1860	1500	3360
3.Munshiganj	123.9	30	2988	1200	4188
4.Chauddagram	24	30	3750	400	4150
5.Daudkandi	55	30	1650	200	1850
6.Laksam	30.6	30	2280	200	2480
7.Lalmai	99.3	30	2106	200	2306
8.Chandina	25.5	30	2100	100	2200

Comparison of Total Distribution Cost After Optimization

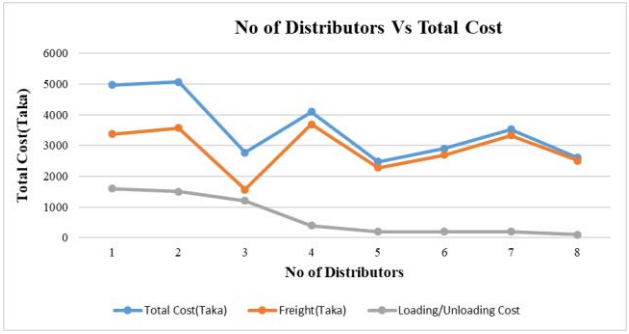

Figure 4. Graphical Representation of Total distribution Cost for distributors of Comilla from Dhaka DC

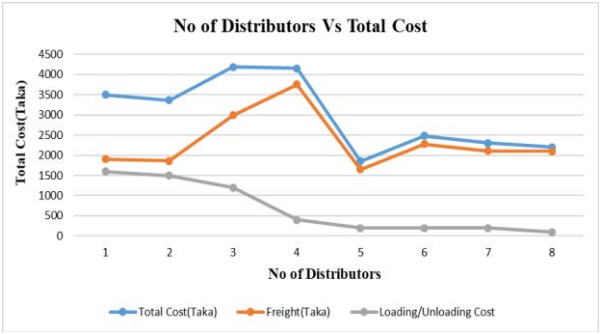

Figure 5. Graphical Representation of Total distribution Cost for distributors of Comilla from Comilla DC

Figure 4 and Figure 5 the graphical presentation of total distribution cost for distributors of Comilla from Dhaka DC(Figure 4) and Comilla DC(Figure 5) that includes both freight cost and loading/unloading cost can be seen. In Graph demonstration between No of Distributors Vs Total Cost for Comilla DC, it can be seen that the total distribution cost of Comilla DC is relatively high wherein after the optimization the total distribution cost for distributors of Comilla from Dhaka DC is Overall relatively low though initial cost is high (Figure 4). Here, Cost optimization for FMCG MNC is our main priority and the graph also shows the positive results.

Number of Trip and Trip Cost Calculation for Comilla DC

By using the equation from previous chapter, the number of trip for Comilla DC have been determined which is 18 trip per month as the sales volume for Comilla DC is 160 ton and the capacity of one truck is 9 ton. Cost for one trip is 12000 taka. So we have determined the cost for 18 trips by multiplying the no of trips with cost for each trip and found the total trip cost as 2,16,000 taka.

Scenario Before Optimization Using Regression Analysis

In case of scenario before optimization, the total distribution cost have been analyzed for distributors of Comilla from Comilla DC to find out the impact of freight cost and loading/unloading cost on total distribution cost as the priority is to optimize the network by the cost optimization method.

Regression Analysis: Total Cost (Tk) vs Freight (tk)

The output of total cost(tk) versus freight(tk) is as follows-

The regression equation is
Total Cost(Tk) = 842.4 + 0.9281 Freight(Tk)
S = 692.497 R-Sq = 50.6% R-Sq(adj) = 42.4%
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	2949530	2949530	6.15	0.048

Error	6	2877315	479553
Total	7	5826845	

The regression equation from the analysis output which represents a coefficient that is 0.9281 and this coefficient indicates that for every additional taka in freight we can expect total cost to increase by an average of 0.9281 taka.

F- value: Here, the F-value from analysis is 6.15 which is larger than the critical value which is 5.98.

- Null Hypothesis, H_0 = Freight doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Freight have a major impact on total cost.

As the F-value is greater than its critical value, so the null hypothesis is rejected and it indicates that the relationship between total cost and freight is statistically significant.

P-value: Here, the P-value from analysis is 0.048 which is less than the significance level 0.05.

- Null Hypothesis, H_0 = Freight doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Freight have a major impact on total cost.

As the P-value is less than its critical value, so the null hypothesis is rejected and it indicates that the relationship between total cost and freight is statistically significant.

Regression Analysis: Total Cost(Tk) versus Loading/Unloading Cost(Tk)

The output of total cost(tk) versus loading/unloading cost(tk) is as follows-
The regression equation is
Total Cost(Tk) = 2387 + 0.9150 Loading/Unloading Cost(Tk)
S = 753.113 R-Sq = 41.6% R-Sq(adj) = 31.9%
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	2423766	2423766	4.27	0.084
Error	6	3403079	567180		
Total	7	5826845			

The regression equation from the analysis output which represents a coefficient that is 0.9150 and this coefficient indicates that for every additional taka in loading/unloading cost we can expect total cost to increase by an average of 0.9150 taka.

F- value: Here, the F-value from analysis is 4.27 which is smaller than the critical value which is 5.98.

- Null Hypothesis, H_0 = Loading/Unloading Cost doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Loading/Unloading Cost have a major impact on total cost.

As the F-value is less than its critical value, so the null hypothesis is accepted and it indicates that the relationship between total cost and freight is not statistically significant.

P-value: Here, the P-value from analysis is 0.084 which is greater than the significance level 0.05.

- Null Hypothesis, H_0 = Loading/Unloading Cost doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Loading/Unloading Cost have a major impact on total cost.

As the P-value is greater than its critical value, so the null hypothesis is accepted and it indicates that the relationship between total cost and freight is not statistically significant. Finally, after analyzing the results including freight vs total cost, which is statistically significant and loading/unloading cost vs total cost, which is not statistically significant, we can say that the overall model is not statistically significant for distributing to the distributors of Comilla from Comilla DC as one relationship is statistically significant and the other is not.

Scenario After Optimization Using Regression Analysis

In case of scenario after optimization, we have analyzed the total distribution cost for distributors of Comilla from Dhaka DC to find out the impact of freight cost and loading/unloading cost on total distribution cost.

Regression Analysis: Total Cost(Tk) versus Freight(Tk)

The output of total cost(tk) versus freight(tk) is as follows-
The regression equation is
Total Cost(Tk) = 314 + 1.126 Freight(Tk)
S = 687.311 R-Sq = 63.2% R-Sq(adj) = 57.1%
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	4866866	4866866	10.30	0.018
Error	6	2834377	472396		
Total	7	7701243			

F- value: Here, the F-value from analysis is10.30 which is larger than the critical value which is 5.98

- Null Hypothesis, H_0 = Freight doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Freight have a major impact on total cost.

As the F-value is greater than its critical value, so the null hypothesis is rejected and it indicates that the relationship between total cost and freight is statistically significant.

P-value: Here, the P-value from analysis is 0.018 which is less than the significance level 0.05.

- Null Hypothesis, H_0 = Freight doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Freight have a major impact on total cost.

As the P-value is less than its critical value, so the null hypothesis is rejected and it indicates that the relationship between total cost and freight is statistically significant.

Regression Analysis: Total Cost(Tk) versus Loading/Unloading Cost(Tk)

The output of total cost(tk) versus loading/unloading cost(tk) is as follows-

The regression equation is shown in the next page.

Total Cost(Tk) = 2765 + 1.167 Loading/Unloading Cost(Tk)

S = 791.696 R-Sq = 51.2% R-Sq(adj) = 43.0%
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	3940551	3940551	6.29	0.046
Error	6	3760692	626782		
Total	7	7701243			

F- value: The F-value from analysis is 6.29 which is larger than the critical value which is 5.98.

- Null Hypothesis, H_0 = Loading/Unloading Cost doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Loading/Unloading Cost have a major impact on total cost.

As the F-value is greater than its critical value, so the null hypothesis is rejected and it indicates that the relationship between total cost and freight is statistically significant.

P-value: The P-value from analysis is 0.046 which is less than the significance level 0.05.

- Null Hypothesis, H_0 = Loading/Unloading Cost doesn't have a major impact on total cost.
- Alternative Hypothesis, H_1 = Loading/Unloading Cost have a major impact on total cost.

As the P-value is less than its critical value, so the null hypothesis is rejected and it indicates that the relationship between total cost and freight is statistically significant.

Finally, after analyzing the results including freight vs total cost, which is statistically significant and loading/unloading cost vs total cost, which is also statistically significant, we can say that the overall model is statistically significant for distributing to the distributors of Comilla from Dhaka DC.

Neural Network Analysis

Here, the two conditions that are mentioned in the previous chapter will be analyzed thoroughly.

Condition-1

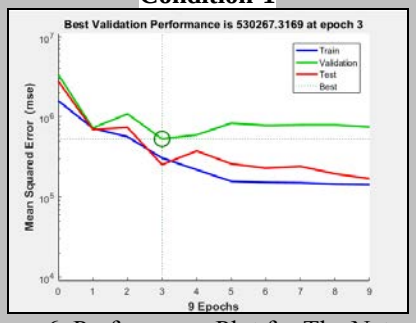

Figure 6. Performance Plot for The Network

Condition-2

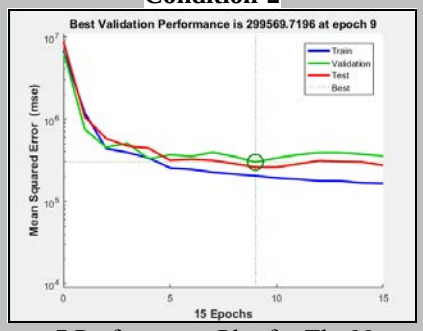

Figure 7.Performance Plot for The Network

Figure 6 is the performance plot for the network under condition-1 where the green line is for validation, red line is for testing and the blue line is for training. The dotted line is the best performance line under this training procedure. The best validation found in 9 epochs. All the three lines have much more deviations from the best fitted line. There is some overfitting between the test and validation as the test curve had increased significantly before the validation curve increased in a certain point. On the contrary, Figure 7 is the performance plot for the network under condition-2 where the green line is for validation, red line is for testing and the blue line is for training. The best validation found in 15 epochs. The validation and test curves are almost similar to each other and all the three lines have very little deviations from the best fitted line. There is no overfitting between the test and validation line. The result is reasonable because of two considerations- (1) The test set error and the validation set error have similar characteristics. (2) No significant overfitting has occurred by iteration 9 (where the best validation performance occurs).The next step in validating the network is to create a regression plot, which shows the relationship between the outputs of the network and the targets. If the training were perfect, the network outputs and the targets would be exactly equal, but the relationship is rarely perfect in practice.

Condition-1

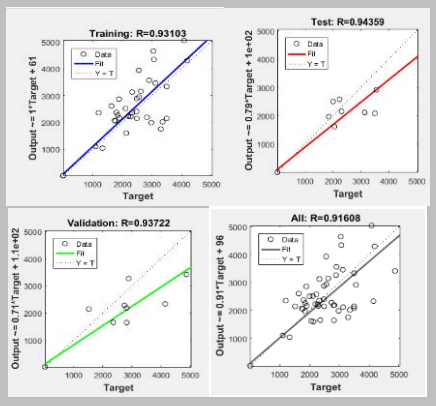

Figure 8. Regression Plots

Condition-2

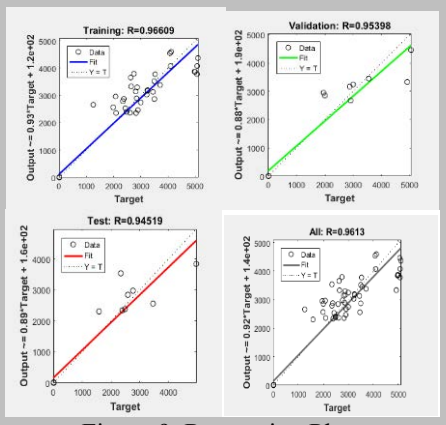

Figure 9. Regression Plots

From Figure 8 it can be seen that the linear plots of the data's of all three- training, validation and testing deviates largely from the best fit regression line data where it also indicates that all three data's combined plot has a fit of 91.608% with the best fitted regression line. The network also shows a performance value of 2.3164×10^{4}. From Figure 9 it can be seen that there is more exact linear relationship of the data's of all three- training, validation and testing respectively compared to those of condition-1 where it also indicates that all three data's has a fit of 96.13%

with the best fitted regression line which is quite better than condition-1. The network also shows a better performance value of 3.5953×10^5 which is actually 1.55×10^1 times better. So there is better feasibility for the data set of condition-2 compared to condition-1 which determines the suitability and better feasibility of the proposed model.

Results and Findings

In this research work, a structured and optimum network for distribution has been generated where the performance has been increased to supply right product at right place in right time. In case of mathematical analysis in MS Excel, it is found that by implementing the proposed model the FMCG MNC can be able to neutralize the amount of loss they have to consider for their existing network. proposed model tends to show better performance than the existing distribution network where the developed network shows 15.5 times better performance with a performance rate of 3.5953×10^5. The following table (Table-7) will give a overall summery of the necessity to implement our proposed model as well as some valuable findings.

Table 7. Summery of necessity and findings

Purpose	Findings
1. Fixed Cost Saving.	1. The FMCG MNC will be able to save 2,96,000 BDT per month.
2.Variable Cost Saving.	2. A total of 96,557 BDT per month will be saved
3. Freight Cost saving	3. It will save a amount of 12,000BDT per trip needed to carry the goods.
4. Reducing Number of Trips.	4. A total of 18 trips can be eliminated.
5. Monthly Trip Cost Saving	5. BDT 2,16,000 will be saved monthly.

Conclusion

Supply chain network design and optimization is a powerful supply chain modeling approach that enables companies to create accurate models of their end-to-end operations to identify major improvements in cost, service, sustainability and risk – often leading to total supply chain network savings. A fast and reliable distribution network is essential to a successful business because customers must be able to get products and services when they want them. It is well accepted fact that to succeed in 21st century, business need to construct highly efficient and effective supply chain networks. This precipitate the necessity to redesign and optimize the distribution network to attain more profitability. While developing this network optimization model, the authors have attempted to reduce the unnecessary logistical expenditure that causes loss of profitability for the MNC. Despite of that, environmental issues has also been taken into concern. Impacts on environment such as noise, Carbon dioxide and carbon monoxide emissions create direct and harmful effects on the environment. Reduction in environmental impact can help to demonstrate corporate social responsibility (CSR). Awareness of environmental issues is growing, and customers, investors and other stakeholders increasingly prefer to deal with businesses that have good environmental credentials. Consideration of increasing profitability along with environmental issues that leads to CSR, helps this network optimization model to be an efficient and sustainable one.

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Dr. Mohammad Morshed is a Professor of Industrial & Production Engineering in the Department of Mechanical & Production Engineering, Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh.

INDUSTRIAL SAFETY ENGINEERING: A SUSTAINABLE SOLUTION FOR OIL, GAS AND REFINERY INDUSTRIES

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Abstract

Safety always being a major concern of any sort of industry since past century. Safety decisions are different for various working situations and surroundings. Oil, Gas distribution organizations or Refinery are home of flammable liquid. So the safety systems of these industries are mostly different from other industries. So different strategic plan & safety model is a must for those highly integrated industries. Before constructing a solution potential hazards are identified and listed down in common categories. To identify hazards and their risk level risk assessment matrix is being used. After classification according to the taxonomy model, a decision is taken using administrative hierarchy. The hierarchy of control is designed for 2 types of decision. Design stage decisions and Safe work decisions are determined by the type and effect of the accident. Finally, 14 crucial safety factors are identified and those factors are tested via collected data and simulation. Data was collected through a questionnaire by visiting related industries like Eastern Refinery Ltd. Bangladesh. A statistical analyzed model has been constructed to show how sustainable the formulated model compared to mathematical calculation.

Keyword

Safety engineering, Safety, Hierarchy of control, Risk and Reliability, Factor analysis

1. Introduction

Oil, gas and refinery sector is the well inter-related and well-established sector. The fuel based industries are very sensitive as the whole business and decisions are related to international market as well as international standards. These industry deals with highly flammable liquids and crudes. Additional safety is a core concern for this sector. Lots of research and safety regulation are being produced for generalized industry and the assumptions are as like as other industries. But if we take a close look the core safety intensive of oil gas and refinery sector is pretty much different from another industrial sector. Here a mistake is not just a mistake, it can be the cause of burning down the whole plant. BP Texas refinery accident has stimulated the safety engineers to rethink about the safety of this sector.

Further topics addressed the roles and responsibilities of workers who are involved in offshore petroleum activities at facilities. There are reasonably practicable steps to take in order to protect the health and safety within the workplace. The final topic highlighted in the guide entails the importance of shift work and reducing fatigue. It is essential to recognize the signs of tiredness that affects a person's physical and mental activity. This year's edition of the guide goes on to identify the causes of fatigue and what appropriate steps to take to protect the health and safety of all in the oil and gas industry.

Some of the catastrophic recent occurrences are BP Texas & Mumbai accident. BP Texas accident took away 15 lives, injured over 170 people, and obligated thousands of residents that lived close to the plant to stay in their homes. The neighbouring country India had an accident in Mumbai in which 11 people died and 11 others were reported missing.

Industrial safety comes with a safety guaranty of mechanical and operational safety first. So at the initial stage, the safety of physical hazard is taken care. The potential hazard identifications and the propagation of those accidents. The successful operations are the sum of successive stages that we desire or demand. On the other hand, the accident is also a successive propagation of stages that we do want or that causes damage to the normal operation sometimes the whole plant. Sometimes the propagations of accidents are identical. Those are easy to protect. But sometimes those propagations are complex and has more than 2/3 stages. In those cases, the accident happing causes are traced by several steps and one of the pillars of propagations is limited to prevent the accident.

Several tools are used to determine the most happing hazard Causes and then the proper action determination is a relative decision according to the source and type of hazard.

2. Source of Hazards

Hazards Exist everywhere in every part of work plants. But after identifying the hazards the most important thing is to spot the source of hazard to stop them.

So, the source of hazard is mostly

- Physical Hazard
- Chemical Hazard
- Biological Hazard
- Hazards Out of Human factors
- Psychosocial Hazards

Among all of the hazards, we are avoiding the biological and psychosocial hazards because they are mostly applicable in firms and corporates world whereas the objective of this research is to identify the industrial safety factor and make a solution.

3. Hazard Analysis

After identification of hazard source, all the identified hazards are analyzed with tools and their actions are taken based on this part's result.

The first tool we are using here is Risk assessment matrix. There is 2 part of risk assessment. First, the position of the hazard is determined with the help of Risk assessment matrix then the level of the risk is determined to form the Risk severity vs probability matrix. What will be possible action toward those hazards are the outcome of this matrix.

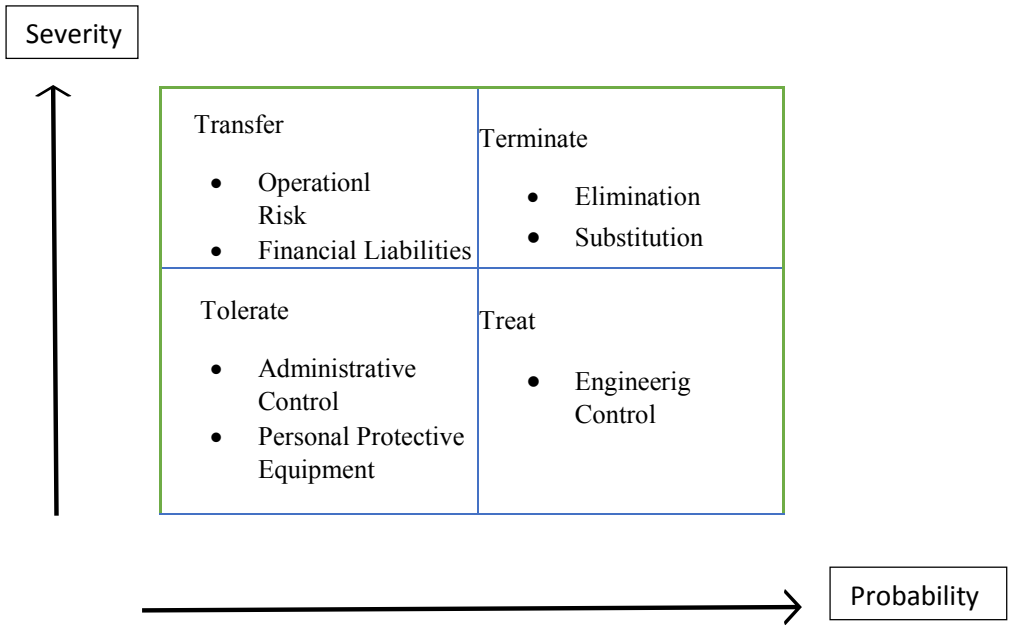

Figure 1. The World of Risk

All the risks are listed down here and the probabilities are also listed. Now from the graph, we can relate the real face to the theory. Here if it is in the 4th quadrant that means in the terminate face we have to do it. Normally it happens in the design face. On the other hand, is it is tolerable range make is less by putting administrative control and other measures. The source of this matrix is Government of South Australia Health and safety services 2006 report.

4. Zone diversification:

Most of the industries are in large space and the system of control is not same at all places. It is even for small companies too. There are certain places that must be taken under intensive supervision and other places are a comparatively lower specification of safety. Those are mainly dependable in various sectors of use. So further study will make things capable of classifying the sector according to the use.

An Industry can be classified into several zones according to its movement as per needed. This rule must be used for KPI industries as these are most vital industries.

5. Action

Accumulation all analysis the ways of prevention must find out. First, we need to sort out what is an accident.

The accident is a combination of hazard, target and situation. When all the 3 components are gathered then an accident occurs which is shown in below (Fig-2). But if one of the components is absent the sequences will be different.

So when an accident protection system is designed rather than trying to control all the 3 components the total system should support to remove one component so that the outcome of the accident is reduced.

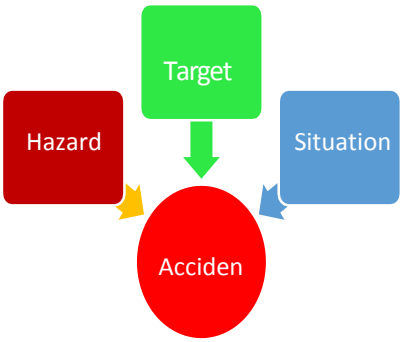

Figure 2. Accident Components

5.1 Hierarchy of hazard control

Hierarchy of hazard control is a system used in industry to minimize or eliminate exposure to hazards. It is a widely accepted system promoted by numerous safety organizations. This concept is taught to managers in industry, to be promoted as standard practice in the workplace. Various illustrations are used to depict this system, most commonly a triangle (Fig-3). The first elements are Elimination and substitutions. In Elimination and substitution, the common terms are Terminate that is Activity generating the risk, Terminate the potential risk in the business-the probability if the occurrence is too high / when it occurs. The dominant type of control will be Preventive. Treat is Risk to reduce the likely impact. Accept the risk probability of occurrence is high, severity impacts will not adversely affect the business or human ability to control the risk internally by providing systems & procedures. The dominant type of control will be- Tolerate means Risk and its likely impact / explore. Accept the risk probability and severity will not adversely affect the business and able to manage those risks internally. Risk to another party is transfer. Transfer the risk or the consequences of the risk to a third party. Self- finance method or to the insured market.

Engineering controls are tool or equipment such as chemical fume hood and biosafety cabinets used to protect against exposure, fencing or guarding or machinery. Are strategies designed to protect workers from hazardous conditions by placing a barrier between the worker and the hazard or by removing a hazardous substance through air ventilation? Engineering controls involve a physical change to the workplace itself, rather than relying on workers' behaviour or requiring workers to wear something. Engineering controls are the third of five members of the hierarchy of hazard controls, which orders control strategies by their feasibility and effectiveness. Engineering controls are preferred over administrative controls and personal protective equipment (PPE) because they are designed to remove the hazard at the source, before it comes in contact with the worker. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection. The initial cost of engineering controls can be higher than the cost of administrative controls or PPE, but over the longer term, operating costs are frequently lower, and in some instances, can provide cost savings in other areas of the process Administrative controls are procedures used to control and minimize risk for hazardous work. Work permits, Emergency preparedness plans etc. are its part. Alter procedures so that smaller quantities may be used.

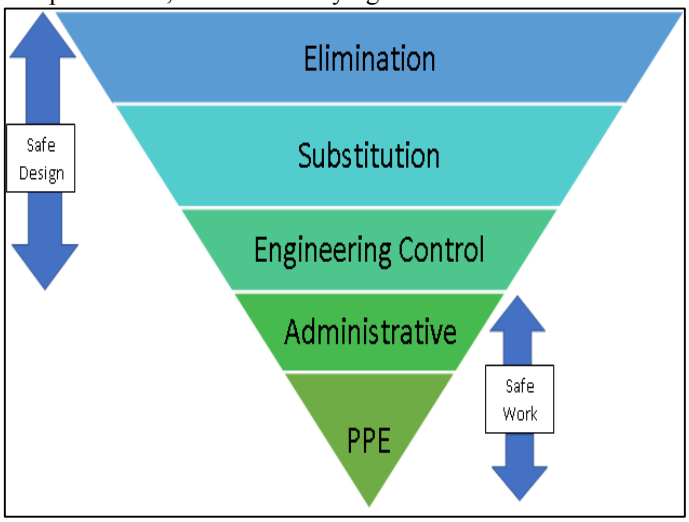

Figure 3. Hierarchy of hazard

Administrative controls are training, procedure, policy, or shift designs that lessen the threat of a hazard to an individual Administrative control are fourth in larger hierarchy of hazard controls, which ranks the effectiveness and efficiency of hazard controls Administrative controls are more effective than PPE because they involve some manner of prior planning and avoidance, whereas PPE only serves only as a final barrier between the hazard and worker. Administrative controls are second lowest because they require workers or employers to actively think or comply with regulations and do not offer permanent solutions to problems. Generally, administrative controls are cheaper to begin, but they may become more expensive over time as higher failure rates and the need for constant training or re-certification eclipse the initial investments of the three more desirable hazard controls in the hierarchy

Identifying and using PPE is being a great safety tool. When all 4 Types of safety measures are taken proper personal protective equipment should be chosen and worn to increase employee protection from all sort of hazards. Refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazard addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. Some of the PPEs are Eyeshield, Hand gloves, Industrial shoes, aprons etc.

Analyzing all the hazard some golden rules are made which is to be followed at any condition.

All general safety factors are

- Obtain a Valid Permit to work before commenting any job
- Conduct gas test
- Verify isolation before work & life protective equipment
- All authorization before working in confined space
- Fall protection equipment
- Authorization before overriding/ dispensability
- Safety critical equipment analysis
- Be aware of work surroundings
- Do not use banded/ unauthorized tools/ belts/equipment for any type of work
- Prepare the checklist for each task
- Do not walk under a suspended load
- Do not smoke outside of designated smoking areas
- No alcohol or drugs while working or driving
- Energy isolations
- Management of Change (MOC) Work arising from temporary and permanent changes to
- Follow prescribed Journey Management Plan

Now the whole tools needed to be combined with a smooth system to run. The working procedures of the hierarchy of hazard control of control is shown below in figure 4.

Here the first step starts with the hazard identification. Depending on the type of hazard the source is determined. Then necessary data is collected from the respective worker/department so that the risk level can be analyzed to take any action against it. After analyzing if the source/ hazard is found extremely high of risk level and cannot be controlled by the internal infrastructure of the industry then the work is outsourced from other sources.

If the source or hazard is controllable then it is further analyzed whether the new hazards are removable with the existing system of training or the organization has to refine the training procedure to remove the problems.

If the hazard is not removable with the tanning then the organization have to think about the design of the system to fit it with the existing problem. So that the total system runs smoothly and then the hazard is removed. Engineering design is not changeable every day. It can be changed one in2/3 year cause the change of any design is extremely costly and time-consuming procedure.

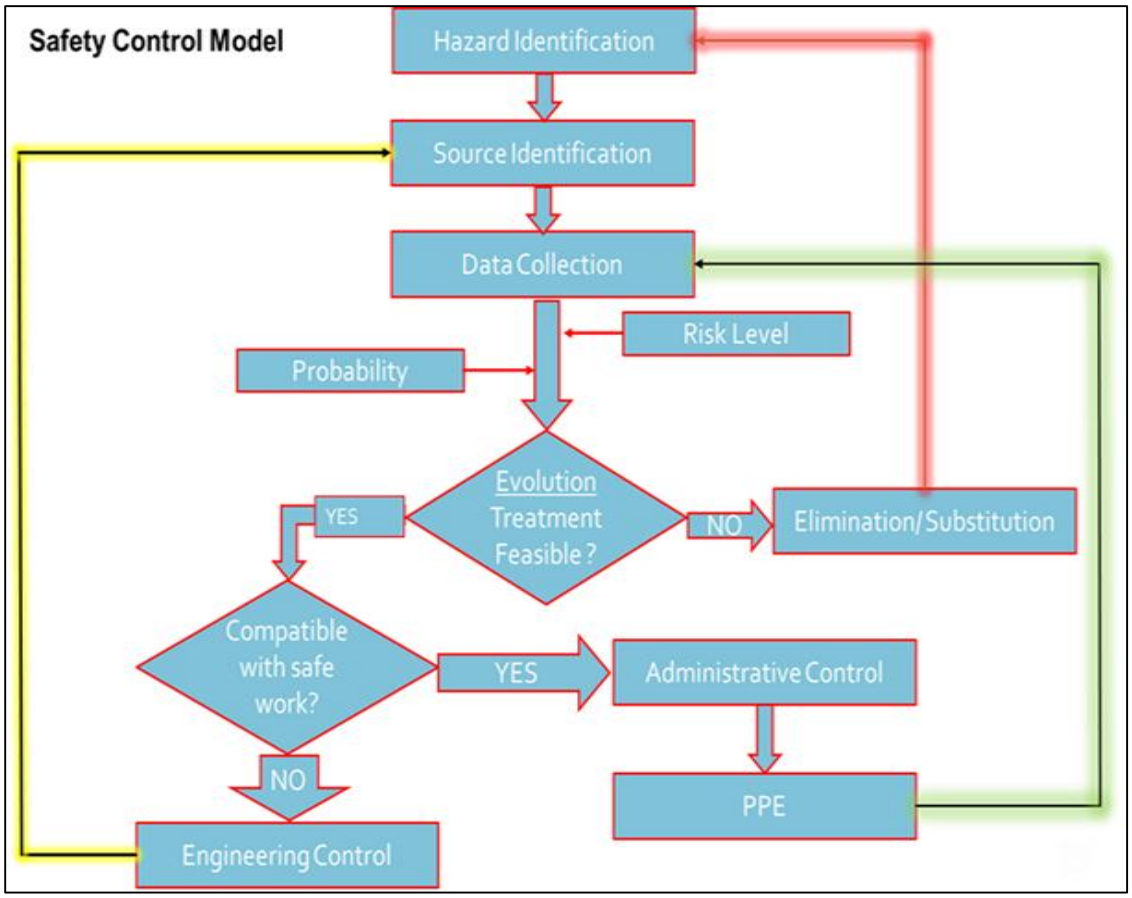

Figure 4. Safety Model

6 Hypothesis Test and Factor Analysis

The study involves a factor analysis to identify the inter-relation among the factors. 14 factors were identified from the proposed safety model. They are valid permit to work, gas test, verify isolation, authorization before working, fall protection, overriding, safety critical equipment, work surroundings, unauthorized tools, checklist, suspended loads, and management of change and management plan.

The data was collected through a survey using Likert scaling among 1 to 5 in two cases; the importance of that factors and the probability of the failure of those factors in our country's related industries. The survey was conducted among people who are working in those fields or previously worked and the students who have already studied about safety in this sector and visited related industries before.

The scaling was given like for the importance of safety factors;

1 = Low, 2 = Above Moderate, 3 = Moderate, 4 = Important, 5 = Very Important.

And for the probability of failure due to incident occurrence

1 = Very Low, 2 = Low, 3 = Medium, 4 = High, 5 = Very High.

After getting data, we analyzed it by using SPSS software.

Table-01: Descriptive statistics for safety factors and probability of incident occurrence

Safety Factors	Importance			Probability of Incident Occurrence		
	Mean	Variance	Standard Deviation	Mean	Variance	Standard Deviation
Valid permit to work	4.07	0.210	0.458	2.33	0.381	0.617
Gas Test	4.13	0.267	0.516	2.53	0.410	0.640
Verify Isolation	3.73	0.352	0.594	2.40	0.257	0.507
Authorization before working	4.00	0.571	0.756	2.67	1.095	1.047
Fall Protection	4.07	0.495	0.704	2.53	0.410	0.640
Overriding	4.00	0.429	0.655	2.27	0.924	0.961
Safety Critical Equipment	4.13	0.1238	0.351	2.60	1.400	1.183
Work Surroundings	4.07	0.0667	0.248	2.40	0.257	0.507
Unauthorized Tools	3.80	0.314	0.561	2.60	0.971	0.986
Check List	4.20	0.457	0.676	2.80	1.400	1.183
Suspended Load	3.93	0.0667	0.258	2.60	0.886	0.941
Remove Smoking	4.07	0.352	0.594	2.40	0.257	0.507
Management of Change	3.93	0.210	0.458	2.53	0.410	0.640
Management Plan	4.27	0.352	0.594	2.53	0.410	0.640

Table 01- shows the descriptive statistics of that factor. Mean, variance and standard deviation were measured to see the differences. The result shows that there is a significant difference between two conditions, so we can tell that the present safety condition in our industries is safe. A bar chart of the mean of those factors in two conditions is given below to realize the difference easily.

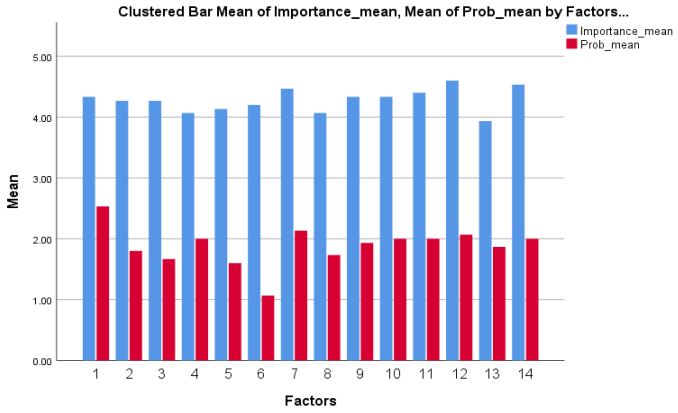

Figure 5. Mean of Importance of safety factors and mean of the probability of failure due to the incident occurrence of the factors (comparison).

Table 02: Wilcoxon Signed Rank Test Statistics

Importance-Probability Pair	**Z**	**P-value**
Valid permit to work	-3.345	0.001
Gas Test	-3.448	0.001
Verify Isolation	-3.397	0.001
Authorization before working	-2.673	0.006
Fall Protection	-3.372	0.001

Overriding	-3.225	0.001
Safety Critical Equipment	-2.979	0.003
Work Surroundings	-3.542	0.000
Unauthorized Tools	-2.684	0.007
Check List	-3.119	0.002
Suspended Load	-3.002	0.003
Smoking	-3.228	0.001
Management of Change	-3.286	0.001
Management Plan	-3.219	0.001

Significant Level= 0.05

Wilcoxon signed rank test used to implement hypothesis test of the factors. It has shown the differences in ratings and the pairing of safety factors among two cases. This test actually interprets the difference between a pretest and posttest. Here, ratings on the importance of safety factors have indicated as pretest and ratings on the probability of occurrence due to failure has regarded as a posttest.

From the table- 02, we have found that there is a significant difference between those two ratings. As the pair was made among two opposite conditions, so the more negative Z value is considered for a better result. This Wilcoxon signed rank test was also conducted in SPSS software. Wilcoxon signed rank test shows that there is a significant difference between the importance rating and the probability of incident occurrence rating ($P<0.05$), pointing to the potential relationship between the two datasets. As such, the null hypothesis that two data sets are the same is rejected. Differences in the ratings are also indicated. However, Wilcoxon Signed Rank Test does not show the correlation between two ratings.

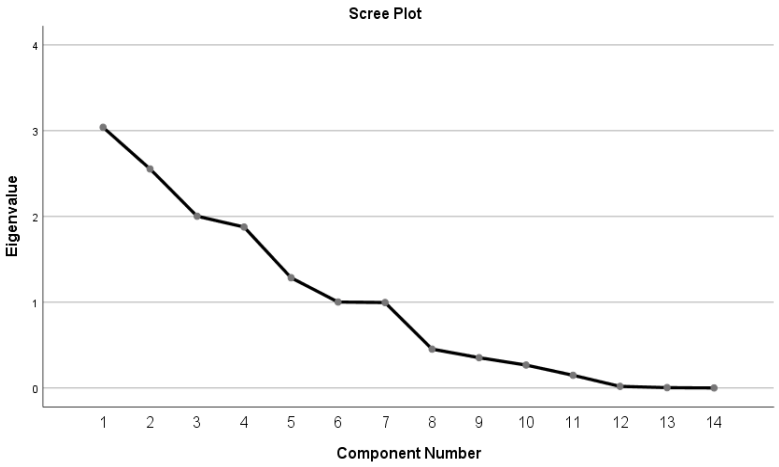

Figure 6. Component Group

From the table, we have observed that except “Authorization before working” and “Unauthorized tools” all others factors have satisfied the conditions. So, we should reject the null hypothesis for those factors whereas we should barely accept null hypothesis for that two factors and feel caution during interpreting the result.

The scree plot is a graph (Fig-6) of the Eigenvalues against all the factors. The graph is useful for determining how many factors to retain or how many component groups should be introduced. The point of interest is where the curve starts to flatten. It can be seen that the curve begins to flatten between 6 and 7. So only 6 components have been retained.

Table03 : Rotated Component Matrix

	Component					
	1	2	3	4	5	6
Valid permit to test	.456					
Gas test					.840	
Verify isolation		.767				
Authorization before working		.919				
Fall protection				.813		
Overriding	.932					
Safety critical equipment			.894			
Work surroundings					.811	
Unauthorized tools			.783			
Check list						.811
Suspended load				.822		
Remove smoking	.899					
Management of change						.551
Management plan			.604			.594

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Factor analysis has shown the correlations between the safety factors. Some safety factors are more connected than the others by eliciting a certain pattern of characteristics. This pattern of characteristics is used for identification of overarching factors affecting the safety of offshore oil and gas installations. The rotated component matrix of factor analysis has given on the table. Safety factors with factor loadings of 0.40 or greater are considered as significant.

Factor analysis identifies six groups of correlated safety factors. The first group has comprised of 3 safety factors, whereas group second, the third, fourth, fifth and sixth group have comprised with 2, 3,2,2,3 safety factors respectively.

From this table-3, we have also identified that, if we give importance on a factor in our model, we also need to give same importance on the factors that have joined with that in the same component group. As an example, if we have observed, component group-3, we can tell that, we need to give similar importance on safety critical equipment, unauthorized tools and management.
As an example, in the component group- 1 (table- 03), there are 3 factors. They are valid permit to test, overriding and remove smoking. According to our result, if we give importance on overriding, we must need to give importance to other safety factors. In this situation, the relation between overriding and remove smoking is stronger than their relationship with valid permit to test. So we cannot ignore any factor in those particular groups. Other five component groups also made relations among their corresponding factors respectively.

Conclusion

The relation between the safety factors is significantly affecting the total safety system. The collected data indicated in section 6 are a source of the statically designed model and it also represented how the factors are interconnected. The safety tools are available all around the theory world but a proper combination of the tools are mandatory for the successful outcome of the model. The model combines the spreader tools into one tool and made easy the decision process for which hazard which decision is more suitable. The values of table 02 mean that the more negative the value is the more factors are fit to the situations. The safety factors are mostly general rules for these highly flammable liquid based industries. Fire is the main enemy of these industries. But without fire other little and miss management can also carry out vital accidents. All of those factors are analyzed and shown in the graph in fig 6. All the systems are accumulated and then analyzed to maximize the reliability of the model.

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Biographies

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Sudipto Pal has completed his graduation from Ahsanullah University of Science and technology from the Department of Mechanical and Production Engineering. His program was Industrial and Production Engineering. He has completed a qualitative research in Safety Engineering. He feels comfortable to work in the sector like Safety engineering, Scheduling, Aggregate production planning, Statistics. He has interest in material handling, Automation and storage system also.

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MEASURING THE SUPPLY CHAIN PERFORMANCE THROUGH KPI IDENTIFICATION AND EVALUATION

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Abstract

Supply chain management has become one of the most discussed topics in business literature. To get the performance desired from supply chain, it requires continuous measuring and monitoring the supply chain Key Performance Indicators (KPIs). The purpose of this paper is to develop a model to identify and evaluate the KPIs of inventory in supply chain, thus to implement lean and to minimize wastages in inventory management. The theoretical framework, focusing on inventory aspects when measuring supply chain performance, is formed and used in order to develop a new inventory system for measuring performance. KPIs are used to determine the crucial factors that can be improved. Taguchi, ABC and EOQ analysis have been implemented which can be utilized as a plan to map the future state and for maximum optimized inventory system. The economic order quantity found for raw materials is 565 tons per order and the economic number of order is 15 orders per year for the company that has been studied. It means if the company order**s** their raw material**s** 15 times a year it will be convenient for them. This process will be the same for other materials as well. Taguchi proposes optimum levels for each factors to increase productivity where the factor's levels corresponding to the highest S/N ratio are chosen to optimize the condition. Such as for the first factor of inventory raw materials, the larger S/N ratio is at level 2, so level 2 is chosen for the first factor which is sourcing. Rest of the factor's levels are chosen in the same way. The factors should be kept at those recommended levels for optimized and improved inventory performance. ABC analysis is done based on defective items due to classify the defects depending on their amount. ABC analysis has helped to identify major defects depending upon their occurrence percentages such as bending has the maximum occurrence percentage (31.4%) which is classified as A class and air defect has the minimum occurrence percentage (2.2%) which is classified as C class. However, before being properly implemented the success of the measures is uncertain.

Keywords: KPI, Inventory, Supply chain, Performance measurement, Taguchi, Lean

Introduction

Supply Chain Management is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders (Lambert & Cooper, 2000). Improving supply chain performance is a continuous process that requires both an analytical performance measurement system, and a mechanism to initiate steps for realizing KPI goals; herein the mechanism is called to achieve KPI goals as "KPI accomplishment", which connects planning and execution, and build steps for realization of performance goals into routine daily work (Jian Cai et al. 2008). To measure supply chain performance, there are a set of variables that capture the impact of actual working of supply chains on revenues and costs of the whole system. These variables as drivers of supply chain performance are always derived from supply chain management practices (K. Ramdas, R.E. Spekman, 2000).

Managing customer and vendor relationships is a critical aspect of managing supply chains. In many cases, the collaborative relationship concept has been considered the essence of supply chain management. However, a closer examination of supply chain relationships, particularly those involving product flows, reveals that the heart of these relationships is inventory movement and storage. Much of the activity involved in managing relationships is based on the purchase, transfer, or management of inventory. As such, inventory plays a critical role in supply chains because it is a salient focus of supply chains (Terry L. Esper, Matthew A. Waller, 2014). According to Womack et al. (1990), the lean production philosophy considers inventory a form of waste that should be minimized. In recent decades, as lean production has gained widespread adoption (IndustryWeek, 2008), lean inventory management has become synonymous with good inventory management (Hall, 1983; Zipkin, 1991; Chen et al., 2005; Cooper and Maskell, 2008). Since measuring performance is considered an important element in order to stay competitive, the purpose of this research is to develop a structured framework for creating and evaluating supply chain performance indicators with the aim of facilitating organizations efforts when measuring supply chain performance. The framework will aim to help firms in their continuous improvement work by selecting and categorizing new performance measures, as well as evaluating existing performance measures.

Literature Review

Measuring supply chain performance provides important feedback information, helps to reveal progress, increase employer's motivation and communication, and helps to diagnose problems (Ramaa et al. 2009). The measures that help a company measure their progress on performance objectives in everyday work are often referred to as key performance indicators (KPIs).

Studies on Supply Chain management

Supply Chain Management is a very broad term, because it incorporates a wide range of activities: transportation & logistics, inventory & forecasting, supplier management, after sales support and reverse logistics are some examples. Inventory management is just one aspect of SCM. About SCM, there are various (slightly) different definitions available, for instance, Supply chain management (SCM) is the management of a network of interconnected business involved in the ultimate provision of product and service packages required by end customers (Harland, 1996). According to Lambert and Cooper (2000), Supply chain management (SCM) is a term that was first introduced by consultants in the early 1980's and since then frequently gained increased attention by both researchers and organizations. Today, it has become one of the most discussed topics in business literature and is considered a key strategic element (Peng Wong & Yew Wong, 2007).

Studies on Lean and Inventory Management

According to Womack et al. (1990), Lean production can be described as a strategy or philosophy that relies on a set of practices (e.g. Kanban, total quality management, etc.) to minimize waste (e.g. excess inventories, scrap, rework, etc.) in order to improve firm performance. Balakrishnan et al. (1996) and Kinney and Wempe (2002) compared the financial performance of a group of firms that had adopted lean production and an equal number of similar firms that had not. While Balakrishnan et al. (1996) observed a significant increase in inventory turnover in the treatment group as compared to the control group. Chen et al. (2005) analyzed inventory data from U.S. manufacturing firms between 1981 and 2000. Assuming that lean production and inventory management principles gained widespread acceptance over this period, they observed a significant decrease in raw material and work-in-process inventories as expected, but no change in finished goods inventories.

Studies on performance measurement and improvement by evaluating Key Performance Indicators

Key Performance Indicators represent a set of measures focusing on the aspects of performance that are vitally important for the current and upcoming success of the company. KPIs are not new to the organizations. They either have not been recognized before or have been abandoned to "gather dust" somewhere, out of sight of the current management team (Parmenter, 2010). Key Performance Indicators must be determined for every single critical success factor of a company. The right KPIs will make a great difference, they will bring along more constant attention from the management because they will tell the management what action needs to take place. Also, KPIs are deep enough in the organization that it can be tied to an individual (Parmenter, 2010).

Performance indicators do not just simply describe what has happened, but they also influence what will happen because they gives input and information for decision makers to make decisions that will further affect the future competitive position of the company. The role of performance indicators in manufacturing is to reflect the current condition of the manufacturing situation, to monitor and control operational efficiency, to propel improvements and to measure the effectiveness of manufacturing decisions implemented (Amrina and Yusof, 2011).

Failte, (2013) stated that Key Performance Indicators (KPIs) are good practices within the hotel industry especially, and the hospitality and tourism industry generally, to use a series of standard Key Performance Indicators to monitor and to benchmark performance. Cable and Davis **(**2004**)** argued that poor facility management could result in inadequate facilities to support functioning, excess facilities not contributing to the organization**'**s mission, cost inefficiencies, inadequacy, and unavailability of facilities for future needs**.**

Cable and Davis **(**2004**)** added that private sector organizations have a profit**-**oriented approach in selecting KPIs, but federal government organizations, like other public entities, emphasize excellent delivery of goods and services to the public**.** They also added that a set of KPIs must be identified and tracked over a period of time so that it can be compared against a baseline in order to examine improvements or deterioration**.**

Theoretical Background

The research is based on supply chain and one of the major driver to improve supply chain is Inventory management, so it is mainly focused on the inventory management system of an industry to implement lean.

Major classification of inventory

It can be classified as raw materials, work in process materials and finished goods.

Factor types

- **Control factors:** Which can be controlled at any time as required
- **Noise factors:** Which can not be controlled

According to these control and noise factors raw materials, work in process materials and finished goods are sub divided into several factors which can affect the overall inventory performance.

Sub dimensions of inventory types according to their factors

Sub dimensions of control and noise factors for inventory raw materials management are shown in table 1

Table 1. Sub dimensions of inventory raw materials management

Control Factor	Noise factor
Sourcing	Material cost
Internal quality audit	Transportation lead time
Order cycle time	Material quality
Warehouse	
Material availability	

Sub dimensions of control and noise factors for inventory work in process materials management are shown in table 2

Table 2. Sub dimensions of work in process materials management

Control Factor	Noise factor
Worker skill	Material quality
Material handling	
Machine downtime	
Production rate	

Sub dimensions of control and noise factors for inventory finished goods management are shown in table 3

Table 3. Sub dimensions of finished goods management

Control Factor	Noise factor
Right first time	Customer complaints
Defective items	Availability of inventory floor space
Inventory utilization	
Over production	

Model Formulation

1. Mathematical Formulation of EOQ

The above graphic method of determining EOQ may not provide the most accurate result. Economic order quantity can be calculated mathematically with a great degree of accuracy as given blow:

Formula

$EOQ=\sqrt{(2\times D\times S)/H}$

Where,

EOQ = Economic order quantity

D = Demand in units

S = Cost incurred to place a single order

H = Holding cost per unit per year

2. ABC analysis (based on defective items)

The ABC classification allows organizations to separate the finished goods into three classes. **A**-very important, **B**-moderately important and **C**-least important. The conventional ABC classification system is intended for grouping items of a manufacturing firm according to annual sales volume. In this paper the ABC analysis is done based on defective items. There are several defects that require important considerations for management like bend, bottom up, bottom down, crack, edge sharp, pinhole, glaze defect, air, iron, sagger spot, kiln dust and other considerations that may need management's utmost attention.

3. Taguchi analysis

For implementing Taguchi in inventory management and to find out which factors should get more priority and which should get less under specific KPI's, we had derived several factors as control factors and noise factors and leveled them out depending on several selection criteria. The factors and levels are given below:

- **Factors and levels of Inventory Raw Materials Management KPI are shown in Table 4**

Table 4. Inventory Raw Material's factors and levels

Sub dimensions	Factors	Score	Description of selection criteria's
Sourcing	Control	1	Supplier is not reliable, not responsible and sourcing cost is high
		2	Supplier is reliable and responsive but sourcing cost is relatively high
		3	Supplier is reliable and responsive and sourcing cost is moderate
		4	Everything is optimized
Raw material cost	Noise	1	If material cost is around 45% of total sell
		2	If material cost is around 40% of total sell
		3	If material cost is around 35% of total sell
		4	If material cost is around 30% of total sell
Transportation lead time	Noise	1	More than 110 days
		2	Within 100 to 110 days
		3	Within 90 to 100 days
		4	Below 90 days
Material Quality	Noise	1	The amount of moisture is more than 30%
		2	The amount of moisture is 25%-30%
		3	The amount of moisture is 20%-25%

		4	The amount of moisture is below 20%
Warehouse management	Control	1	Over depressive warehouse
		2	Average wraehouse management
		3	Proper management, record keeping and items availability is maintained
		4	No obsolete items are kept and item availabilty is ensured
Material availability	Control	1	Poor
		2	Availability is quite uncertain
		3	Frequently face product's unavailbility during processing
		4	Always raw materials are available on time
Internal Quality Audits	Control	1	Occurs once in a month
		2	Occurs in a weak
		3	Occurs twice in a weak
		4	Occurs daily
Order Cycle time	Control	1	It is too large than it required
		2	It is quite slow
		3	Time is moderate but it can be improved
		4	Improved and efficient order cycle time

- **Factors and levels of Inventory Work In Process Materials Management KPI are shown in Table 5**

Table 5. Inventory Work In Process Material's factors and levels

Sub dimensions	Factors	Score	Description of selection criteria's
Material Quality	Noise	1	If the grain size is less than 5mm and not well extracted
		2	Well extracted and 5mm grain size
		3	Well treated or extracted and grain size more than 10mm
		4	Well treated and extracted and particle size 5mm-10mm
Worker Skill	Control	1	New worker
		2	Have limited experience
		3	Well trained
		4	Well trained and have high skill
Production Rate	Control	1	Produces 1000 piece/hour
		2	Produces 1500 pices/hour
		3	Produces minimum 1875 pieces/hour
		4	Produces more than 1875 pieces/hour
Machine Downtime	Control	1	Large downtime
		2	Moderate downtime for maintainance
		3	Instant action to restart the production

		4	No downtime
Material Handling	Control	1	Manual handling, no automation
		2	Manual handling with little automation
		3	More automated with little manual handling
		4	Totally automated system

- **Factors and levels of Inventory Finished Goods Management KPI are shown in Table 6**

Table 6. Inventory Finished Good's factors and levels

Sub dimensions	Factors	Score	Description of selection criteria's
Defective items	Control	1	Defects percentage is more than 20 %
		2	Defects percentage is not more than 15 %
		3	Defects percentage is less than 10%
		4	Defect percentage is less than 5%
Over Production	Control	1	If leads to excessive inventory, over production and also discourage smooth flow of goods
		2	If it leads to excessive inventory only and too early production
		3	Very little excessive inventory & over production which doesn't discourage the flow
		4	No over production
Right first time	Control	1	Probability of correct at first time is less than 30%
		2	Probability of correct at first time is 30- 60%
		3	Probability of correct at first time is 60-90%
		4	Probability of correct at first time is more than 90%
Customer complaints	Noise	1	If company receives complain from buyer in every contract
		2	If company receives complain from buyer within two contract
		3	If company receives complain from buyer in within 4 or 5 contract
		4	If company doesn't receive any complain from buyer
Inventory Utilization	Control	1	If production schedule not level & inaccurate forecasting with unreliable supplier
		2	If production schedule is in level but little inaccurate
		3	If production schedule is in level having large lot size
		4	Everything is optimized
	Noise	1	Floor space availability is poor

Availability of Inventory Floor space		2	Floor space availability is quite uncertain
		3	Floor space availability is moderate
		4	Floor space availability is excellent

Model Implementation

1. Economic Order Quantity (EOQ)

Table 7 contains the required data for the analysis which was collected from Paragon Ceramics Industry Ltd.

Table 7. Collected data for EOQ analysis

Sl no.	Material	Consumption per month	Price per ton
1	Raw material	700 ton	18000 tk
2	Color	2 ton	5000000 tk
3	Packaging material	70 ton	30000 tk
4	Decal paper	3.5 ton	55000 tk

- Per day production- 45000 piece
- Raw material cost- 30% of total sell
- Inventory capacity- 4/5 lacks table ware
- Lead time- 60 days between order receiving and delivery

EOQ sample calculation

For Raw material
Demand, D= 8400 ton/year
Ordering cost, S= 143640000tk/year
Holding cost, H=7560000tk/year

So, Q=$\sqrt{\frac{2DS}{H}}$= 565 units
and No.of order per year = 15

For Color
Demand, D=24ton/year
Ordering cost, S=114000000tk/year
Holding cost, H=6000000tk/year

So, Q=$\sqrt{\frac{2DS}{H}}$ = 31 units
and NO. of order per year = 1

Table 8 shows the economic order quantity and number of orders per year for each materials according to the analysis.

Table 8. Economic Order Quantity for each materials

Sl No	Components	Demand Ton/year	Ordering cost/year	Holding cost/year	EOQ(ton)	No. of order/year
1	Raw material	8400	143640000 tk	7560000 tk	565	15
2	Color	24	114000000 tk	6000000 tk	31	1
3	Packaging paper	840	23940000 tk	1260000 tk	184	5
4	Dacale paper	42	2194500 tk	115500 tk	40	1

From the above table it can be seen that for raw materials the optimum economic order quantity is 565 ton and the number of order per year is 15. It means if the company order**s** 565 tons of raw material**s** for 15 times in a year it will be convenient for them and there will be no wastages or minimized wastages. This process will be the same for the other materials as well.

2. ABC Analysis (based on defective items)

If the product is defected, it is categorized in different classes like A class, B class or C class according to the majority of defects. And if the product is not defected, it goes to the export class.
We have conducted an ABC analysis on paragon ceramic company's defective products.

Table 9 shows the type of defects and their categories.

Table 9. Categorizing types of defects

Types of Defect	No. of defected Item	Percentage of defect Item	Category
Bend	2200	31.4%	A
Shivering	550	7.8%	B
Bottom up	1000	14.2%	B
Bottom down	900	12.8%	B
Pinhole & Pitting	1400	20%	A
Crack	600	8.5%	B
Glaze defect	200	2.8%	C
Air	150	2.2%	C
	∑7000		

Sample Calculation

For Crack = (600/7000) *100% = 8.5 % (in B category)
For Bend = (2200/7000) *100% = 31.4% (in A category)
For Glaze defect = (200/7000) *100% = 2.8 % (in C category)

The defects are re ordered in table 10 according to their categories.

Table 10. Reordering defects

Types of ABC	Name of defects	Percentage (%)
A	Bend	31.4
A	Pitting & Pinhole	20
B	Bottom up	14.2
B	Bottom down	12.8
B	Crack	8.5
B	Shivering	7.8
C	Glazing Defect	2.8
C	Air	2.2

From the above ABC analysis, the defect's types and percentages are found and the main defects which occur mostly in the ceramic industry are selected as well. It can be seen that the main focus should be given on reducing the Class-A type defects which are bending, pitting and pin holing. Then the focus should be given on Class-B type defects which includes bottom up, bottom down, cracking, shivering. The least focus should be given on Class-C type products which includes Glazing defect and air defect. And if the main defects are minimized it will be a good waste minimization as well.

3 (a). Taguchi Analysis (For inventory raw materials management KPI)

To select an appropriate orthogonal array for conducting the experiments, L16 array was used where total runs were 16 for 5 factors. Each of the 16 experiments were conducted 8 times (128 experiments in all) as there were 3 noise factors to account for the variations that may occur due to the noise factors. The objective function for productivity is larger-the-better type of control function which was used in calculating the S/N ratio.

All these values are tabulated in the following table 11.

Table 11. Taguchi analysis for inventory raw materials management KPI

Sourcing	Internal Quality Audit	Order Cycle Time	Warehouse Management	Material Availability	Measured value of hourly production								SNRA1	MEAN1
1	1	1	1	1	1842	1857	1848	1848	1870	1856	1870	1860	65.37297	1856.375
1	2	2	2	2	1850	1865	1864	1871	1862	1849	1872	1841	65.38634	1859.25
1	3	3	3	3	1845	1858	1870	1843	1862	1844	1843	1848	65.35071	1851.625
1	4	4	4	4	1850	1853	1863	1842	1863	1845	1865	1861	65.36778	1855.25
2	1	2	3	4	1844	1875	1874	1869	1856	1874	1870	1871	65.42075	1866.625
2	2	1	4	3	1851	1874	1859	1865	1864	1851	1872	1855	65.39642	1861.375
2	3	4	1	2	1846	1865	1859	1843	1846	1873	1872	1861	65.38103	1858.125
2	4	3	2	1	1868	1856	1865	1865	1864	1852	1868	1866	65.40414	1863
3	1	3	4	2	1847	1875	1864	1845	1844	1857	1875	1875	65.39079	1860.25
3	2	4	3	1	1865	1858	1857	1848	1846	1860	1846	1850	65.36085	1853.75
3	3	1	2	4	1843	1863	1846	1860	1868	1871	1854	1842	65.37055	1855.875
3	4	2	1	3	1843	1852	1843	1848	1865	1841	1846	1842	65.33148	1847.5
4	1	4	2	3	1859	1847	1867	1843	1859	1871	1854	1842	65.36767	1855.25
4	2	3	1	4	1856	1846	1869	1863	1847	1857	1874	1875	65.39392	1860.875
4	3	2	4	1	1846	1868	1857	1847	1873	1848	1844	1851	65.36298	1854.25
4	4	1	3	2	1842	1859	1866	1843	1850	1849	1844	1859	65.35021	1851.5

From the above analysis the following graph in figure 1 was plotted which identifies the optimum levels for each factor which has been shown in table 12.

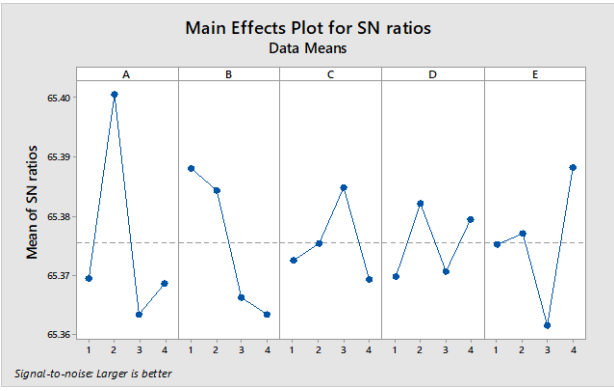

Fig 1. SN ratios for increasing productivity

Factors	Level
Sourcing	2
Internal quality audit	1
Order cycle time	3
Warehouse management	2
Material availability	4

Table 12. Optimum levels for each control factor

If the proposed levels are implemented according to the corresponding factors, the performance will be improved and optimized with minimum wastages in the inventory system.

3 (b). Taguchi Analysis (For inventory work in process materials management KPI)

To select an appropriate orthogonal array for conducting the experiments, L16 array was used where total runs were 16 for 4 factors. Each of the 16 experiments were conducted 2 times (32 experiments in all) as there was 1 noise factor to account for the variations that may occur due to the noise factor. The objective function for productivity is larger-the-better type of control function which was used in calculating the S/N ratio.
All these values were analyzed in the same process as raw materials management KPI was tabulated in table 11.

From that analysis the following graph in figure 2 was plotted which identifies the optimum levels for each factor which has been shown in table 13.

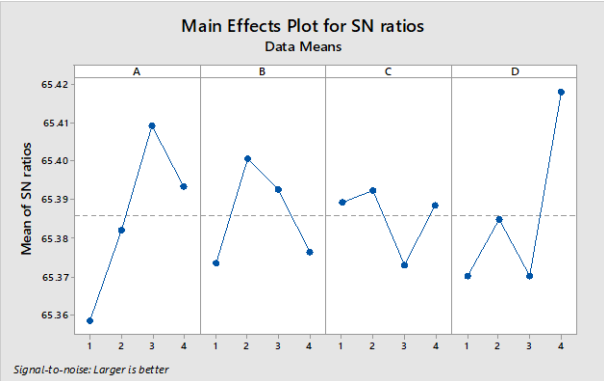

Fig 2. SN ratios for increasing productivity

Factors	Level
Worker skill	3
Material handling	2
Machine downtime	2
Production rate	4

Table 13. Optimum levels for each control factor

3 (c). Taguchi Analysis (For inventory finished goods management KPI)

To select an appropriate orthogonal array for conducting the experiments, L16 array was used where total runs were 16 for 4 factors. Each of the 16 experiments were conducted 4 times (64 experiments in all) as there were 2 noise factors to account for the variations that may occur due to the noise factors. The objective function for productivity is larger-the-better type of control function which was used in calculating the S/N ratio.
All these values were analyzed in the same process as raw materials management KPI was tabulated in table 11.

From the above analysis the following graph in figure 3 was plotted which identifies the optimum levels for each factor which has been shown in table 14.

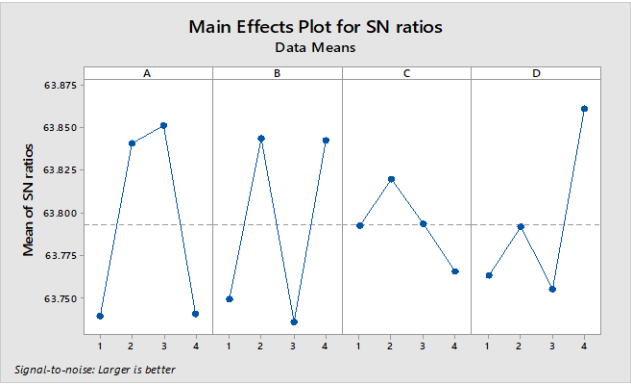

Fig 3. SN ratios for increasing productivity

Factors	Level
Right first time	3
Defective items	2
Inventory utilization	2
Over production	4

Table 14. Optimum levels for each control factor

For these three inventory management KPIs, the proposed levels should be implemented according to the corresponding factors, for improved and optimized performance with minimum wastages in the inventory system.

Conclusions

The main purpose of this paper was to identify and evaluate the KPIs of supply chain and to improve them. The first approach was to identify the KPI's of inventory management as it is one of the main drivers of supply chain. As supply chain has a vast area so it was decided to focus on a specific driver. By improving these KPIs, it can affect the overall supply chain performance and its framework.

For the research purpose, a study was conducted at Paragon Ceramics Ltd. Gazipur to monitor the inventory system and for collecting the required data. Three methodologies were used to analize those data. Those were Taguchi analysis, EOQ analysis and ABC analysis. From those three analysis several decisions were made to improve the inventory management performances, thus to implement lean in the inventory system.

From taguchi analysis the optimum recommendations for rapid improvement of inventory management KPIs were proposed. Taguchi proposed optimum levels for each factors to increase productivity at an optimum level which would not be a burden for inventory management. From EOQ analysis the economic order quantity per year for the company was measured which can be cost efficient as well as can save inventory capacity and can make proper use of it. And finally ABC analysis was done due to catagorize the defective and non defective items and their rapidness of occurrence and to identify the remedies to several defects for increasing non defective production rate.

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Management of The Logistics System of UBER in Bangladesh

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Abstract

In today's world, logistics systems are threatened by all kinds of uncertainties. Problems like location problem, traffic problem, scheduling problem, safety problem are being faced frequently. As a result, an effective and efficient management scheme is of a top most priority. This paper concisely explores, identifies and give directions to problem management of logistics systems in several critical areas. The reason for doing this is to improve the management system of UBER logistics system and at the same time propose some works that can be done in the near future. Various studies regarding management of logistics systems have been done to know their findings and limitations. Different methodologies have been applied for solving all the uncertainties and problems. At the end, utilization of logistics system has been done with the use of several tools like one way ANOVA, TSP, CPM, VRP etc. This paper ends with a proposal of various future research directions for advancing management of logistics systems of UBER.

Keywords
Logistics (Transportation); Management; UBER; Optimization

Introduction

Uber is mainly an app based car service founded in 2009 in San Francisco, California, United States and is now operating in 581 cities around the world. Uber uses a disruptive business model driven by digital technology (ICT driven) to trigger a ride-sharing revolution. Once downloaded and an account is created, UBER app allows customers to summon nearest driver at the push of a button. Once the ride is over, payment can be done by cash or by credit card. Following the ride, the customers are highly encouraged to rate their experience and have the option of leaving additional feedback about the driver through the app.

The services that UBER provides are UBER X, UBER BLACK, UBER POOL and UBER SUV. Uber has not limited itself to a particular segment of cars or to a particular segment of people. There is Uber X, Uber Black for those who love to travel in a black car, Uber Taxi for those looking for cost-efficient solutions and Uber SUV for those who want luxury. And there is an addition to motorcycle services which is named as UBER moto. Uber has come a long way from cabs. UBER is continuously adding new streams of revenue into its business model.

From a trip, the drivers are given 20% of the share and UBER keeps rest 80% (fig 1.1). So this runs along with the sharing of economy

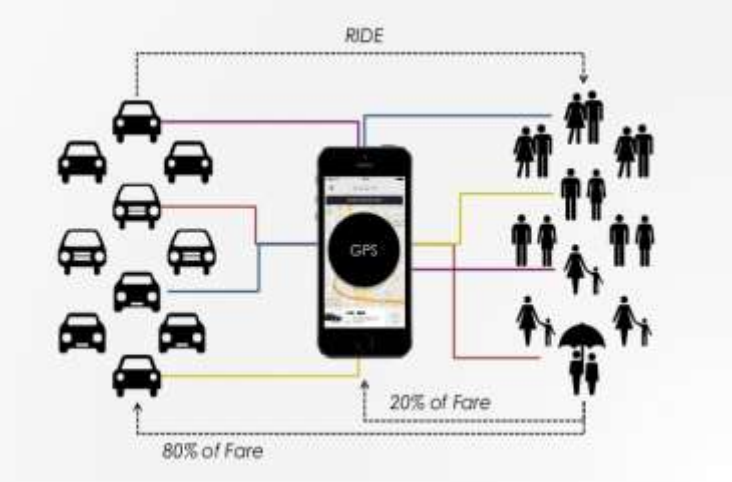


Figure 1. UBER fare shares with drivers

Some of the objectives of this study are first to provide a literature review on logistics management and according to the findings and shortcomings of the authors, having information about the logistics management system. Then render a case study on UBER to know the ins and outs of UBER. After collecting and knowing all the necessary information regarding UBER and the logistics management system, introduce appropriate scheduling and optimizie the route with the use of proper methodologies. And last of all, inaugurate an integrate app and bring about immense improvements and changes with some future plans in UBER Taxi industry.

Literature Reviews

Various works had been done previously regarding logistics management. Some of the findings and shortcomings of different authors are prescribed below:

Hai Lu & Yirong Su (2002) Logistics and Transport Management: an approach towards overall supply chain efficiency

In their study, they tried to exploit a solution in which Schenker, as a logistic provider, was actively involved so that inbound logistic performance can be more effective and efficient which would benefit all participants in the value chain. They started by investigating the unique features of the inbound logistic system with a comparison of the outbound, and this was then followed by a description of the current inbound logistic operation systems, from both an information flow and material flow perspective. They found that all inbound operations can be categorized into that of traditional demand to supply model to that of the VMI model. In approaching overall supply chain efficiency, a model hypothesis was therefore created as a future oriented solutions. Parameters were also defined to evaluate the performance of inbound logistics. Finally, with the assistance of the Supply Chain Operation Reference (SCOR) model, a case study of Volvo car inbound logistic operations has been made to illustrate the merits of our hypothesis and its improved results.

Xiang Li (2014) Operations Management of Logistics and Supply Chain: Issues and directions

This paper sets out to propose some hot issues in the current research, through a review of related literature from the perspective of operations management in addition with some insights and future research directions in this field. Organizations adopt numerous business improvement methodologies to improve business performance. Logistics as well as supply chain management has been regarded to be the crucial factor for the companies to obtain competitive edge. In this paper, a tutorial on the current research of operations management of logistics and supply chain has been provided. the conception of logistics and supply chain management has been clarified first in this paper, which defines the scope of our related research papers. The core of this paper is that several hot issues in this field were provided with examples to show how these researches contribute from different research angles. Finally, the paper concluded with the insights obtained from their analysis and future study directions in this field.

Dong-Wook Kwak (2017) Management in International Container Logistics Operations: Risk Analysis and Mitigation Strategies

The aim of this thesis is to investigate risk management strategies for international logistics operations that can minimize the occurrence and/or the impact of risks in order to achieve a desirable logistics network. For this purpose, international logistics risks were analyzed to find out critical risk areas, and then strategies to mitigate those risks were developed and validated in relation to organizational orientations and outcomes. The findings of this research contain International logistics risks consists of value streams; information and relationships; logistics activities; and the external environments. information and relationships risks were found to generate self-enhancing risk loops, thereby creating subsequent risk impacts after disruptions. To mitigate these risks, firms involved in international logistics implemented strategies, such as building a stable logistics network, leveraging logistics information, leveraging outsourcing contracts and developing logistics collaboration, although the level of implementation depends on the business context. Among the four strategies, building a stable logistics network and developing logistics collaboration strategies were most effective in strengthening both robustness and resilience in the logistics network. Customer orientation had positive impacts on all four strategies, but disruption orientation and quality orientation influenced certain types of strategies.

Jiangye Zhao & Zhu Zhu (2013) Risk Investigation of logistics management & method in Chinese non-metallic mineral industry

The purpose of this thesis is to investigate the risks in logistics management and logistics methods for the non-metallic mineral companies. The authors review the current situation of logistics management and logistics method from the non-metallic mineral companies and find out the problems or risks from these companies. In the conclusion part, the authors gave out the answers about the common risks in the literature for logistics management and logistics outsourcing, the characteristics of logistics in non-metallic mineral companies and the risks. This part also included limitation in this thesis and it shows the further study, which the authors want to study in the future.

Case Study on UBER

UBER journey in brief

Uber was founded by Travis Kelanick and Garrett Camp in U.S. as UBER Cab in March 2009. In July 2010, UBER went live for the first time ever in San Francisco. UBER started raising millions of dollars in the year 2011. UBER expanded its business in the years 2013 and 2014. The usage of UBER became more
than Taxis at a certain point and it grew more and more in the business market. After that, it kept on receiving millions of dollars in different equities and it is still growing as a business.

How UBER service works

UBER service works with the following 5 steps:

Step 1 (Request a cab): The first step is about creating a demand. People have a smartphone app which lets them request a cab instantly or schedule it for some time later.

Step 2 (Matching): As soon as the request is made, a notification about your details is sent to the nearest driver. Cab driver has the option to accept or reject the ride. In case he rejects, notification is sent to another driver in that area.

Step 3 (Ride): Customer can track the cab when it is arriving and the ETA is also shown to the customer. The meter starts as soon as the customer sits in the cab which can be tracked through the customer side app as well. Friendly drivers make sure that the ride is comfortable for the passenger.

Step 4 & 5(Payment & Rating): Once the ride is over, customer gets an option to rate the driver. Rating system is an important part of Uber's business model as it lets a person know about the driver before booking a ride and helps him trust the driver.

UBER in Bangladesh

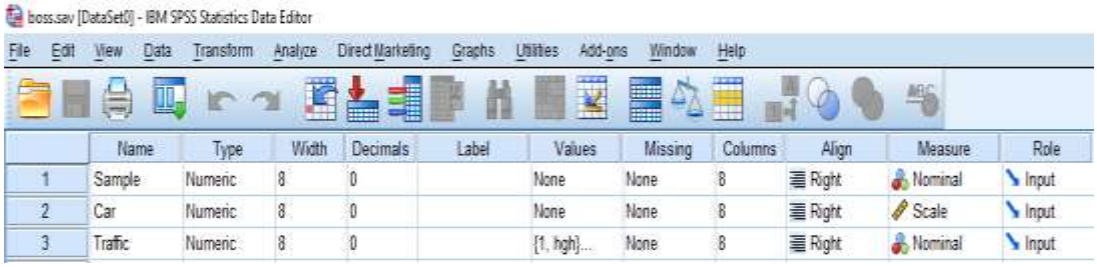
Bangladesh, being newly the part of UBER provide only the UBER X service. Dhaka is the only city to use UBER. There are approximately 2000 UBER cars in Dhaka city. UBER Dhaka City service area has been shown in fig 2.

Figure 2. UBER service area in Dhaka city

Methodologies

One way ANOVA in SPSS Statistics: Finding how the availability of cars is dependent on traffic jam by using one way ANOVA in SPSS statistics.

Here availability of cars acts as dependent variable & traffic that occurs in road acts as independent variable (fig 3)



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Sample	Numeric	8	0		None	None	8	Right	Nominal	Input
2	Car	Numeric	8	0		None	None	8	Right	Scale	Input
3	Traffic	Numeric	8	0		[1, hgh]...	None	8	Right	Nominal	Input

Figure 3. Dependent and Independent variables

After putting all the necessary datas, the result of one way ANOVA test looks like this (fig 4)

Car

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
hgh	6	3.17	.753	.307	2.38	3.96	2	4
medium	7	5.00	.577	.218	4.47	5.53	4	6
low	5	7.80	.837	.374	6.76	8.84	7	9
Total	18	5.17	1.978	.466	4.18	6.15	2	9

Figure 4. Result of one-way ANOVA test

In the graph (fig 5) it is shown that how availability of cars is dependent on traffic jam

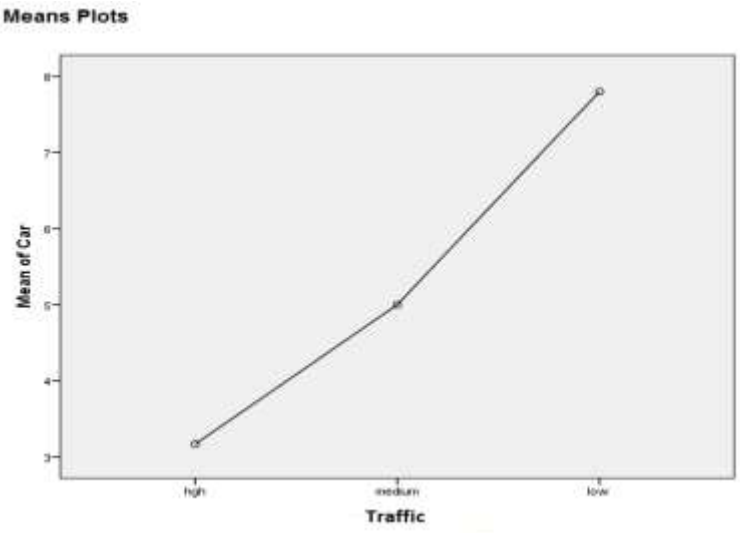


Figure 5. Time period vs mean of car availability graph

Travelling Salesman Problem (TSP): Finding the shortest possible route that visits each places exactly once and returns to the origin city.

For a given path, shortest possible route has been found (fig 6).

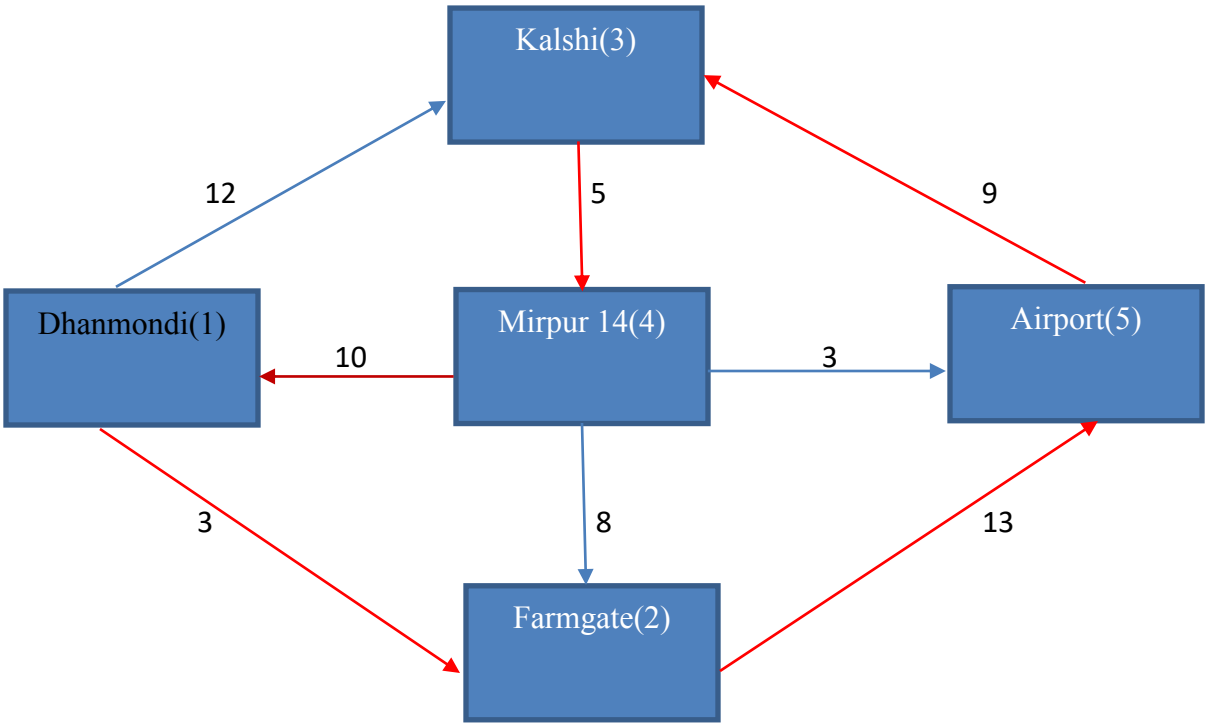


Figure 6. Rout optimization using TSP

The optimum path looks quite like this

1 → 2 → 5 → 3 → 4 → 1

3 13 9 5 10 =40

Critical Path Method (CPM): Determining the critical path and project completion time in the following routes (fig 7)

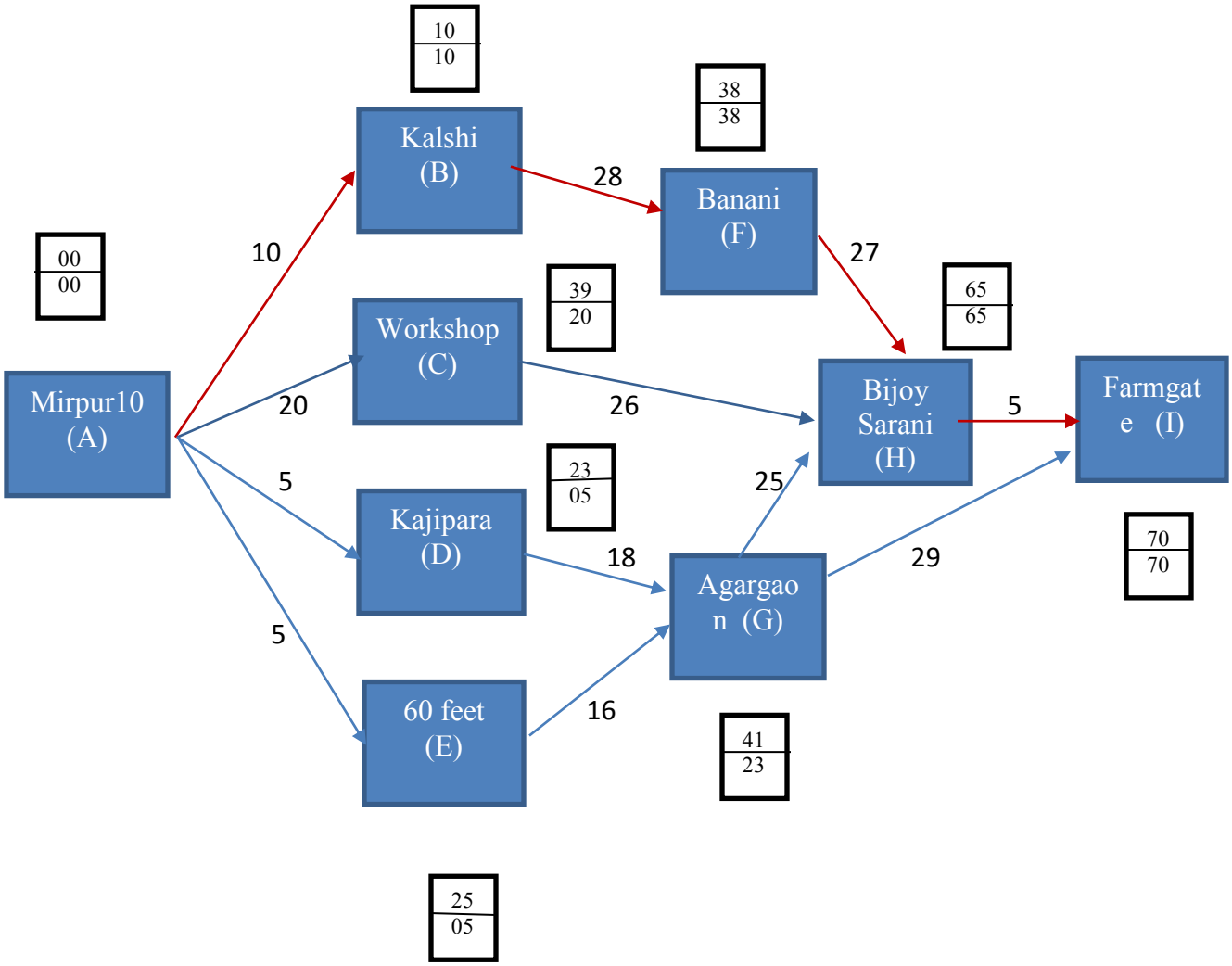


Figure 7. Critical path for different routes

Th critical path from Mirpur to Farmgate is 70 minutes and the sequence of the path becomes the following:

Mirpur(A) ⟶ Kalshi(B) ⟶ Banani(F) ⟶ Bijoy Sarani(H) ⟶ Farmgate(I)

Vehicle Routing Problem (VRP):

Single depot vehicle routing problem: The total routine shall be the shortest and the biggest marched routine of any single vehicle as well . A single objective model is set up upon these conditions (fig 8).

Multiple depot vehicle routing problem: The objective of the problem is to find routes for vehicles to service all the customers at a minimal cost in terms of number of routes and total travel distance, without violating the capacity and travel time constraints of the vehicles (fig 9).

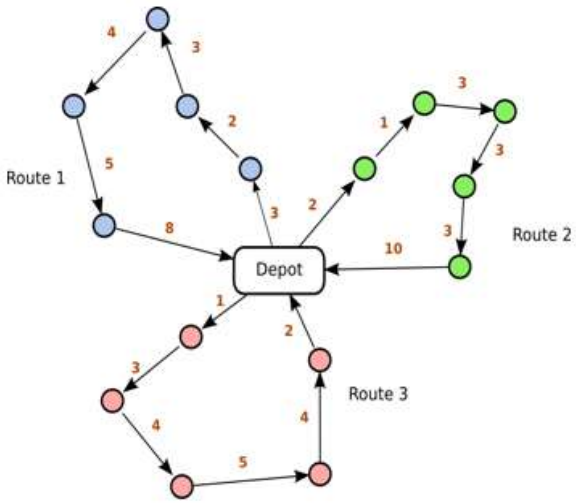


Figure 8. Single depot vehicle routing problem

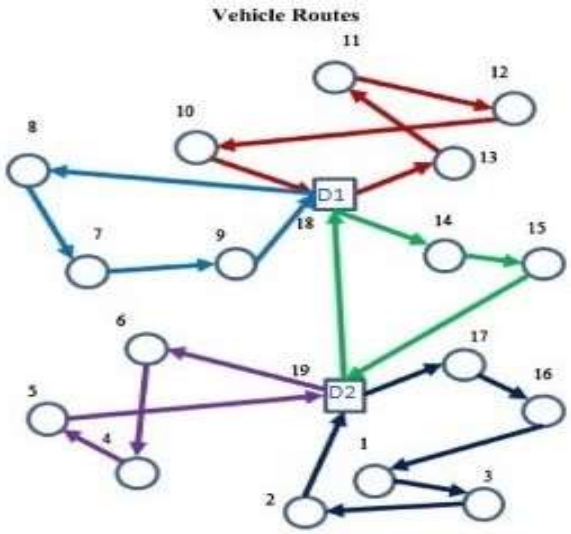


Figure 9. Multiple depot vehicle routing problem

Survey Method: General methodological framework of survey method is shown in fig 10

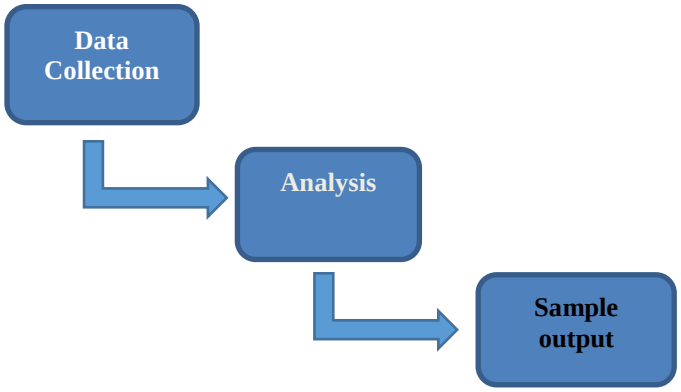


Figure 10. General methodological framework

Conclusion

UBER has been a pioneer in the sharing economy and in the changes in industry. Transportation by car is not a new concept; neither is GPS or smartphone payments for that matter. However, in taking all of these systems that currently exists and combining them to solve a problem that is seen in the existing taxi service, UBER have been able to revoulutionize and will improve more in the near future.

Several woks were done previously regarding current situation of the logistics methods, and logistics management implemented strategies. Keeping in mind all the previous works, we worked on identifying, exploring & giving directions to problem management of logistics systems in several critical areas.

Case study on UBER has been done for baseline information. Optimization of service routes has been measured with the help of TSP and CPM methods.Using TSP, it is found that the travel distance is 40 kilometers when finding shortest possible route that starts with Dhanmondi and visits places like Mirpur, Kalshi, Farmgate, Airport exactly once and returns to Dhanmondi. Critical path from mirpur to farmgate is found 70 minutes using CPM. A set of questioniare has been formualted and coded to conduct a survey on the users and drivers to identify their experiences. Appropriate scheduling has been introduced by applying VRP. The dependency on car availibilty and real time traffic situation is analysed by one way ANOVA. On an average, minimum number of available cars are found 2 and maximum 9 for different places in different time periods using one way ANOVA. Over and above that some of the future research directions have been proposed.

Plan Towards Future

Some of the future plans include: expanding app based business to every cities in Bangladesh, using good vehicle tracking system to ensure safety & security, guiding drivers with knowledge of local traffic rules & routes via training, introducing more services like UBER pool service, adding transportation modes & emergency services and mitigate driver's and customer's risk.

Our Proposed App

Our proposed app is likely to have well developed GPS system. It will be capable of showing proper framework presentation with the data from survey, show traffic in different locations in different times and also it will be able to indicate optimal route. In the near future more transportation modes are going to be included in the app. It will aslo include an emergency call button . All in all it will be start of something new.

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Improvement of Transportation Efficiency Using Simulation-Based Decision Support System

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Abstract

Transportation plays a vital role in exporting and importing various goods around the world and it is also considered as an important aspect of GDP growth and gaining economic scale in Bangladesh. Due to lack of developed infrastructure, transportation cost is much higher due to the unwanted waiting time and costs. This article has proposed a new framework for simulation-based decision support systems to improve the transportation efficiency with the help of M/M/S Queuing Simulation and Queuing cost model at Chittagong Sea Port to reduce per day total ships queuing under current arrival rate. The results and analysis of the proposed model show that there is further opportunity to accommodate more ships at the seaport due to the reduction of ship queuing cost at a utilization rate of 92.10%. Nonetheless, the reduction in ship queuing cost will eventually contribute simultaneously to the improvement of container handling services and will increase the economic activities due to the escalation in the number of container handling at Chittagong Sea Port.

Keywords
Transportation, Decision support system, Queuing, Simulation, Optimization.

Introduction

The transportation system provides mobility or the ability to get from a place of origin to a place of destination for people, goods, and services. However, transportation also has a large share of global carbon dioxide emissions, which are one the leading causes of anthropogenic climate warming. Transportation is the only sector where emissions have steadily increased since the 1990s according to the Kyoto protocol, which highlights the importance of transportation efficiency improvement. There are different types of transportation systems are available in Bangladesh. Among them, our main concern is water transport system or more specifically Sea Port. Since 1888 Chittagong Sea Port, the important and main port of Bangladesh with the shore base facilities has been playing an essential part in the economic development of the country. It is considered the heart of the economy. This port creates the opportunity of flexible and cost-effective foreign trade to be carried out through this port with all the South Asian countries as well as other Asian countries for its geographical location. Moreover, sufficient and low-cost labour readily exists here. However, Chittagong port is suffering from the problems of poor operational efficiency. As a result, this port is considered for transportation efficiency improvement purpose by analyzing ships queuing process at the port by means of reducing total ships queuing cost per day in a such a manner so that Chittagong Port Authority gets more profits and ships come more often at Chittagong Sea Port rather than diverting to neighbouring seaports.

Since this paper is dealing with simulation and decision support system, so it is mandatory to have a proper idea about these topics.

Simulation

Simulation is the imitation of the operation of a real-world process or system over time. The behaviour of a system as it evolves over time is studied by developing a simulation model. This model takes the form of a set of assumptions concerning the operation of the system.

The assumptions are expressed in: -

- Mathematical relationships
- Logical relationships
- Symbolic relationships

The model solved by mathematical methods such as differential calculus, probability theory, algebraic methods has the solution usually consists of one or more numerical parameters which are called measures of performance. However, Simulation itself does not optimize the solution for the problem, it simply runs the model according to the specifications. Design of Experiments is also frequently done with simulations. Simulations are also frequently used to enhance learning, where the main purpose is not to improve a system. According to Banks et al. (2005) simulation process consists of below phases

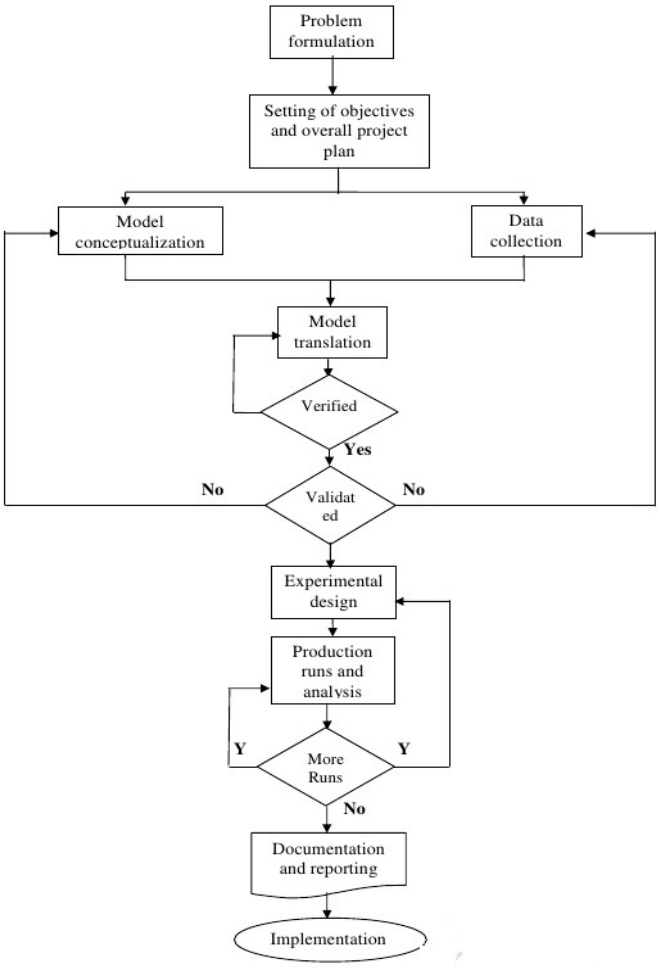


Figure 1. Simulation Process (Banks et. Al 2005)

Figure 1. shows the simulation process as a flowchart. Some differences may occur due to different simulation approaches, but in general, the processes are the same.

Decision Support System

A decision support system (DSS) is a computerized information system used to support decision-making in an organization or a business. A DSS lets users sift through and analyze massive reams of data and compile information that can be used to solve problems and make better decisions. According to Courtney (2001), Decision Support System (DSS) consists of seven phases (Courtney 2001) which are presented in Figure 2.

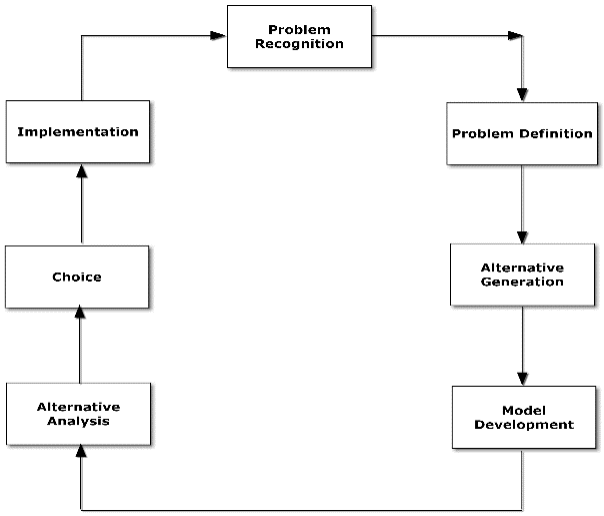


Figure 2. DSS decision-making process (Courtney 2001)

The process starts with problem recognition. After the problem has been recognized, it needs to be properly defined. Alternatives can be generated when the definition is known and the decision-making model can be developed. The different alternatives provided by the model are analyzed and a decision is then made. Finally, the decision needs to be implemented. This follows the decision process first proposed by Simon (1960). Courtney (2001) has expanded the model to include more decision-makers and their mental models, but this is mostly an issue with Group Decision Support Systems.

According to Shim et al. (2002), model-driven DSS consist of three phases: formulation, solution, and analysis. During the formulation phase, the actual problem is translated to an algebraic form. In the solution phase the model is optimized, and in the final phase results of the model are presented to the user. The formulation phase will also impact on how the solution is obtained. Most of the methods use a mathematical programming approach, e.g. a collection of mathematical functions is created and the minimum or maximum value is then obtained by using various algorithms.

Right after the proper understanding of Simulation System and Decision Support System, transportation efficiency can be improved with the help of Discrete Event Simulation which deals with queues and servers and entity.

Discrete Event Simulation

Discrete Event Simulation describes how a system evolves over time with discrete flow units or jobs. A discrete event simulation is a model (mathematical and logical) of a physical system that has changed at precise points in simulated time. Usually, DES uses queues and servers (Banks et al. 2005). The entities enter the model through a source and go into a queue. As soon as a server is available, the entity gets processed after a delay. After a delay, the entity can go into another server and may end up in a queue. The queuing facilities may involve certain design with the limited capacity to reject the customers who arrive after the capacity is reached. The customers may arrive at certain time distribution and certain queuing discipline or first come first serve. The servers that provide services to customers may have certain service time distribution or certain configuration such as serial or parallel servers. Customers waiting for service, the management of parts inventory or military combat are typical types of DES.

Since ships are diverting to neighbouring seaports due to poor operational efficiency and non-standard service time at Chittagong Sea Port, M/M/S queuing simulation is considered to improve the transportation efficiency.

M/M/S Queuing Simulation

In queueing theory, a discipline within the mathematical theory of probability, the M/M/S queue is a multi-server model. In Kendall's notation, it describes a system where arrivals form a single queue and are governed by a Poisson process, there are S servers and job service times are exponentially distributed. The performance of this queuing system where arrivals occur at rate λ according to a Poisson process , service times have an exponential distribution, with parameter μ, the buffer is of infinite size, so there is no limit on the number of customers it can contain. The model with infinitely many servers is the queue. Here ships are customers in terms of the scenario.

Formulas for M/M/s queuing simulation are as bellows: -

Arrival Rate, $\lambda = \frac{Number\ of\ ships\ arrivals\ in\ per\ unit\ time}{Inter\ arrival\ time}$

Service Rate, $\mu = \frac{1}{mean\ service\ time}$

Number or server = S

Utilization factor, U= $\frac{\lambda}{s\,\mu}$

Probability that there are no ships in system, $P_0 = \frac{1}{[\sum_{i=0}^{S-1} \frac{1}{i!}(\frac{\lambda}{\mu})^i] + \frac{1}{s!}(\frac{\lambda}{\mu})^n (\frac{s\mu}{s\mu-\lambda})}$

Average number of ships in the system $L = \frac{\lambda\mu(\frac{\lambda}{\mu})^s}{(S-1)!\,(S\mu-\lambda)^2} P_0 + \frac{\lambda}{\mu}$

Average number of ships in the waiting line(queue) $L_q = (L - \frac{\lambda}{\mu})$

Average time a ship spends in waiting line for service, (queue) $W_q = \frac{L_q}{\lambda}$

Average time a ship spends in system, (in waiting line and being served time), $W = (W_q + \frac{1}{\mu})$

Probability that there are "n" ships in system,

For $n \leq s$ $P_n = \frac{\rho^n}{n!} P_0$

For $n > s$ $P_n = \frac{\rho^n}{s!\,s^{n-s}} P_0$

Queuing Cost Model will be used as a part of transportation efficiency improvement with this M/M/S Queuing Simulation.

Queuing Cost Model

After getting the data using M/M/S queuing simulation model, Queuing cost model is used to optimize total queuing cost and improving the overall transportation efficiency. For this purpose Queuing cost model prescribed by Zdenka Zenzerovic and Edna Mrnjavac is used for analyzing queuing cost scenario at Chittagong Sea Port. Total ship queuing costs and berth non-occupancy costs are computed as follows:

Ship queuing costs,

$$C_w = C_w \times L_Q \times t \quad \text{..... (1.1)}$$

Non-occupancy berth (server) cost,

$$C_b = C_b \times (S - \rho) \times t \quad \text{..... (1.2)}$$

Total Queuing Cost,

$$C = [\{ C_w \times L_Q \times t \} + \{C_b \times (S - \rho) \times t\}]$$

$$C = [\{ C_w \times L_Q \} + \{C_b \times (S - \rho)\}] \times t \quad \text{..... (1.3)}$$

If it is taken into consideration,

$$W_Q = \frac{L_Q}{\lambda} \text{ then, } L_Q = W_Q \times \lambda \text{ and } \rho = \lambda/\mu$$

So, Eq. (1.3) can be written as Total Queuing Cost,

$$C = [\{ C_w \times \lambda \times W_Q \} + \{C_b \times (S - \rho)\}] \times t \quad \text{..... (1.4)}$$

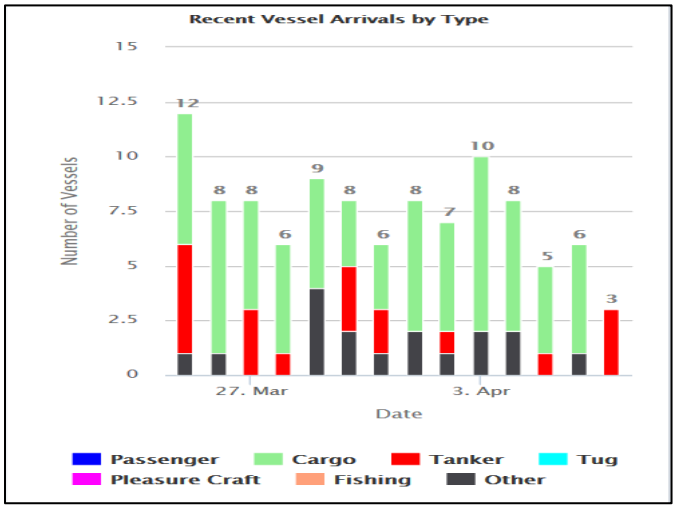
By solving Eq. (1.4) total queuing cost can be calculated at Chittagong Sea Port for efficiency improvement purpose.

Where,

- C - is the number of total costs expressed in currency units in an observed time unit (example: in USD/hour),
- L_Q - is the average number of container ships in the queue,
- S - is the number of container berths,
- ρ - is the berth occupancy rate; $\rho = \lambda/\mu$,
- t - is the length of time period for which costs are computed (e.g. day, month, year),
- C_w - is the amount of costs caused by waiting of ship, expressed in currency units for an observed time unit (e.g. in USD/hour/ship),
- C_b - is the amount of costs arising from non-occupancy of berth, expressed in currency units for an observed time unit (e.g. in USD/hour/berth).

Data Analysis of M/M/S Queuing Simulation at Chittagong Seaport

To improve transportation efficiency in terms of ships at Chittagong Sea Port, at first statistics of recent ships (vessels) arrivals is collected for time duration period of 14 days (25th March 2017 to 7th April,2017) at Chittagong Sea Port. Figure 3. describes that on average 7.42 ships came at the Chittagong Port from 25th March to 7th April 2017. Amount of vessels arrivals showed several fluctuations under the certain period for which data was collected.



Source : www.marinetraffic.com/en/ais/details/ports/2743

Figure 3. Vessel arrivals at Chittagong Port

Ships handling statistics from 2010 to 2016 was also collected from the seaport authority which is shown in Table 1.

Table 1. Ships handling statistics from 2010 to 2016

Year	Ships Handled
2010	2308
2011	2079
2012	2136
2013	2294
2014	2566
2015	2730
2016	3014
Total ships Handled	17,127
Average ships handling per year	2447
Average ships handling per month	203
Average ships handling per day	7

Source: www.cpa.gov.bd

Table 1. describes that on average 2447 ships/year and 203 ships/month were handled over the periods till 2016.

In addition, Table 2. shows in total 19 berth (servers) are being used at present for servicing ships (vessels) at Chittagong Sea Port. The number of general berths is 6 while container berths are 11 and 2 other types of berths found at Chittagong Sea Port.

Table 2. Number of Servers for Ocean-going Vessels

Total Berths (servers)	Quantity	Length	Draft
General Berth (Conventional Berths)	6	186	8.5 → 9.2
Container Berths	11	186	8.5 → 9.2
Others	2	186	8.5 → 9.2
Total	19		

Source: www.cpa.gov.bd

With the help of M/M/S Queuing simulation current scenario at Chittagong port was analyzed which is shown in Table 3.

Table 3. Existing data at Chittagong M/M/S simulation

Input values	
Per Ships Service Time	2.5 days
Arrival Rate, λ	7 ships/day
Service Rate, μ	0.4 ships/ day
Number or server (berth), S	19
Output Values	
Utilization factor, U	92.10%
Probability there are no ships in system, P_0	1 x 10^{-7}
Average number of ships in the system, L	26.442 ships/day
Average number of ships in waiting line, L_q	8.94 ships/day
Average time a ship spends in waiting line,W_q	1.27 day
Average time a ship spends in system, W	3.77 days

Table 3. shows that average time a ship spends in waiting line is still 1.27 days and per ships service time is 2.5 days which is far behind of international standard of 1 day. In addition, Figure 4. illustrates that maximum waiting time was found 3.6 days in 2008.However average waiting time of per ship is 1.27 days which is comparatively less at present than previous periods.

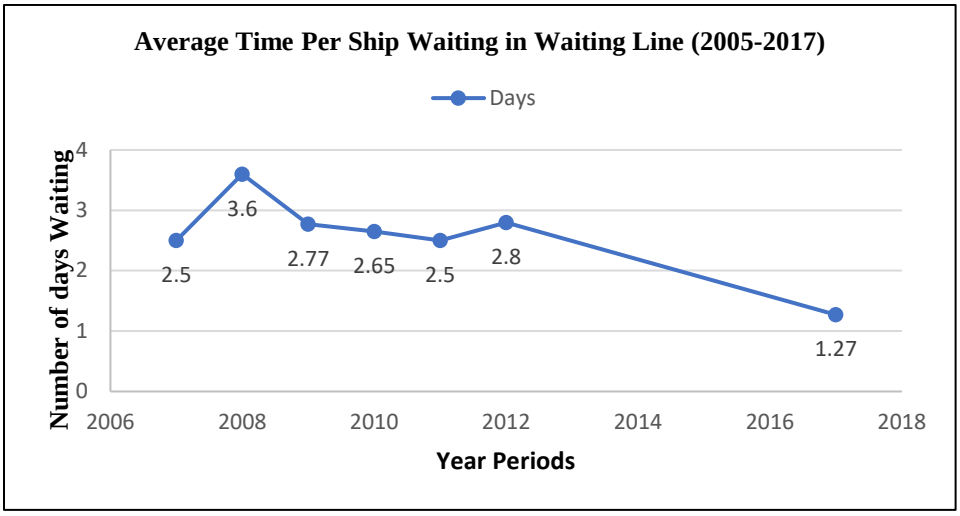


Figure 4. Average waiting time in queue by per ship at Chittagong Sea Port

After that Queuing cost model prescribed by Zdenka Zenzerovic and Edna Mrnjavac was used for analyzing queuing cost scenario at Chittagong Sea Port.For Arrival Rate of 7 ships/day at Chittagong Port,

Total Queuing Cost,

$$C = [\{ C_w \times \lambda \times W_Q \} + \{C_b \times (S - \rho)\}] \times t$$
$$= [\ \{12{,}500 \times 7 \times 1.27\} + \{3 \times 24 \times (19 - 17.5)\}] \times 1$$
$$= \text{US \$ } (111{,}125 + 108) \text{ /day}$$
$$= \text{US \$ } 111{,}233 \text{ /day}$$

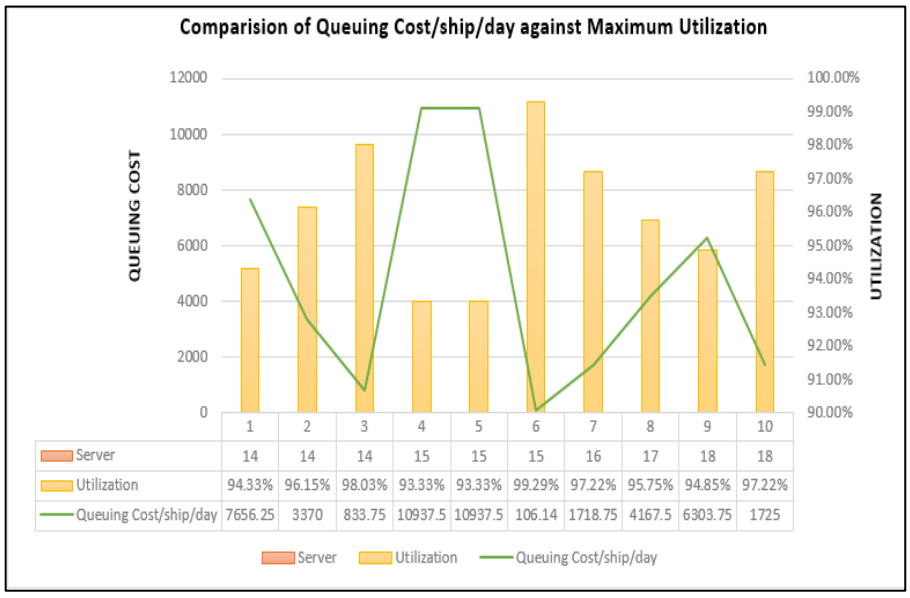
Besides per day under same arrival rate of 7 ships/day at present 1800 TEU containers are handled per day at Port. Clearing charger/per container at Chittagong Sea Port is US $600.

Total Cost of Clearing container, = US$ (1800 x 600)
= US$ 1,080,000/day

It has been found that for single ship per day queuing cost is US $ 15,890 under arrival rate of 7 ships/day at Chittagong Sea Port which is also higher than neighbouring seaports and per container clearing cost is US$ 600 which is only US$(150-200) at neighbouring seaports. Moreover, Chittagong Port is far too small for the new-generation ships to dock at. The port can only be accessed by vessels with a maximum 185 meters of length and 9.5 meters of depth (draft).

In addition, servicing time in Bangkok is two days and one day in Singapore whereas in Chittagong Sea Port it is still 2.5 days. However, according to a World Bank Group assessment sometimes due to inconvenience at Chittagong Port on average, it takes around 183 hours or 7.6 days to clear and unload shipments, which is high compared to other port authorities around the world. At that scenario under current arrival rate of 7 ships/day total queuing cost/day increases to US$ 665, 000 from US $ 111,125. Analyzing all the circumstances, it is clearly understandable service time and waiting time per ship at the port should be reduced to stop ships diverting to neighbouring seaports.

As a result, with the help of available 19 servers under steady state condition and maximum utilization of system respect to tolerable limits by port improvement of operational efficiency at Chittagong Sea Port was carried away.



	1	2	3	4	5	6	7	8	9	10
Server	14	14	14	15	15	15	16	17	18	18
Utilization	94.33%	96.15%	98.03%	93.33%	93.33%	99.29%	97.22%	95.75%	94.85%	97.22%
Queuing Cost/ship/day	7656.25	3370	833.75	10937.5	10937.5	106.14	1718.75	4167.5	6303.75	1725

Figure 5. Queuing Cost/ship/day at Chittagong Sea Port under arrival rate of 7 ships/day considering optimization of servers (berth) via maximum utilization rate

Since Chittagong Port Authority stated to keep mandatory per ship queuing cost not less than US$ 4000/day and utilization rate not less than 50%. For this reason, according to Figure 5. under current arrival rate of 7 Ships/day at Chittagong Port, per ship queuing cost worth of US$ 4,167.5/day is proposed for effective ships (transportation) management

Under proposed queuing simulation utilization rate has been increased to 95.75% from 92.10 % and service time has been reduced to 2.3 days from 2.5 days and average time per ship spends in waiting line has been also reduced to 0.3334 days (8 hours) from 1.27 days in order to reduce queuing cost of per ship per day at Chittagong Sea Port. According to simulation still, there will be 2 servers unused out of existing 19 servers at Chittagong Port which could be used effectively to serve more ships if arrival rate of ships increases or for other purposes.

Queuing cost also has been reduced compared to previous existing queuing cost at Chittagong Sea Port which is shown in Table 4. compared to previous queuing cost at an arrival rate of 7 ships/day at Chittagong Port.

Table 4. Comparison of Queuing Cost under arrival rate of 7 ships/day at Chittagong Port

Type of Cost	**Existing Queuing Cost in US$ (per day)**	**Proposed Queuing Cost in US$ (per day)**	**Reduction in US$ Queuing Cost (per day)**
Ships queuing costs	111,125	29,172.5	82,007
Unoccupied berths costs	108	52.56	
Total queuing costs	111,233	29,225.06	

In addition, Rear Admiral Khaled Iqbal, chairman of Chittagong Port Authority (CPA) stated that in 2016, they handled 2,346,909 (TEUs) containers and 7.72 crore tons of cargo. As a result, it is expected that due to a reduction per ship service time to 2.3 days, the average waiting time per ships at the port by 0.3334 days and total queuing cost reduction of US $ 82,007 will eventually increase ships arrival rate at Chittagong port and increase amount of container handling resulting gaining economic growth in Bangladesh.

Conclusion

This thesis has proposed a new framework for simulation-based decision support systems in consideration to transportation. The lacking found from literature review has been considered in the thesis paper. As a result, Queuing cost model has been introduced for further improvement of transportation efficiency with the help of queuing simulation of M/M/S system. Since per ship service time and queuing cost of ships per day has been reduced by controlling average per ships waiting time under proposed simulation, so ships will tend less to divert to neighbouring seaports which will eventually make an increase in national economic growth due to increase number of ships arrival rate and container handling. Besides utilization has been increased by 3.65% from 92.10%.

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Risk Minimization of Warehousing System by showing Probable Total Costs towards any Certain Company with the help of Monte Carlo Simulation

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Abstract

Warehousing System is a mandatory part of any existing distribution network which is specially designed to accommodate long-term storage of goods which may include raw materials, work in process materials, packing materials or finished goods associated with manufacturing. Since warehousing has a huge percentage of total supply chain cost, it costs not only a huge amount of money but also requires a large space, which highlights the importance of warehousing efficiency. However due to lack of proper approach towards the forecasting of warehousing system many companies face the loss of significant profits. This article highlights a new way for uplifting the performance of warehousing system by numerical example with the help of Monte Carlo Simulation through total probable cost calculation by controlling order quantity, reordering point, lead time to reduce the effects of holding costs and ordering costs for any certain companies. Eventually, it will contribute to the improvement of customer service level and will influence the performances of entire supply chain more effectively. Nonetheless, many companies will also be able to customize their warehouse according to their necessity to reduce the risk of over inventory.

Keywords
Warehousing System, Monte Carlo Simulation, Reordering Point, Lead Time, Decision Support System.

Introduction

Warehousing System in any supply chain consolidates to reduce transportations costs and achieving economies of scale in manufacturing or purchasing or to provide value-added service to customers. It has also been recognized as one of the main operations where companies can provide tailored services to their customers and gain competitive advantage. Moreover, effective use of warehouse minimizes the losses and helps to increase the profit more prominently. Typically warehouses are large buildings that are often filled with shelving, equipment and other items that pertain to the business of the warehouse owner. A warehouse can serve several functions beyond acting as a storage facility, however. The use of a warehouse largely depends upon the needs of its owner. In order to evaluate the use of warehousing in business, it is essential to understand ways in which warehousing functions to add value to products. Essentially, warehousing provides time and place utility for any product. However, most of them share some general pattern of material flow, and typical warehouse operations include: receiving, put away, internal replenishment, order picking, accumulating and sorting, packing, cross-docking, and shipping which is prescribed in Figure 1.

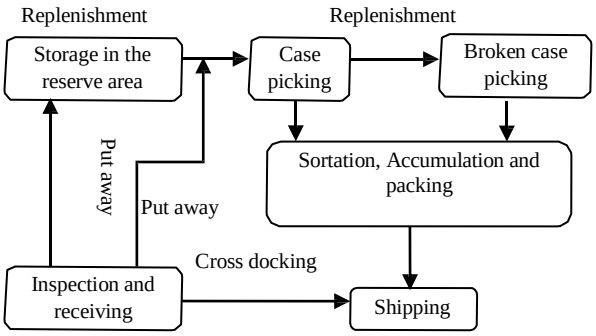

Figure 1. Typical Functions of Warehousing System

In recent times warehouses have been going through various challenges such as – supply chains are becoming more integrated and shorter, globalized operation, customers are more demanding and technology changes are occurring rapidly. In order to cope up with these challenges, organizations are seeking constantly for adopting innovative approaches. In order to consume less time and resources more effectively, it is mandatory to conduct a simulation. Hence this paper is dealing with the Monte Carlo Simulation for better decision support system.

Simulation and Decision Support System

To understand the Monte Carlo Simulation properly it is mandatory to have basics of simulation and Decision Support System. Simulation is the imitation of the operation of a real-world process or system over time in order to understand the behaviour of a system as it evolves over time is studied by developing a simulation model. Whereas Decision Support System (DSS) is a computerized information system used to support decision-making in an organization or a business.

The simulation model is solved by mathematical methods such as differential calculus, probability theory, algebraic methods has the solution usually consists of one or more numerical parameters which are called measures of performance. Design of Experiments is also frequently done with simulations. On the contrary, DSS lets users sift through and analyze massive reams of data and compile information that can be used to solve problems and make better decisions.

According to Banks et al. (2005) simulation process consists of below phases

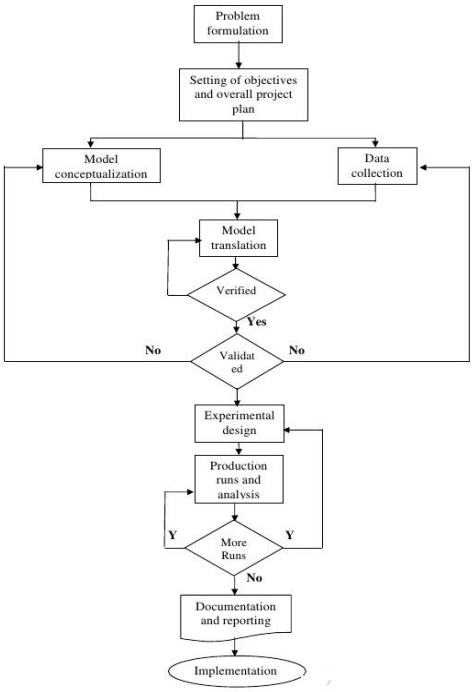

Figure 2. Simulation Process (Banks et. Al 2005)

In addition, according to Power (2002), five different dominant DSS components are as bellows :

- **Communications-driven DSS:** It is a type of DSS that enhances decision-making by enabling communication and sharing of information between groups of people. At its most basic level, a C-D DSS could be a simple threaded e-mail. At its most complex, it could be a web-conferencing application or interactive video.

- **Data-driven DSS:** Data-driven DSS emphasizes the use of large amounts of structured data. They are especially used to present time-series of both internal and external data. Most often this will come in the form of a data warehouse – a database designed to store data in such a way as to allow for its querying and analysis by users. Another example of a data-driven DSS would be a Geographic Information System (GIS), which can be used to visually represent geographically dependent data using maps.

- **Document-driven DSS:** The purpose is to provide document retrieval and analysis techniques with the help of storage and processing technologies. Document-driven DSS are support systems designed to convert documents into valuable business data. While data-driven DSS rely on data that is already in a standardized format that lends itself to database storage and analysis, document-driven DSS makes use of data that cannot easily be standardized and stored. The three primary forms of data used in document-driven DSS are oral (i.e. transcribed conversations) , written (i.e. reports, memos, e-mail and other correspondence) and video (i.e. TV commercials and news reports).None of these formats lends themselves easily to standardized database storage and analysis, so managers require DSS tools to convert them into data that can be valuable in the decision-making process. Examples of document-driven tools can be found in Internet search engines, designed to sift through vast volumes of unsorted data using keyword searches.

- **Knowledge-driven DSS:** Knowledge-driven DSS are systems designed to recommend actions to users. Typically, knowledge-driven systems are designed to sift through large volumes of data, identify hidden patterns in that data and present recommendations based on those patterns. Knowledge-driven DSS contain some kind of artificial intelligence which recommends actions to the users. It can use various rules or data mining techniques to achieve this.

- **Model-driven DSS:** It emphasizes the access to a model and its manipulation. Model-driven support systems incorporate the ability to manipulate data to generate statistical and financial reports, as well as simulation models, to aid decision-makers. Model-based decision support systems can be extremely useful in forecasting the effects of changes in business processes, as they can use past data to answer complex 'what-if' questions for decision makers.

Besides, according to Shim et al. (2002), model-driven DSS consists of three phases: formulation, solution, and analysis. During the formulation phase, the actual problem is translated to an algebraic form. In the solution phase the model is optimized, and in the final phase results of the model are presented to the user. The formulation phase will also impact on how the solution is obtained. Most of the methods use a mathematical programming approach, e.g. a collection of mathematical functions is created and the minimum or maximum value is then obtained by using various algorithms.

After the proper understanding of Simulation System and Decision Support System, risk minimization warehousing system can be conducted by Monte Carlo Simulation.

Monte Carlo Simulation

In the meantime studying the simulation and Decision Support system above it is clearly untestable that Monte Carlo simulation is definitely a part of Simulation Technique which follows a computerized mathematical technique. Monte Carlo Simulation uses repeated random sampling to simulate data for a given mathematical model and evaluate the outcome. This method was initially applied back in the 1940s when scientists working on the atomic bomb used it to calculate the probabilities of one fissioning uranium atom causing a fission reaction in another.

During a Monte Carlo simulation, values are sampled at random from the input probability distributions. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. Monte Carlo simulation does these hundreds or thousands of times, and the result is a probability distribution of possible outcomes. In this way, Monte Carlo simulation provides a much more comprehensive view of what may happen. It tells you not only what could happen, but how likely it is to happen. This simulation performs risk analysis by building models of possible results by substituting a range of values, a probability distribution, for any factor that has inherent uncertainty.

Probability Distributions for Monte Carlo Simulation

Without probabilistic simulation, it is nearly impossible to perform Monte Carlo Simulation. For this reason by using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis. Common probability distributions include:

- **Normal – Or "bell curve."** The user simply defines the mean or expected value and a standard deviation to describe the variation in the mean. Values in the middle near the mean are most likely to occur. It is symmetric and describes many natural phenomena such as people's heights. Examples of variables described by normal distributions include inflation rates and energy prices.

- **Lognormal –** Values are positively skewed, not symmetric like a normal distribution. It is used to represent values that don't go below zero but have unlimited positive potential. Examples of variables described by lognormal distributions include real estate property values, stock prices, and oil reserves.

- **Uniform –** All values have an equal chance of occurring, and the user simply defines the minimum and maximum. Examples of variables that could be uniformly distributed include manufacturing costs or future sales revenues for a new product.

- **Triangular –** The user defines the minimum, most likely, and maximum values. Values around the most likely are more likely to occur. Variables that could be described by a triangular distribution include past sales history per unit of time and inventory levels.

- **PERT-** The user defines the minimum, most likely, and maximum values, just like the triangular distribution. Values around the most likely are more likely to occur. However values between the most likely and extremes are more likely to occur than the triangular; that is, the extremes are not as emphasized. An example of the use of a PERT distribution is to describe the duration of a task in a project management model.

- **Discrete –** The user defines specific values that may occur and the likelihood of each. An example might be the results of a lawsuit: 20% chance of positive verdict, 30% change of negative verdict, 40% chance of settlement, and 10% chance of a mistrial.

Typical Steps in Monte Carlo Approach

Depending on the number of factors involved, simulations can be very complex. But at a basic level, all Monte Carlo simulations have four simple steps:

- **Identifying the mathematical model (Transfer Equation):** To do a Monte Carlo simulation, a quantitative model of the business activity, plan, or process is necessary which a firm/company/person wish to explore. The mathematical expression of the process is called the "transfer equation." This may be a known engineering or business formula, or it may be based on a model created from a designed experiment (DOE) or regression analysis.

- **Defining the Input Parameters:** For each factor in consideration to transfer equation, a determination is required to know about how its data are distributed. Some inputs may follow the normal distribution, while others follow a triangular or uniform distribution. Then a determination of distribution parameters for each input is needed. For instance, someone would need to specify the mean and standard deviation for inputs that follow a normal distribution.

- **Creating Random Data:** To do valid simulation, one must create a very large, random data set for each input—something on the order of 100,000 instances. These random data points simulate the values that would be seen over a long period for each input. For instance: Minitab can easily create random data that follow almost any distribution you are likely to encounter.

- **Simulating and Analyzing Process Output:** With the simulated data in place, one can use transfer equation to calculate simulated outcomes. Running a large enough quantity of simulated input data through model will give a reliable indication of what the process will output over time, given the anticipated variation in the inputs.

Advantages of using Monte Carlo Simulation Approach

Monte Carlo simulation provides several advantages over deterministic, or "single-point estimate" analysis:

- **Probabilistic Results:** Results show not only what could happen, but how likely each outcome is.
- **Graphical Results**: Because of the data a Monte Carlo simulation generates, it's easy to create graphs of different outcomes and their chances of occurrence. This is important for communicating findings to other stakeholders.
- **Sensitivity Analysis:** With just a few cases, the deterministic analysis makes it difficult to see which variables impact the outcome the most. In Monte Carlo simulation, it's easy to see which inputs had the biggest effect on bottom-line results.
- **Scenario Analysis:** In deterministic models, it's very difficult to model different combinations of values for different inputs to see the effects of truly different scenarios. Using Monte Carlo simulation, analysts can see exactly which inputs had which values together when certain outcomes occurred. This is invaluable for pursuing further analysis.
- **Correlation of Inputs:** In Monte Carlo simulation, it's possible to model interdependent relationships between input variables. It's important for accuracy to represent how, in reality, when some factors go up, others go up or down accordingly.

Data Analysis for Numerical Examples of Monte Carlo Simulation

To minimize the risk of warehousing system with the help of Monte Carlo Simulation, Excel Data Analysis is formulated with the help of Risk Analysis Pro to show several numerical examples under different conditions. The main intention was to show probable total cost by controlling order quantity, reordering point, lead time to reduce the effects of holding costs and ordering costs for any certain companies so that customer service level and performances of entire supply chain more could be increased effectively. Since Lost Opportunity Cost is required for the formulated Excel Analysis of Monte Carlo Simulation, it can be either collected from certain organization according to their respective policy.

Maximum capacity for any certain company was assumed to be about 2000 units whereas Lost Opportunity cost was assumed to be around US$ 190 for the numerical example. Calculation of lost opportunity cost was done accordingly to below via online "Time Value of Money Calculator" from http://www.free-online-calculator-use.com/time-value-of-money-calculator.html#calculator. (Figure 3.)

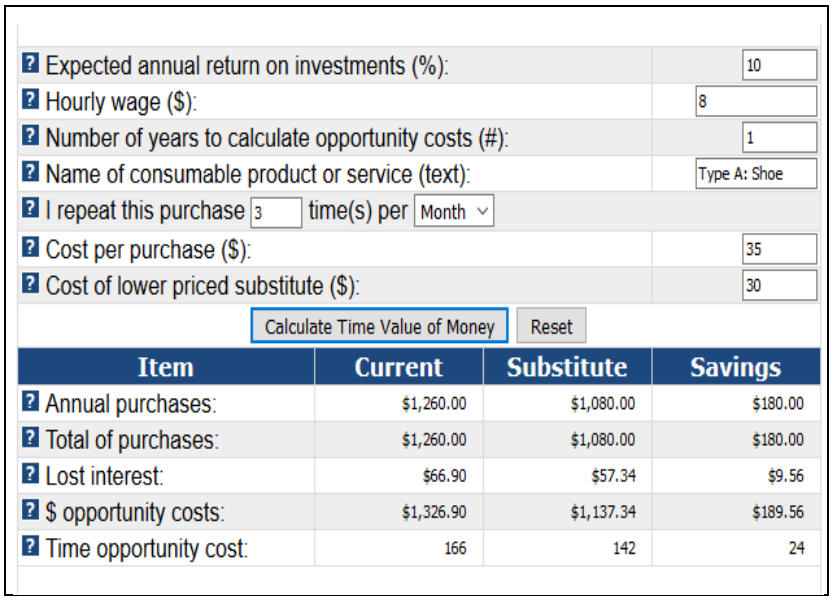

Figure 3. Lost Opportunity Cost Calculation by Online Calculator

Assuming that "Type A Shoe" will be ordered 3 times per month where per unit cost is US $ 35 while the less costly product is near to US $30 with the same hourly age of US$ 8 per employee Lost Opportunity Cost of US$ 189.56 ≈190 is found with the help of this calculator. However, Lost Opportunity Cost also can be directly gathered from the authority of the certain company. It depends on certain company's policy.

After getting the lost opportunity cost several simulations (Monte Carlo Simulation) are carried away with the help of Risk Analysis Pro to find out probable total cost for each run under various conditions(condition-1,condition-2 and condition-3) followed by Table 1. , Table 2. and Table 3 where assumption for ordering cost is US $35/unit, holding cost is US $ 0.45/unit and lost opportunity cost is US $ 190/year.

Table 1. Condition-1 for Monte Carlo Simulation for warehousing

Order Quantity (units)	Lead Time (weeks)	Reordering Point (units)	Ordering Cost/ Item (US $)	Holding Cost/Item (US $)	Lost Opportunity Cost (US $)
1500	3	350	35	0.45	190
	2				
	1				

Finding Total Cost by Simulation Run 1 for 3 weeks lead time under condition 1 (Table 1):-

Total Holding Cost	$20,394
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$20,464

Finding Total Cost by Simulation Run 2 for 2 weeks lead time under condition 1 (Table 1):-

Total Holding Cost	$20,736
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$20,806

Finding Total Cost by Simulation Run 3 for 1 week lead time under condition 1 (Table 1):-

Total Holding Cost	$22,137
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$22,207

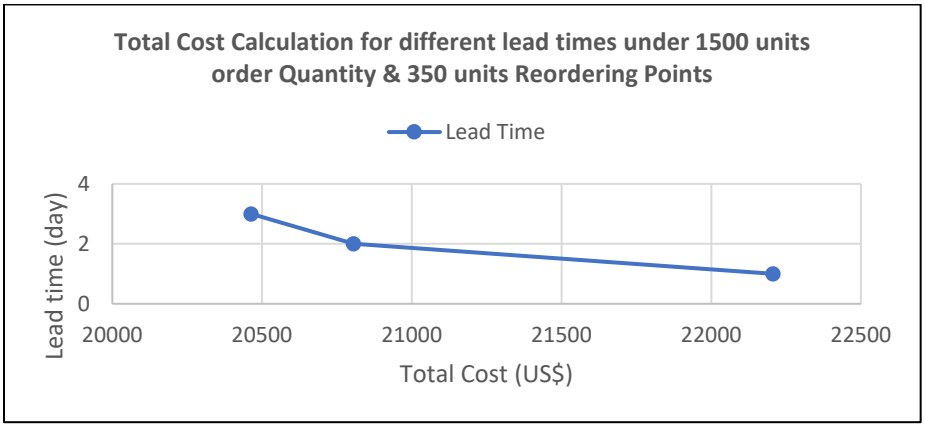

Figure 4. Total Cost Calculation for different lead times under constant Order Quantity & Reordering Points

Figure 4. elaborates that for an order quantity of 1500 units and reordering points of 350 units total probable costs were found to be US $20,464, US $20,806 and US $22,207 respectively for the lead time of 3 weeks, 2 weeks and 1 week.

Table 2. Condition-2 for Monte Carlo Simulation for warehousing

Order Quantity (units)	**Lead Time (weeks)**	**Reordering Point (units)**	**Ordering Cost/ Item (US $)**	**Holding Cost/Item (US $)**	**Lost Opportunity Cost (US $)**
1500	3	350 300 250	35	0.45	190

Finding Total Cost by Simulation Run 4 for 350 units reordering point under condition 2 (Table 2):-

Total Holding Cost	$21,166
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$21,236

Finding Total Cost by Simulation Run 5 for 300 units reordering point under condition 2 (Table 2):-

Total Holding Cost	$20,655
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$20,725

Finding Total Cost by Simulation Run 6 for 250 units reordering point under condition 2 (Table 2):-

Total Holding Cost	$19,519
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$19,589

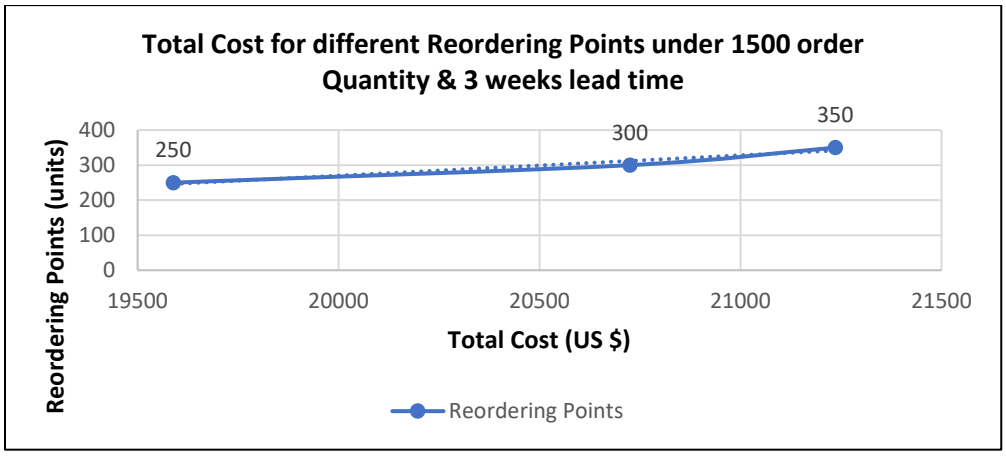

Figure 5. Total Cost Calculation for different Reordering Points under constant order Quantity & lead time

For order quantity of 1500 units and lead time of 3 weeks' total probable costs were found to be US $21,236, US $20,725 and US $19,589 respectively for the reordering points of 350 units, 300 units and 250 units which are shown in Figure 5.

Table 3. Condition- 3 for Monte Carlo Simulation for warehousing

Order Quantity (units)	Lead Time (weeks)	Reordering Point (units)	Ordering Cost/ Item (US $)	Holding Cost/Item (US $)	Lost Opportunity Cost (US $)
1500	3	350	35	0.45	190
1300					
1000					

Finding Total Cost by Simulation Run 7 for 1500 units ordering quantity point under condition 3 (Table 3):-

Total Holding Cost	$21,207
Total Order Cost	$70
Total Opportunity Cost	$0
Total Costs	$21,277

Finding Total Cost by Simulation Run 8 for 1300 units ordering quantity point under condition 3 (Table 3):-

Total Holding Cost	$18,399
Total Order Cost	$105
Total Opportunity Cost	$0
Total Costs	$18,504

Finding Total Cost by Simulation Run 9 for 1000 units ordering quantity point under condition 3 (Table 3):-

Total Holding Cost	$14,187
Total Order Cost	$140
Total Opportunity Cost	$0
Total Costs	$14,327

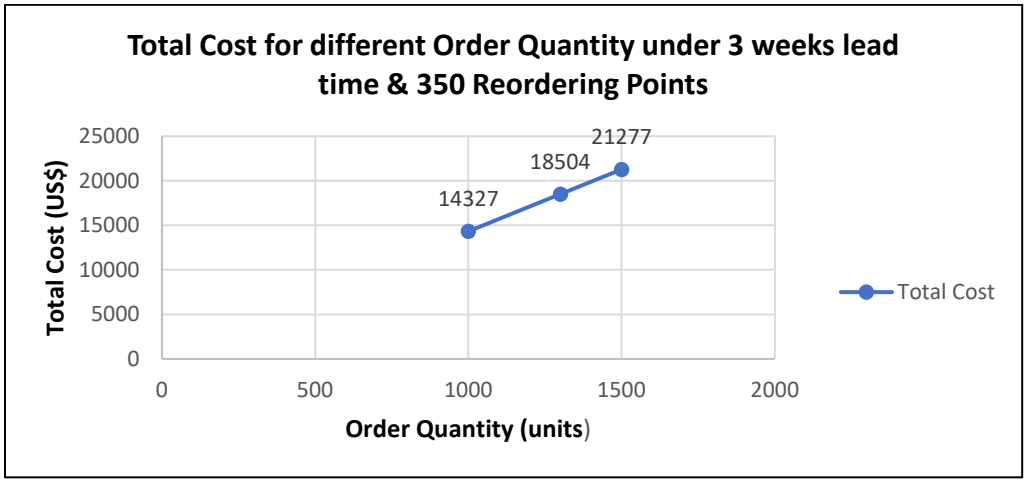

Figure 6. Total Cost of 3 weeks lead time & 350 Reordering Points for different Ordering Quantity

Total probable costs were found to be US $21,277, US $18,504 and US $14,327 respectively for an order quantity of 1500 units,1300 units and 1000 units while lead time was fixed to 3 weeks and reordering points at 350 units showed in Figure 6.

Table 4. Summary of Total Cost Calculation for different scenarios

Simulation Run No	Total Cost (US$)	Average Total Cost (US$)	Conditions		
			Ordering Quantity(unit)	Reordering Point (unit)	Lead Time (weeks)
Run 1	20464	21159	1500	350	3
Run 2	20806				2
Run 3	22207				1
Run 4	21236	20517	1500	350	3
Run 5	20725			300	
Run 6	19589			250	
Run 7	21277	18036	1500	350	3
Run 8	18504		1300		
Run 9	14327		1000		

From the Summary Table 4. , it is clearly understood that for different conditions different total costs were generated found from 9 simulation runs. Average total Costs are also shown in table 4. Thus for various conditions of ordering quantity, reordering points and lead times various total costs and average total costs can be generated so that certain company could make profits and survive in the market.

Hence Risk minimization for Warehousing System Could be done by Monte Carlo Simulation.Moreover, efficiency can be improved by knowing average total costs which refer various ordering quantity, reordering points and lead times as they have an impact on holding cost and ordering cost per unit items.

Conclusion

This article has proposed a new way for uplifting the performance and risk minimization of warehousing system by showing a numerical example with the help of Monte Carlo Simulation through total probable cost calculation by controlling order quantity, reordering point, lead time to reduce the effects of holding costs and ordering costs for any certain companies. Different Probable total cost is shown in summary in Table 4. so that with the help of this simulation analysis any company can forecast upcoming demand and control inventory without any significant loss.Hence we can conclude that risk minimization through warehousing system could be key the performance factor for competitive Supply Chain Management by Monte Carlo Simulation.

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