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A theoretical Assessment framework of Inventory Management System in wind tunnel facilities

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Abstract

Inadequate spare parts stock or inventory leads to wind tunnel facilities unavailability and loss of revenue if the wind tunnel subsystem or equipment fails and cannot be repaired or replaced immediately. At the point when the extra part is required however missing in stock, it must be requested from a provider. This causes the operational downtime relying upon the lead time of the extra part. On the other hand, inventory management which handling, controlling and storage of the spare parts is a cost driver for wind tunnel facilities in operating and maintaining wind tunnels. During wind tunnel breakdowns, maintenance personnel spent too much time trying to find and procure spare parts. Requisition amount depends on gut feel and past experiences, with some casual conference with the maintenance technicians and specialists. Although the number of studies have been conducted in the past two decades to address this issues, therefore the aim of this paper is to theoretically assess the theoretical assessment framework of inventory Management System in wind tunnels and the results of the critical analysis of the current literature clearly demonstrates that there are flaws in the current body of knowledge related to the effectiveness of inventory management in the aerospace industry, especially in wind tunnel facilities and also few of those studies concentrated on spare parts inventory management.

Keywords: Inventory Management, Wind Tunnel

1. INTRODUCTION

It is such a big battle for every wind tunnel testing organization to capitalize on its wind tunnel utilization whilst also increasing the wind tunnel's operations and flexibility. Making sure that the wind tunnel is functioning, operational and delivering at ideal capacity is critical, as well as managing and controlling maintenance processes have a direct influence on the running costs, service levels and then profitability. To exceptionally support wind tunnel facility maintenance and production, it is vital to have appropriate inventory management for the maintenance and repair of the equipment available when needed. The term inventory incorporates material like unpolished, in process, got done with bundling, spares and others, loaded keeping in mind the end goal to take care of an unpredicted demand or conveyance later on. Save parts recommend to the parts essentials for keeping required asset in strong working condition by meeting repair and maintenance necessities caused by breakdowns and preventive maintenance. There is a time when both service and equipment management are enhanced so they wind up achievable destinations. Bharadwaj, Silberschmidt and Wintle (2011) pointed out that inventories used on equipment maintenance are

predominantly impacted by equipment support arrangements. Planned maintenance always had respectably expectable interest for extras and it surely is conceivable to arrange parts arrival in the nick of time for utilization. To operate this world class equipment (Wind Tunnel), plant operators need accurate information combined with the ability to act quickly in response to impeding emergency breakdowns. But from time to time, the organization is facing an increased down time of the wind tunnels, higher repair costs, immediate equipment spare parts unavailability and too many obsolescence due to the ageing of the facilities and financial losses. Finance and plant managers will generally provide for the purchase of the material or parts necessary to keep the wind tunnel facility running in order to maintain production levels. However, availability does not have to mean on the shelf, and when needed does not necessarily imply the right way.

In the wind tunnel facilities, unprepared maintenance activities because of emergency breakdowns and the absence of accessible parts effect on-going hardships and additionally the extra charge of acquiring the parts or inventories at a short period of time. Most of wind facilities are also old complex equipment. Managing complex equipment spare parts is quiet a big challenge, especially if you have several different types of subsystem whereby each need its unique set of parts required for both planned and unexpected preventative maintenance. As the wind tunnel equipment ages, the cost of maintaining, upgrading and repairing existing equipment increases. The legacy equipment is not easy to replace. The main reasons for this maintenance increased costs being the lacks of immediate availability of spare parts of this legacy equipment from original equipment manufacturers (OEMs) and original equipment which in many cases do not existing anymore. This study will assess the wind tunnel facility inventory management and its effectiveness.

1.1 BACKGROUND

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1.2 INVENTORY MANAGEMENT HISTORICAL BACKGROUND

When we look back in the history of the Christianity, inventory management was first thought up by Noah when he counted and add up the clean and unclean beasts and creatures for the Ark. But for briefness sake, we will jump forward to the up-to-date times. The word inventory comes from the French word "Inventaire" and Latin word "Inventariom", which proposes a list of things found. The word inventory comprises material like raw, in process, completed packaging, replacements and others, kept in order to encounter an unforeseen demand or supply in the future. Another definition of Inventory is the materials whenever required by acquiring adequate number and kind of

inventories. This procedure usually comprises of controlling the transfer of the components in order to avoid the inventory from becoming too large, or decreasing to levels that could put the process or operation of a business into jeopardy. Inventory Management is also defined as all the events needed for the procurement, storage, sales, clearance or dispatch or materials usage. Inventory managers have to stock up when required and efficiently use available storage space, in order to have the storage space not surpassed. In addition, three more definitions are chosen are suitable for the research. Ballou (2004) characterizes inventories as a combination of raw materials, suppliers, parts and completed products that show up at various focuses throughout the organization's logistic systems. As described by Aquilano, Chase and Jacobs (2006), the inventory is the items or stock of all the element or possessions utilized in any organization and they further explained the inventory system as the arrangement of approaches and the controls that observes the amount of inventory and regulate whatever amount of inventory have to be preserved, when inventories have to be replaced and how bulky orders should be handled. Inventory Management, as characterized by Chase (2008), is the "administration of the supply of anything or asset utilized as a part of any organization". Following on this explanation, the inventory management system is the course of action of methodologies and controls used to ensure sensible levels of inventories. Inventory management is worried about setting the right stock levels, selecting demand regularities and showing immaculate demand sizes. He furthermore characterized the term 'supply' as the degree at which stock or spare part is restocked and the term 'request' as the degree at which stock is drained. Stock along these lines goes about as the boundary between the supply and the request rate.

2. GAP IDENTIFICATION IN THE CURRENT LITERATURE

To begin with the critical assessment of the literature review on the effectiveness of the inventory management system in wind tunnel facilities, final total combination journals and articles and publications from both small medium enterprises and large organizations were well-thought-out to be satisfactory for the devotions of this research. The greatest essential period in this collected works retrieval procedure was a computer search of the ISI Web of Science Database. The exploration period included the 2 decades from January 1997 to 2017. The searched only focused on peer reviewed articles published in English, by means of the descriptor ‘‘manufacturing inventory management’’ in the heading of each article, just about 1300 summaries were retrieved for evaluation from the stated era. A guided manual search was then piloted for manufacturing in automotive, mining, food, aerospace and few other since inventory management in these sectors is very critical and common and they also are the key sectors in the global economy growth. Each publication retrieved over this process was wisely studied before a choice was made on its inclusion in the literature review. The researcher required that all articles debates the inventory management system in manufacturing industry. This necessity excluded numerous journals retrieved from the database, as the descriptor that was used produced summaries from several publications that did not automatically define the inventory management system. And that is how only 30 publications were reviewed. Precisely, articles assessed in this study are clearly focused on inventory management system in wind tunnel facilities. It should be pointed out that studies that did not meet this requirement were not taken into account. The cataloguing of most of the grouping of the articles was fairly modest and direct, by means of the exclusion of most research area and resource type. As individual publication was studied, it was categorized according to the following groups: Publication year, Country of research, Number of citations of the publication, Research Area and Research Source type. To this end the table 1 below shows the 15 best studies that were conducted over the past two decades in the field of inventory management in wind tunnels.

Table 5: Publications' Critical Assessment table

REFERENCES	**STUDY INFORMATION**		**MANUFACTURING**					**METHODOLOGY**	
Author publication year	**Region**	**Firm Size**	**Food**	**Mining**	**Automotive**	**Aerospace**	**Other**	**Qual**	**Quant**
Roy and Guin (1999)	india	Large		×					×
Yao and Carlson (1999)	USA	Large	×					×	
Koste and Malhotra (2000)	USA	Large			×			×	
Soman, van Donk and Gaalman (2004)	Netherlands	Large	×					×	
Mohanty and Deshmukh(2001)	India	Large		×				×	
Braglia and Zavanella (2003)	Italy	Large					×	×	
Duray (2004)	USA	Large			×				×
Soman and van Donk, Gaalman (2004)	Netherlands	Large	×					×	
Boughton and Horvath (2006)	USA	Large		×					×
Haq and Kannan (2006)	India	Large			×			×	×
Defregger and Kuhn (2007)	Germany	Large		×					×
Matsui (2007)	Japan	Large			×				×
Perona and Saccani, Zanoni (2009)	Italy	SME	×					×	
Alfaro and Rabade (2009)	Spain	Large	×					×	×
Yuan and Gao (2010)	China	Large			×				×

An anticipated model of JIT purchasing in an integrated steel plant is discussed by Roy and Guin (1999). They in some way, discovered that the notion has not infiltrated down to the emerging world where various companies are still suffering from "not developed here" kind of disorder. They considered the Identification and cataloguing of resources and merchants which can be brought under JIT system and the proposing of a shipping partnership model to collect items from the suppliers. Although the authors conducted a very significant research on the JIT purchasing model,

their big focus was to work out an intangible model for the JIT application in the acquisition division of a combined Indian steel plant. The authors focus was more on the steel plant mining industry using qualitative research method to work out the just in time purchasing model. The inventory management system concepts were never properly addressed.

The impact of real-time data communication on inventory management by Yao and Carlson (1999) suggested a qualitative way of coming up with a model that will monitor the periodic lot processing and reporting of inventory amounts, their locations and movement. They also proved that the increased inventory precision and relevance of real-time data permits the whole range of events of suppliers, sales and supply employees and consumers to be performed with self-assurance and improved cost-effectiveness. Although this significant research in the large distribution firm in food industry appears reasonable, it is sensed that this is centred on the solo product by product investigation and may never embrace the truth when a group of merchandises and their collaborations with size are well-thought-out. The authors focused more on the radio frequency data communication system that will provides an interactive exchange of information anywhere in a facility and not addressing the importance of the products storage, lead times and the capacity which forms part of the most crucial characteristics of the inventory management.

Queries are consequently raised regarding whether interchanges happen among different features for a given flexibility dimension is the discussion focussed in Kostre and Malhotra (2000). While their study was based on the perception into the tactical choices made by the large automotive organizations in USA, industry wide as well as firm-specific qualitative data from the automotive manufacturing industry was used to respond these queries and to show that numerous main characteristics of manufacturing elasticity have been developed and leveraged otherwise by other manufacturers. In their study, the researcher did not offer an in-depth assessment of specific characteristics of elasticity in the inventory management of automobiles and also to show that that has a leveraged and highlighted differently. Those aspects are essential, however, if elasticity is to be more fully understood. The study is only focussed on automotive manufacturing industry.

Mohanty and Deshmukh (2001) conducted the study reengineering of materials management system in the Idian petroleum refinery. They mentioned that materials management work is dependably a noteworthy worry to the administration of any modern industrial organization as high inventory and a wasteful obtainment process influence the benefit and profitability of all things considered. Issues increase because of an exceptionally current business condition in India. Henceforth, current materials planning, acquisition processes and stock management frameworks need a re-look regarding a fluctuating business condition. This research demonstrates a thorough change in materials management capability of an Indian oil refinery through business process re-engineering (BPR) by breaking down current procedures, recognizing key issues, determining outlook changes and creating re-designed procedures through client value analysis. Although BPR was performed on existing procedures of “materials planning and acquisition" and “warehousing and surplus transfer", it was discovered that the re-engineered processes for materials management function in India petroleum refinery prompted a few upgrading tasks that were identified by the group of senior manager who took part in the re-engineering implementation. Those tasks were implemented in a coordinated system with the use of the condition of workmanship information technology instruments.

Despite the fact that Mohanty and Deshmukh conducted this significant study about reengineering of material management in the mining industry (petroleum), the researcher’s main focus was on the analysis of the current material management procedure by using the qualitative research method in examining the existing practice and never addressed the effectiveness of the inventory management in this regard. In his study, Duray (2004) administered a survey questionnaire to large 126 automotive manufacturing plants and the questionnaire contained the items that would allow the strategic look at the employment of the bulk customization typologies in view of particularity what's more, client inclusion can be utilized to recognize and order mass customizers. It seemed like this grouping decides the underlying decision of process outline and decides the aggressive abilities of the assembling plant. Be that as it may, the influence of modularity and client participation on the particulars of the production system have not been

sufficiently talked about. With all these well written research, it seems like the point of client participation in the production sequence does not make a noteworthy difference in the selection of inventory management, but does contribute to the choice of scheduling systems. The study was quantitative and only focused specifically on the automotive industry.

In their research of the joint make to stock and make to order in food production system, Soman et al (2004) examined in detail an variety of production management concerns with regards to large food processing companies where consolidated make to request and make to stock generation is normal. Their qualitative research is just in view of the organizations that take into account an expanding variety of items with changing considered requests and management qualities like capacity usage and setup, to various market divisions thus that they are moving to more make to order production. Despite the fact that this paper explored various issues as for the Netherlands MTO-MTS circumstances in food industry only, the particular inventory management perspectives are barely been addressed in a this research.

Boughton and Horvath (2006) conducted the study on environmental assessment of shredder residue management such ad glass, rubber, plastics, fibres, dirt, and fines that is left after ferrous and nonferrous metals. In their study, they used the life cycle evaluation method to measure and describe the human well-being and environmental influences of landfilling and three rescue choices (complementary energy and mineral fodder for cement manufacturing, hydrolysis to light fuel oil, and material retrieval for recycling). Through their quantitative research in the US mining industries, they further compared the description of releases in relation to possible influence categories of world-wide warming, freshwater aquatic poisonousness, acidification, eutrophication, human toxicity, photochemical oxidant formation, and earthly ecotoxity.

They discovered that above 3 million kilograms of SR produced in the U.S. every year are administered by landfilling. Over and above that, the researchers also pointed from their research that material retrieval or energy retrieval substitutions to landfilling can be useful for the reason that of preservation of non-renewable possessions and the decrease of unwanted dumping. The outcomes of this end-of-life influence evaluation displayed that the addition for cement manufacturing alternative was ecologically useful to the existing exercise of landfilling and seems restored when compared to the other management approaches considered. Even though Boughton and Horvath conducted this significant study about environmental evaluation of shredder deposit management in mining industry (cement manufacturing), the researcher's main focus mainly on environmental assessment they never addressed the effectiveness of the inventory management in this regard.

One of the first study on the design of an integrated supplier selection and multi-echelon distribution inventory model in a built-to-order supply chain environment is by Haq and Kannan (2006).The research deals with the expansion of a combined supplier selection and multi-echelon delivery inventory model for the OEM corporations in a built-to-order supply chain environment by means of fuzzy logical chain of command process and a inherited set of rules. The authors designed the combined qualitative decision-making of the supplier selection model by means of fuzzy logical hierarchy process with that of the quantitative carefully worked-out model for the delivery inventory supply chain by means of a hereditary set of rules to the built-to-order environment. They further suggested that the model is confirmed by bearing in mind the case study in a big tyre business in Southern India. The researchers utilized both qualitative and quantifiable qualities, i.e. the initial stage of the model focuses on the selection of the greatest supplier, in that the qualitative characteristic is utilized, and in the second stage the measureable quality is utilized to unravel the MEDIM scientific model.

The researchers focused a lot on the model that synthesis of three components in automotive industry and they are the production charges at every plant for all stages, the inventory at every plant, distributors, vendor and merchant for all stages and the path between points where the merchandise is transported from the plant to suppliers, from suppliers to the merchant, from the merchant to the vendor, and then to client for all stages. Although this study addresses most of the inventory management factors, it is only focused on automotive OEM.

Defregger and Heinrich (2007) examines the revenue management for a make-to-order organization with restricted inventory volume. They have sown that the revenue management is customarily reflected as a tool of service tasks and it is also substantial possibility for use in manufacturing set-ups. The usual encounters in make-to-order manufacturing are stable manufacturing volumes and a countless variation in obtainable products, going along with noticeable variations in demand and cost-effectiveness. This paper explores a likelihood of the application of revenue management at ThyssenKrupp VDM, a large company in German steel mining industry, leading to significant developments in numerous areas.

In order to produce input statistics for revenue management, the authors used retrieved historic order data acquired from an wide database that holds common data (e.g., type of client, date and time of order, date and time of distribution), technical details (e.g., alloy, cold or hot-rolled, geometric sizes), data about production (e.g., start of production, production tracks, volume intake, work plans, rework), and commercial data (e.g., price, costs for sales, carriage, material, and production) for every order. Again, data about the production system together with the presented volume was utilized. Defregger and Heinrich's quantitative insights, tools and ideas for this research are relevant but the need for more insight will be great. They also mentioned that further investigation needs to be piloted in the zone of bringing up-to-date estimate and existing volume, along with the subsequent re-optimization. In this research, it sounds that no methodical outline for bringing up to date and re-optimizing in the make to order network setting currently exists. In conclusion, this is some of Defregger and Heinrich's best work but this time the authors' main focus is only in German mining manufacturing companies.

The research performed by Matsui (2007) yields an empirical analysis of just-in-time production in Japanese manufacturing companies. This article emphases on the necessities for just-in-time (JIT) production structures and the roles and significances of JIT production for manufacturing organizations. This paper used quantitative research method to report 9 trustworthy and effective measurement gauges regarding JIT production practices for 46 manufacturing firms in Japan. Established on these measurement gauges and a brief superscalar, the authors demonstrated that JIT production structures add to developing economic performance, and that well-organized equipment layout has a solid influence on the economic situation of the manufacturing firms. The research results reported about 14 scales that are closely linked with JIT production. The researchers mutually portrayed a dedicated and synchronized firm, great problem-solving capability of human resources, a concrete foundation for total quality management, steady or foreseeable information structures, inter-functional technology expansion, and the business/manufacturing approach boosting well-designed combination. Even though this journal examined a number of concerns with respect to the Japanese manufacturing companies' situations, the authors dealt with only automotive industry and the specific inventory management aspects are hardly been dealt with in this collected work.

Combining make-to-order and make-to-stock inventory policies in small medium enterprises manufacturing by Marco et al (2009) suggest the quantitative way that concentrates on decoupling idea and inventory policy choices in manufacturing businesses distributing products with dissimilar demand arrangements and customisation stages. The researchers revealed that adopting a clean make-to-order method might harshly disturb the reaction time for typical and steady products, whereas, then again, a wholesome make-to-stock policy might effect in surplus inventory. To overcome this, enterprises have a habit of adopting crossbreed and active make-to-order and make-to-stock policies, but conclusions are repeatedly made without the backing of a balanced model. In this article, the researchers developed a balanced model to back inventory management decisions in a make-to-order and make-to-stock background plus bridging the breach between theory and practice. From the case study, the author developed a decision-making methodology that engages simple models, approaches and apparatuses, as a result making it appropriate for practical employment in small and medium sized enterprises (SMEs). Dissimilar product characteristics are examined in this research with the aim of developing an outline for selecting the most appropriate decoupling fact and replacement policy (such as economic order quantity, EOQ) and for defining the factors of the selected policy (such as lot mass). The research shown the easiness of the technique alongside the encouraging results accomplished in this first case study employment propose that the new structure has the prospective to advance the inventory policies embraced by

small medium enterprises in a make-to-order and make-to-stock framework and should be polished and advanced through additional case study investigation. Although this seems logical, the authors specified that inventory scheduling concerns such as production and volume, along with acquiring, are left for yet to come expansion. They were not addressed and the study is only addressing the make-to-order together with make-to-stock policies for only small food manufacturing companies in Italy.

The dialogue is largely encouraged by the Spanish case study piloted by Alfaro et al (2009) in the in food industry. Their intention in this investigation was to demonstrate that traceability can become much beyond just a way to assure food safety. To demonstrate this notion, the authors established a longitudinal case study of one organization in the Spanish vegetable industry. They further showed the motives why this company decided to instrument an electronic traceability system, and they described how the utilization of its traceability system has provided them with various qualitative benefits alongside the different phases of their supply chain, their manufacturing tasks and their inventory and logistics events. The authors focus was just on food industry and the equipment maintenance inventory management was not addressed by the authors in this study.

Yuan and Gao (2009) examined a closed-loop supply chain system for inventory decision making models. The researchers pointed that the system entails of a vendor, a manufacturer, a dealer, and a merchant. The request from the vendor is fulfilled whichever by freshly manufactured merchandises or by remanufactured products which are equivalent to the new ones in purpose and quality. The authors applied one manufacturing sequence and no less than one remanufacturing sequence policy and no less than one manufacturing sequence and one remanufacturing sequence policy to the manufacturer's manufacturing as well as remanufacturing tasks, and provide the equivalent processes to regulate the ideal system policy in the entirely dispersed decision-making case and the entirely consolidated decision-making case by exclusion philosophy and the dissimilarly purpose. The results of this quantitative research are general since it shows on the research that the manufacturer be likely to embrace one manufacturing cycle and at no less than one remanufacturing sequence policy when the profit rate is advanced; or else, the manufacturer tends to embrace at no less than one manufacturing sequence and one remanufacturing sequence policy.

This research offers a closed-loop supply chain structure which only comprises of a sole element. It is anticipated that the scheduling prospect of the system is immeasurable and the system comprises of a vendor, a manufacturer, a supplier, and a merchant. The request of the client is satisfied by the vendor product inventory and the request of the retailer is fulfilled by the manufacturer product inventory which comprises of freshly manufactured products and remanufactured products. Even though the above collected works investigated the inventory decision-making in a sole enterprise with manufacturing and remanufacturing operations, none of them pays consideration to the influence of the synchronization of the manufacturer's manufacturing and remanufacturing operations on the inventory decision-making of other performers in the supply chain system and again the research in mainly performed on the automotive original equipment manufacturers of China.

The paper, trends in food packaging and manufacturing systems and technology by Mahalik and Nambia (2010) aims to explore ways for food manufacturing companies to expand their efficiency in terms of sustaining safety, by means of maintainable wrapping supplies, employing malleable and consistent expertise, and embracing recognized management moralities. In this article, the researchers looked into the high-tech in the food processing and packaging industry taking into consideration current developments in the arenas of clever packaging and materials together with the application of nano science and technology, computerization and control technology, standards, and their application set-ups, and in conclusion, the production management values and their developments for the food industry. A wide-ranging evaluation on the above and associated zones is presented in suitable directive.

The analysis of collected works was used, it is clear that though the investigators have concentrated on single feature of the processing, packaging, and manufacturing and the results shows that there is necessity for a more all-inclusive methodology to system investigation whereas understanding the scope of the whole operations. Much attention has been drawn to practical implementations of these advancements and little research has been conducted to show the inventory management of the raw materials. The research aims only at large food industry.

Fore and Msipha (2010) did some researches about the preventive maintenance using reliability centred maintenance in a ferrochrome manufacturing company. High production in manufacturing involves high equipment dependability and plant readiness. The purpose of this article is to demonstrate the administration of preventive maintenance by use of the Reliability Centred Maintenance (RCM), steering at ferrochrome processing plant. They pointed out in their research that preventive maintenance is over and over again abandoned, distressing process stability, and thus compromising product quality because of the drops and instabilities in operating temperature. They revealed that the equipment failures have a tendency to be recurrent and longer, consequently affecting production objectives. Start-up failures are also experienced after conducting maintenance and also that the maintenance division is affected by the unpredictability of the equipment's operational arrays, and faces trials in coming up with an operative spare part inventory management administration.

This points to disaster management, thus accumulating the direct cost of maintenance. They suggested that RCM be utilized to form a cost-effective preventive maintenance approach to report the leading reasons of equipment failure. The qualitative research method was piloted in a form of model comparisons and the interviews. The study results also displayed that the plant spares inventory is disordered, there are typically costs related with purchasing spares in an urgency and the maintenance or spare parts inventory is not well-ordered. This is regularly exposed by the absence of spares when necessary. Although this significant research in the large mining industry seems logical, it is felt that the authors focused more on the spare parts inventory, which is a good thing and not addressing the importance of the products storage, lead times and the capacity which forms part of the most crucial characteristics of the inventory management. This research is only aimed at mining companies.

The research, An investigation of the application of fuzzy set of philosophies in production and operations management by Wong and Lai (2011) aims to classify the research tendencies in and publication openings for the applications of the uncertain set models method in production and operations management. Their key discoveries indicated that:

- The greatest general applications are size planning, forecasting, inventory control, and product design.
- Some application regions make added use of specific kinds of fuzzy methods.
- The fraction of applications that speaks to mi/unstructured kinds of production and operations management difficulties is growing.
- The most general technologies combined with the fuzzy set concept method are hereditary/evolutionary set of rules and neural systems.
- And the greatest common improvement instrument is C Language and its extension.

The researchers' assessment settles numerous investigation tendencies, some of which are unpredicted and some of which challenge former discoveries. Although this significant study was conducted, the researchers' main concentration was on the past developments in fuzzy set philosophy research in production and operations management application zones, and do not analyze how fuzzy set theory could be functional in dissimilar types of inventory management applications. The study did not show in-depth understanding of how fuzzy set theory to advance proficiency and efficiency in various inventory management zones, and also did not show the exploration of the promising role that fuzzy set theory might play in inventory management applications. The study was just is for general manufacturing industry in china and nothing about the wind tunnel inventory management system was addressed. The study Periodic Review Inventory Management with Contingent Use of Two Freight Modes with Fixed Costs by Jain, Groenevelt and Rudi (2011), investigated a stochastic inventory ideal of arm that sources the product from a make-to-order manufacturer, and can ship orders by a mixture of dual goods in transit means. The researcher revealed that dual shipping approaches vary in lead-times, and each has axed and a quantity proportional cost for every use. They further emphasized that ordering decisions are made periodically; however, the inventory carrying and back-order fine charges are sustained endlessly in time. They used data about demand for the duration of the accomplishment of manufacturing to decide on how to assign units between the two shipping methods. By carrying-

out an extensive numerical quantitative research, they derived the ideal shipping method distribution policy and demonstration that the ideal ordering policy is not an (s;S) policy in overall. The researchers provided restrictions for the ideal policy and perform a stationary analysis of the model assuming an (s;S) policy. They further showed that the best (s;S) policy achieves time ordinary likelihood of being in-stock equivalent to the percentage of fine cost amount and the totality of penalty cost rate and carrying cost rate. In this significant research, the main focus was existence of big economies of gauge in shipping prices as compared to ordering cost, it is logical to trust mainly on the inexpensive shipping method and use the other under extreme conditions. This is also for food manufacturing and transportation companies. None of the issues encountered in the wind tunnel facilities inventory management or aerospace industry inventory management were addressed.

CONCLUSION

In this paper the literature review was done on number of papers in manufacturing industry. While all those reviewed papers are present with respect to inventory management, the specific inventory management in wind tunnels is hardly been dealt with in the literature. There are no exploration papers that openly talk about the wind tunnel facilities inventory management and its effectiveness. The researcher argue that this is undoubtedly necessary. From the researcher description of Aerospace research tool (Wind Tunnel) a number of detailed inventory management features that are special significance to the effective inventory management system (include important characteristics of wind tunnel inventory management system) can be derived. The literature is reviewed on inventory management and determined that some beneficial philosophies were existing. On the other hand, the majority of contributions do not report those specific features of wind tunnel inventory management. This paper introduces an overall structure to assess the effectiveness of inventory management in wind tunnel facilities

REFERENCES

Alfaro, JA. and Rabade, LA. (2010) Traceability as a strategic tool to improve inventory management: A case study in the food industry. *International journal of Production Economics*. 118 (1), pp. 104-110.

Boughton, B and Horvath, A. (2006) Environmental assessment of shredder residue management. *Resources Concervation and Recycling*. 47 (1), pp. 1-25.

Braglia, M and Zavanella, L. (2003) Modelling an industrial strategy for inventory management in supply chains: the 'Consignment Stock' case. *International Journal of Production Research*. 41 (16), pp. 3793–3808.

Defregger, F and Kuhn, H. (2007) Revenue management for a make-to-order company with limited inventory capacity. *Business Research Journal*. 3 (2), pp. 173-190.

Duray, R. (2004) Mass customizers' use of inventory, planning techniques and channel management. *Production Planning & Control*. 15 (4), pp. 412-421.

Fore, S and Msipha, A. (2010) Preventative Maintenance using reliability centered maintenance: A case study of a ferrochrome manufacturing company. *South African Journal of Industrial Engineering*. 21 (1), pp. 207-235.

Haq, AN and Kannan, G. (2006) Design of an integrated supplier selection and multi-echelon distribution inventory model in a built-to-order supply chain environment. *International Journal of Production Research*. 44 (10), pp. 1963–1985.

Koste, LL and Malhotra, MK. (2000) Trade-offs among the elements of flexibility: a comparison from the automotive industry. *International journal of Production Economics*. 28 (6), pp. 639-710.

Mahalik, NP and Nambiar, AN. (2010) Trends in food packaging and manufacturing systems and technology. *Trends in food science and technology*. 21 (3), pp. 117-128.

Matsui, Y. (2007) An empirical analysis of just-in-time production in Japanese manufacturing companies. *International journal of Production Economics*. 108 (1–2), pp. 153-164.

Mohanty, RP and Deshmukh, SG. (2001) Reengineering of materials management system: A case study. *Business Process Management Journal*. 7 (5), pp. 394-408.

Perona, M, Saccani, N and Zanoni, S. (2009) Combining make-to-order and make-to-stock inventory policies: an empirical application to a manufacturing SME. *Production Planning and Control*. 20 (7), pp. 559-575.

Roy, RN and Guin, KK. (1999) A proposed model of JIT purchasing in an integrated steel plant. *International journal of Production Economics*. 59 (1–3), pp. 1.
Soman, CA, van Donk, DP and Gaalman, G. (2004) Combined make-to-order and make-to-stock in a food production system. *International journal of Production Economics*. 59 (1–3), pp. 1.
Yao, AC and Carlson, JG. (1999) The impact of real-time data communication on inventory management. *The South African Journal of Business Management*. 48(3). PP. 63

BIBLIOGRAPHY

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