Selecting the best layout for the container terminal using Modeling and Simulation Techniques

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Abstract

Supply chain management is the key to the success and playing a large role in the modern world in every manufacturing and service sector. The effectiveness of the material handling system has a valuable impact on the excellence of supply chain. Although this is a non-value adding process but, can't be avoidable. Therefore, it is required to minimize the cost, time and effect of the material handling system. To analyse and simulate the MHS, port container terminal operations are taken in to study. Every operation in the CT is handling the material. In order to perform the effective handling, storage and retrieval at the stack is very much important. To execute the effective system, it is required to analyse the different scenarios such as various layouts and change of operations using mathematical modelling and Simulation techniques. These results of the different scenarios are compared for the efficiency of the stack.

Keywords
Supply Chain Management, Material Handling system, Simulation, Effective layout

1. Introduction

Supply chain management is the key to the success and playing a large role in the modern world in every manufacturing and service sector. The excellence of supply chain is depending on the effective material handling system. Although this is a non-value adding process but, can't be avoidable. Therefore, it is required to minimize the cost, time and effect of the material handling system. To perform the material handling in the efficient way it is need to adopt a proper strategy or concept of current world. Many concepts are developed by the masterminds from various countries across the world such as Just-In-Time concept, Toyota Production System, greening the supply chain and Lean manufacturing. In this study Lean supply chain management concepts are used to develop the material handling system.

To create and analyze the effective material handling system, we have to select a place where the material handling plays a vital role in the operation. Hence, port container terminal has been taken as our basement and need to develop the simulation model of the material handling system of the terminal.

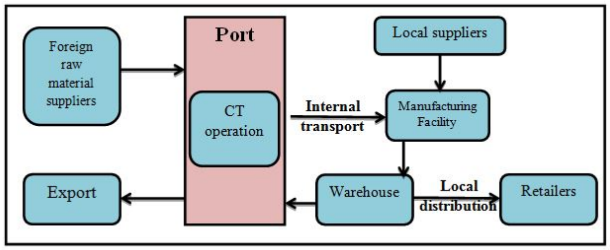


Figure 1. CT operations in the entire Supply Chain

The efficient use of these resources is the basis for granting customers the service level they are entitled to. Moreover, the more efficiently a terminal can use its resources, the more profit can be generated for the shareholders. In container terminal operations, the storage yard plays an important role for a terminal's overall performance because it links the seaside and landside and serves as the buffer area for storing containers. Therefore, storage and stacking logistics has become a field that increasingly attracts attentions in both academic and practical research during the recent years.

2. Literature Review

Many researches have been conducted in the area of container terminals and its operations by several researches from time to time. Operation of a landside container exchange area which is serviced by multirole semi-automated rail mounted gantry cranes is studied by Gary et.al (2007). They have proposed a three stage algorithm of scheduling of cranes, control of stacking and the allocation of delivery locations to manage the container exchange facilities [1].
Dharmapriya et.al (2011). proposed a value stream mapping for dedicating and random placing of containers in order to coordinate the operations of warehouse operations critically throughout the supply chain [2]. Increasing the efficiency and reducing the transport costs are few of their final outcomes. A study on routing the straddle carriers during the loading operation of export containers in the port terminal is presented by Hwan et.al (1999). A beam search algorithm is developed in order to sort out the carrier routing issue. They proposed a methodology for determining the visiting sequence of yard bays and number of containers to be picked up at each bay as their results of their study [3].
Liu et.al (2004). used single criterion decision making method to demonstrate the impact of automation and terminal layout on terminal performance [4]. They reveal the impacts of deploying automated guided vehicle system on container terminal systems in their study. The problem of forming an optimized solution for storage space allocation with various interrelated container terminal handling activities has been presented by Said et.al (2015). They implemented an approach using discrete-event simulation modeling to find the optimized solution [5].
Ilaria et.al (2007). provide the overview of decision problems which arise in the management of a container terminal. They focus on the impacts that gate operation and transshipment operations have on the yard. They proposed a novel solution by defining a new class of decision problems which integrate the tactical and the operational planning levels [6].
A rolling horizon approach is used by Chuqian et.al (2003) to solve the problem related to all the resources in terminal operations, including quay cranes, yard cranes, storage space, and internal trucks. Initially, they decomposed the issue into to levels and each level is formulated as a mathematical programming model for further analysis [7]. Deniz et.al (2013).presented a study to minimize the transportation costs and the number of re-handling moves while storing the export containers at the terminal yard [8]. The problem has been formulated in two stages. While the first stage assigns the containers of the same vessel to a group of yard bays via an optimization model, the second stage decides on the exact location of each container. They developed a simple interface for assisting the decision makers for storing each container and keeping track of the storage position in order to maintain an efficient flow throughout the operations.
This literatures are clearly state the storage optimization methods for CT. According these authors they were mentioned the individual part of the storage such as stack orientation, YC movement, reshuffling, in and out bound operations and so on. But in this study it is going to elaborate an integrate approach of all the container terminal operation belongs to the storage part.

3. Methodology

In this project a structure methodology is used in order to handle several container terminals operations optimization problems. Initially, basic yard storage model was developed using the conventional layout arrangements with PM, YC and stacks. In the basic model, we have considered the condition of first-come first served at the stack. After the basic conventional layout model, it is our concern to analyze different layout models such as chevron layout and Fishbone layout. Same combinations of PMs and YCs are maintained to test the efficiency improvement of operations.
In each phase mathematical modeling is developed individually. Thereafter individual and integrated simulation models are built using simulation software. The proposed methodology is given as the schematic plan in figure 2. Initially, mathematical models for each problem will be developed. These models will represent the container terminal stack operations like: resource allocation, calculation of stowage time, number of entities in the waiting line, etc. Thereafter the same operations will be developed as simulation models using simulation software and the simulation results for different scenarios will be compared for further analyses.

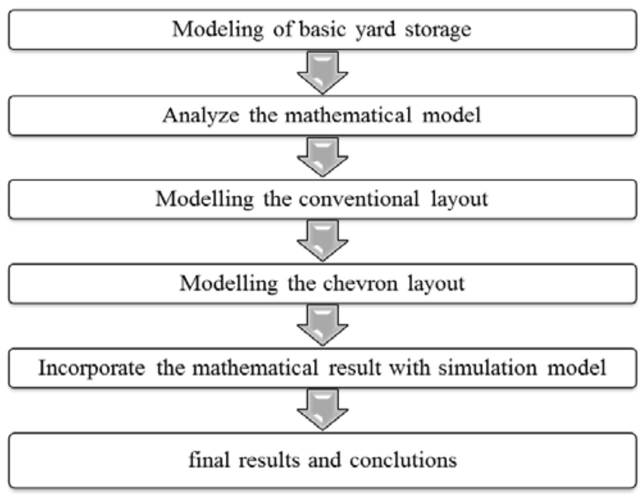


Figure 2. Methodology of the Study

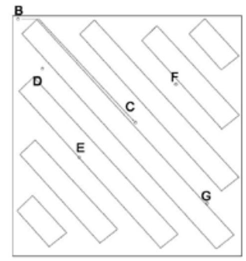
Mathematical Modelling

CT operations and problems can be modeled as server models since; there are entities which are similar to service stations/ servers and service receivers with waiting lines.

3.1. Movement calculations

Here the movements in the conventional layout and chevron layout are calculated. There are five points selected with the same coordinates in both layouts. Then the total travel distance from the point B to each point are calculated. Finally all the travel distances are added to get the total travel distance. The details are given in Table.

Table 1: Distance travel calculations

Movement From B (0,0) to	Distance (ft)	
	Conventional layout	Chevron layout
		
C (250,250)	500	353.55
D (50,100)	150	113.21
E (200,300)	500	337.92
F (400,150)	550	459.63
G (450,400)	850	608.19
Total	2550	1872.5

Efficiency increased for chevron = [(2250-1872.5)/2250] x100
= 26.56 %

3.2. Stacking capacity

Stacking capacity is calculated for the particular area of the stack with these three layouts. Then the capacity changes are made with respect to the conventional layout. Stacking capacities of these three layouts are given below in the table.

Table 2: Stacking capacity of three layouts

Block Type	TGS	TGS changes
Conventional	349	100%
Chevron	367	100%—106.5%

TGS- Twenty-foot Ground Slot

4. Modeling And Simulation

The simulation model of a container terminal has been developed using simulation software called Flexsim, which have required features to model logistics related problems.

Simulation model of the layout arrangement

In this part there were two models simulated and analysed using the Flexsim software.

4.1. Conventional layout

This conventional layout is simulated in the flexsim environment using the 500ft × 500ft storage area and there are 7 rows of 25×6×3 containers located and each of the rows has an YC.

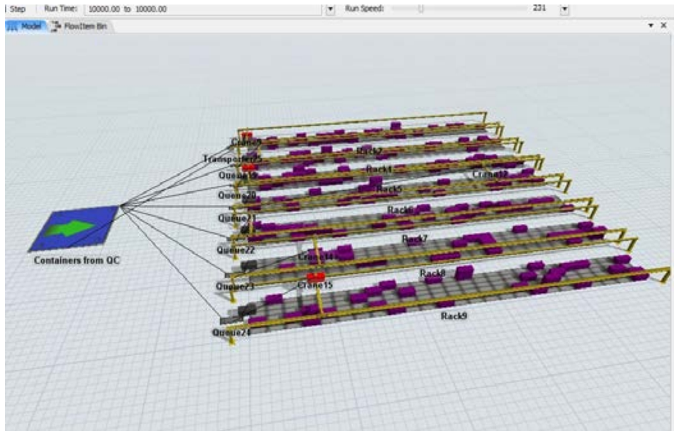


Figure 3: Simulation window of conventional layout

4.2. Chevron Layout

This chevron layout is also has the storage area of 500ft × 500ft. But here 9 rows are implemented as fit to the storage size. Every row has different capacity of the containers from 33×6×3 to 6×6×3. Each row has the separate YC for the operations. This layout arrangement helps to achieve the lean supply chain management through reducing the space for the stack and the reducing the minimum travel distance.

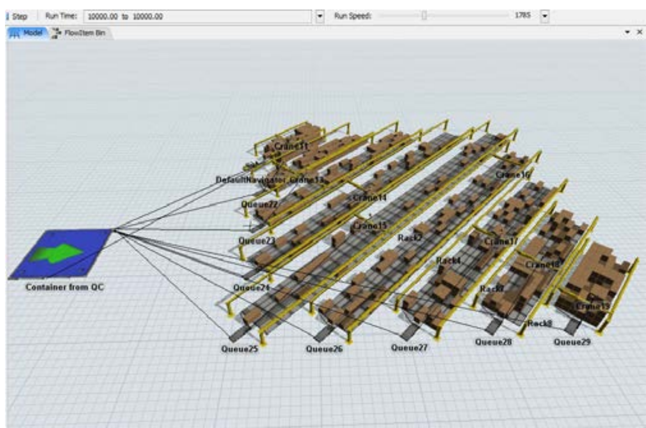


Figure 4: Simulation window of chevron layout

5. Results

Results from the simulation model are shown in the table below for the two layout types. For this analysis the conditions were maintained as same for both layouts. The block size is 500ft × 500ft. Each row of stack has separate YC and same No. of PMs. When we compare two layouts at the same time, Table of result is created as following,

Table 3: Results comparison of two layouts graphically

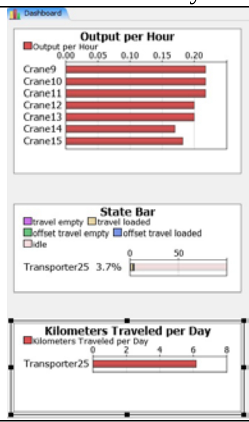
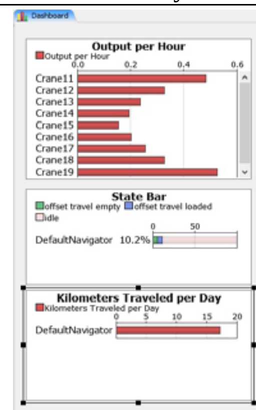
Conventional layout	Chevron layout
	

Table 4: Results comparison of two layouts analytically

Parameter	Conventional layout	Chevron layout
Output of the cranes per hour	0.18 - 0.22	0.2 - 0.5
Navigator travelling percentage	3.6%	10.2%
Navigator travel distance per day (km)	6.1	17.5

From this table we can clearly identify that the chevron layout is very much efficient than the normal layout. Therefore further studies this chevron layout is considered as the stack layout.

6. Discussion And Conclusions

In this project following conclusions can be made corresponding to the project objectives. The proposed simulation models which are incorporated with lean concepts to represent a container terminal and its several operations can be used for several testing with different scenarios to maintain smooth work flow within a CT. These models will help to optimize resource usage, reduce waiting time, reduce ship turnaround time, minimize empty travel time of vehicles, optimize the storage and I/B and O/B operations.

Further, the models for separate loading and unloading scenario, and simultaneous loading and unloading scenario can be used as per requirement by considering the constraints and limitations. Integrated scheduling plan is presented based on the simulation results obtained. Integrated scheduling plan provides different combinations of resources required to optimize the CT operations and storage.

Also, this study presents an overview of CT terminal operations, which gives a brief idea on current CT related issues, and the possible studies which can be carried out to improve the efficiency of the CT operations.

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Biography

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