Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 03, March -2018

# OPERATIONS OPTIMIZATION AT TKD CONTAINER TERMINAL

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**ABSTRACT-** *The development of containerization and its incessant expansion comprises alterations and technological advances in container terminals. In the current period of "vastness", regardless of existing fleet congestion, container companies increasing the intake of containers at the terminals to take advantage from economies of scale and to decrease operating costs. Subsequently, container terminals dealing with the problem of service delay.In dainty of this, this report is concentrating on the optimization of handling operations in the container yard, which is most important and complex area of terminal on which terminal efficiency mainly depends. In precise, it attempts to: (1) determine optimized size of block storage in the container or storage yard; (2) developing the optimized container yard layout, in which it focusses on each aspects individually such as internal truck's traveled distance optimization. In order to challenge these issues, two different analytical models are developed in this report. The first model targeted to evaluate the optimal size of each factor of container yard block. And, second analytical model aims to minimize the total distance travelled by internal trucks during container handling operations to facilitate optimal container yard. Finally, the numerical experiments are described in this report to prove the practicality of the different analytical models developed by concentrating on one aim of increasing the efficiency of container terminal. These can be useful by other researchers, organizers and terminal workers to optimize the container terminal operations, to increase their efficiency rates and to enhance terminal throughput without suffering large investment. Becoming technically efficient, the terminal will be more cost- efficient as well, resulting in the overall optimization of terminal performance.The results of this study describe and prove, how an infidel factor such as block storage capacity, yard layout by considering internal truck performance, etc. can enhance the efficiency of container terminal.*

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***Keywords-*** *container terminals, container yard, storage capacity, yard block, yard layout ptimization, block size, re-handling moves, and terminal operation*

## 1. INTRODUCTION

**General:**

Containerization is the most important trade due to its high values and steadily increasing trend in the market of global business. It includes number of operation and equipment to establish the transportation of goods using containers from source to destination.

**Container:**

Containers are rectangular shaped boxes used to transport goods from one location to another. These are used in import and export of cargo through a combination of different modes of transport viz. water transport (ships) and inland transport (trains and trucks) besides being moved by the yard equipment (gantry, yard trucks, and reach stackers) in the container depot. There is a variety of containers depending upon their sizes namely 20/40 feet conventional containers, 20/40 feet cubical containers, 45 feet type containers, tank type containers [42]. 40 feet type containers are generally used for international export-import only. Figure 1 shows one TEU (20 feet), and two TEU (40 feet) general, and 2 TEU cubical containers. Containers are specified in terms of TEU's (Twenty- feet Equivalent units) with 40 feet type containers termed as 2 TEU. Containers are basically divided on the basis of types of goods they are having. On the basis of this classification, they are divide into four types of containers; dry goods, liquid goods, majority cargos, and special goods desiring protection from the environment effects. According to their purpose containers are divided into general purpose, refrigerated, cubical, having upper part open, flat upper part and tank type containers.

 

20 feet 40 feet 40 feet cubical

**Figure 1: 20 feet, 40 feet general and 40 feet cubical containers**

**Container Yard:**

Container yard is a space in the terminal where all the operation related to container terminal take place. Basically the structure of the container yard is rectangular, but some time the shape of the container yard is irregular. At TKD container terminal which is a basically dry port, the structure of the container yard is rectangular in shape. Container yard basically consist of storage area that is blocks where import and export containers are kept, rail where trains are stands and containers loaded and unloaded to and from the trains, there is also transfer lanes from which internal trucks or external truck (sometime) move in the yard, and types of handling cranes (RTG (rubber tyred gantry crane), RMG (rail mounted gantry crane) etc.). The layout of the container yard basically shows the location of each component of container yard, which is shown in figure 2 Container yard basically have two types of storage block layout that is parallel and perpendicular layout. Parallel storage block layout is the layout in which storage block is align parallel to rail or quay side, in this layout yard cranes can travel from one block to another and container blocks are devoted to either inbound or outbound containers (no mixed blocks). Perpendicular storage block layout is the layout in which storage block is align perpendicular to rail or quay side, in this layout yard cranes cannot travel from one block to another that they are fixed on one storage block. At TKD container terminal parallel yard layout is used and in general most of the Asian container terminals are using parallel yard layout.

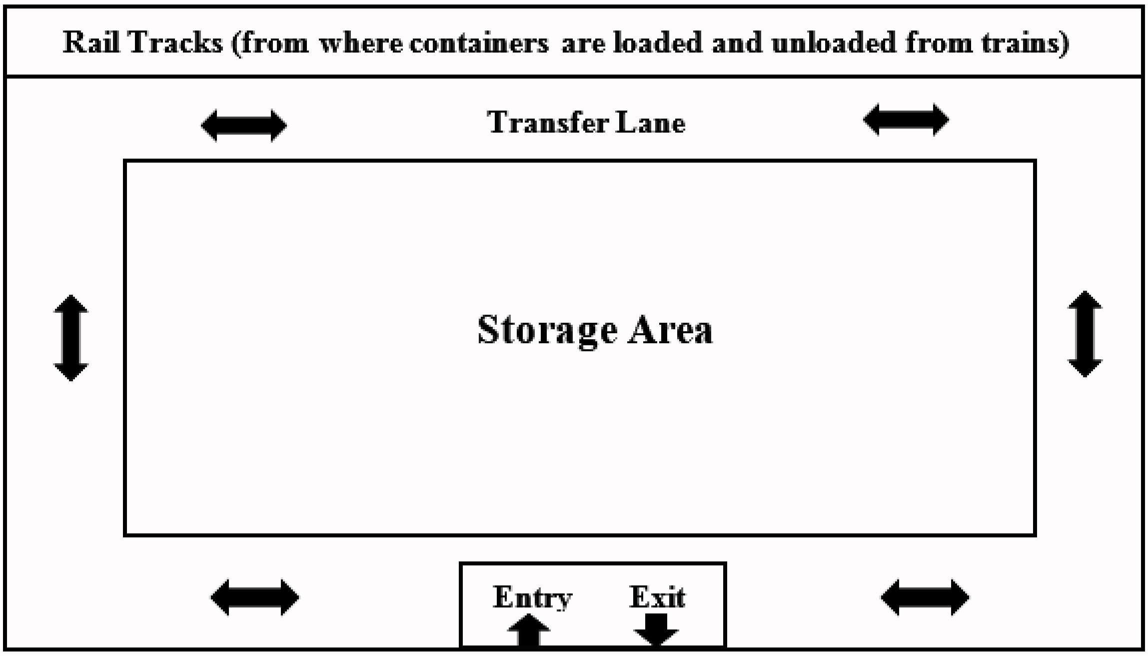


**Figure 2: Layout of a container yard**

**Block of a container yard:**

A block is basic unit of storage space at container terminal. A yard layout constitute number of blocks for storage. In Asian countries there is separate blocks for inbound and outbound containers, the number of inbound container blocks is always greater than number of outbound container blocks. Because in Asian countries import is higher than export.

A block constitute three parameters, i.e. number of bays (block length) (L), number of tier (H), and number of rows (W) as shown in figure 3. When these parameter's value increase then size of block is also increase.

 

The block storage capacity depends upon these parameters, higher the values of these parameters higher the block storage capacity.

Block storage capacity = L×H×W.

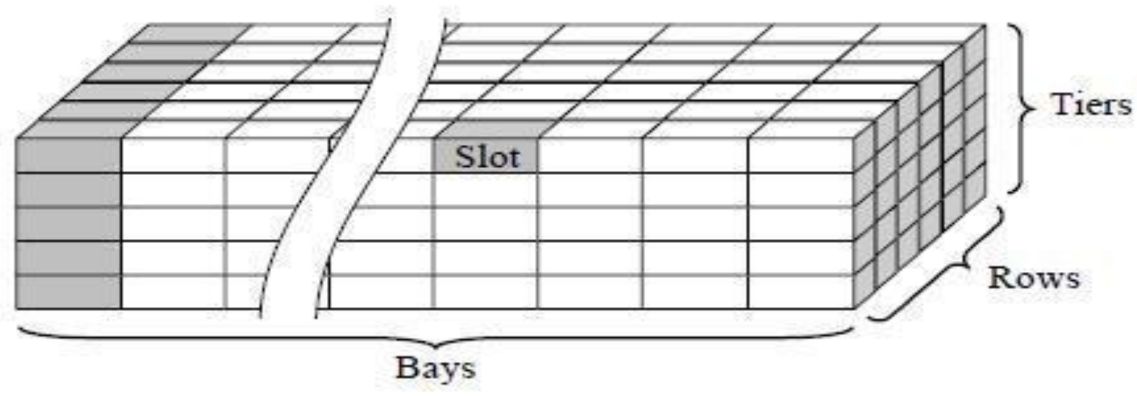


**Figure 3: Block of a container terminal [4]**

**Container Handling Equipment:**
At container terminal there are number of operations associated with a container and these operations are performed using handling equipment such as:

**Reach Stacker:**
A reach stacker is a type of handling equipment with a telescopic boom and top-lift accessory used for lifting and stacking containers. Figure 4 show's a reach-stacker that functions in the container terminal. It is basically used to stack containers and to load them into trucks, tractors or trains. Its storage capacity is approximately equal to 500 TEU per hectare. It can stack container up to three container height.


**Figure 4: Reach stacker [38]**

**Cranes:**
At TKD container terminal there are two types of cranes are used i.e. rubber tyred gantry crane (RTGC) and rail mounted gantry cranes (RMGC). RTG cranes are basically having tyres for movement and these are used move container within a storage block and between storage blocks and it has high productivity [43]. RMG cranes are having wheels, which is mounted on rails, so that it has only straight type movement of crane. Its task is devoted to only one train or block. It is generally used for unloading of containers from trains and it can stack container up to five container height.

 

**Container Terminal Operations:**

In today's scenario containers are most important equipment for intermodal transportation. Every container have their standard size and unit, which suits to trucks, trains and ships. In- depth container is the key connection between different types of transportation modes. This report is basically devoted to TKD container terminal which is an inland container depot. Inland container terminal generally termed as open system for goods flow between two interfaces, i.e. train side, for loading and unloading of containers from trains and gate, for in and out of container from the terminal. Terminal operations are basically performed in chain (Zondag et al., 2010) [44] and this operational chain is shown in figure 5.

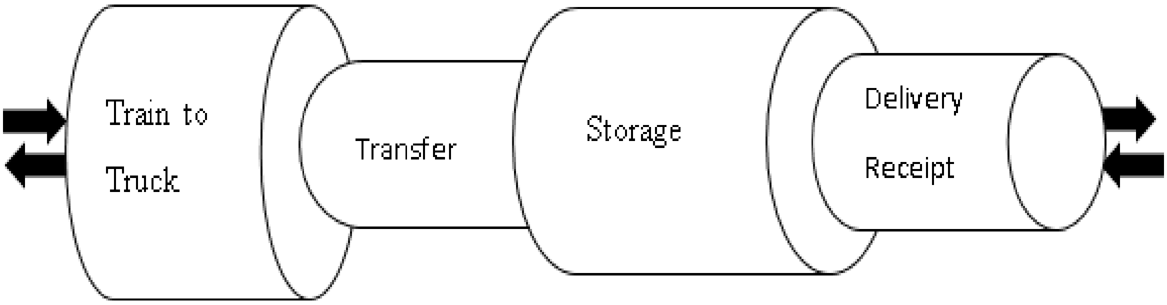


**Figure 5: Chain of terminal operation**

**Motivation:**

TKD container terminal is the largest dry port of South East Asia and it is the main centre for exporter and importer of entire north part of India. This container terminal starts operating in New Delhi in 1993 and its exact location near Okhla Industrial Area [45] and it expands over 44 hectares of land and this location is surrounded by highly populated roads and colonies. It is one of the container terminal of CONCOR (Container Corporation of India, which is a PSU responsible for all task regarding container in India). TKD container terminal have railway lines and road entrance which brings container from ports (from Gateway ports such as Mumbai, Nhava Sheva, Chennai, Haldia, Calcutta and Kandla) and companies. As discussed above it is a huge container terminal, so that there are huge numbers of containers are existing and large number of containers are coming and going to and from the terminal. To study and observe the entire container terminal, we organised a visit to TKD container terminal. We found that there is number of issues which motivates us to work on it and these issues are:

Workload at night is very high and low in day time, due to this operational efficiency of terminal is not good at night, but fair in day time.

- Due to multiple operations (on same time there is operation of unloading of container from internal truck and loading of container to external truck for delivery), so there is a problem of traffic jam.
- Management of blocks is poor i.e. structure of storage blocks in storage yard is improper such as some blocks having three heights and some of them having five heights.
- Inefficient operation by yard cranes i.e. there is no proper schedule for RMGC and RTGC for doing container handling operations, such as sometime for doing one operation there are two RTGC at same point.
- Communication gap between operators and controller due to high noise of Yard trucks (internal) and external Trucks (basically at TKD container terminal, internal and external trucks are manually operated i.e. they have no advance technology in it, and their maintenance schedule are also not regular (not preventive), so that they run in bad condition until they get failed).
- Communication gap between railway employees and controller of yard (as we know there is always some conflicts between PSU employees and Govt. employees, so that way of communication between yard operator and railway employees are not descriptive and favorable, it cause bullwhip effect in the supply chain of container terminal.)
- Yard utilization is improper i.e. at TKD container terminal location of container handling equipment, operators, control office are not at proper, due to this there is problem of container misplace, distance travel by internal trucks are expensive and operators job efficiency is very less.

After discussing all above point, we come to the point that TKD container terminal have number of issues, which effects its productivity, so there is a need of some modification i.e. improvement in terminal's operation and it motivates us towards work, which is done in this report.

## 2. Problem description and Objectives

As discussed earlier a container terminal is a place whose main function is to provide temporary storage to containers, which is on their way from source to destination. Main focus of this project is on TKD container terminal because this project in collaboration with **CONCOR** of India. At TKD container terminal there is no operations related to vessel (ship) (operations such as loading and unloading of container from the ship, scheduling berth allocation of ship, minimizing berthing time etc.) because it is an inland container depot as discussed earlier.At TKD container terminal there are basically four types of operations are performed and these are: railside operation, transport operation, storage and stacking operation and operations related to delivery and receipt of container. As usual there is number of problems associated with each of these operations, such as:

- Problems related to waiting time: truck waiting time (trucks are waiting near the train, storage blocks for getting loaded or unloaded), customer waiting time (external trucks of customer are waiting near the inbound and outbound container blocks to get load or unload).
- Problems related to scheduling: internal trucks scheduling when there is limited number of trucks available for doing the transportation operations, crane scheduling for stacking of containers in stacks and loading/unloading of containers and train scheduling i.e. on which rail track train will come for loading and unloading of containers.
- Problems related to cost: truck travelling and operating cost, crane operating and maintenance cost, yard controlling cost.
- Problem related to yard layout: truck travelling distance (distance travelled by internal truck for transportation of container from train to storage blocks and vice-versa), Crane deployment i.e. how much yard crane needed and their location in the yard, container re-handling or reshuffling in the storage block, customer service level i.e. level of customer satisfaction when they come to the container terminal for receiving or dropping the container, train sozourn time i.e. time duration between when train come at container terminal and when it leaves the container terminal, traffic congestion i.e. overcrowding of internal and external truck of the terminal which stops the operation of the terminal.

Therefore, **CONCOR** wants to improve the operational efficiency of TKD (Tughlakabad) container terminal to achieve the demand in minimum cost. After visiting to TKD container terminal, we see the problems which decrease its operational efficiency such as inefficient utilization of Yard Cranes, improper block size and improper yard layout etc. So, to increase container terminal efficiency the above problem should be removed. So, this project's modelling part is split in to two parts, according to container terminal requirements. The two parts are:

- Optimization of block size.
- Optimization of container yard layout.

But after considering all points and considering the above two parts, which we thought that it can improve the efficiency of the TKD container terminal, we come to the point that to achieve above two parts we have to aim number of problems. So, main objectives of this project is in such a way that main purpose of this project i.e., to facilitate efficient operations at TKD container terminal, achieved. So, the objectives needed to increase the efficiency of container terminal operations are given as follows:

- Maximizing the block storage capacity (i.e., optimize the value of number of tier, bay and rows of the block).
- Optimize the container yard layout (i.e., number of block, number of YCs, number of rail track, distance travelled by internal truck, customer service level, container re- handling or reshuffling, traffic congestion, and train sozourn time etc.)
- Facilitate efficient operation at the container terminal (i.e., decrease in container traffic in the passageway).

## 2. LITERATUREREVIEW

**General:**

The transportation of goods through containers has increased manifold in the past few decades resulting in competition amongst the ports in order to provide better customer services. To achieve better service, the operations starting from platform allocation, loading/unloading of containers, transportation through trucks inside the yard, and piling/rescues should take place in the most efficient and economic manner keeping in mind the safety of the operations. And, terminals are facing the problem of controlling an increasing number of containers in very short time and at minimum cost. Consequently, container terminals are enforced to increase handling capabilities and to achieve increase in productivity. The problem of remitting and scheduling of the internal trucks at the container terminal has been comprehensively studied by number of researchers. And, number of study are also done regarding storage allocation. But regrettably; most of these studies are not directly related to container terminals due to their uniqueness. So, it is required to develop algorithms or models, which is generic or sometime specific for any container terminal. Since efficiency and productivity of the container terminal are the main objectives for any terminal i.e., optimal layout, optimal operations. This chapter is broadly divided into two parts i.e., first part describe literature reviews regarding optimization techniques and methods used, and second part describe about container terminal's fundamental activities and other things.

**Literature Review on Optimization Techniques and Methods:**

Optimization models are created to achieve the best solution of a given problem under given conditions. Generally optimisation models are depend on some types of mathematical programming methods/technique. Some effective applications of these methods/techniques to container terminal operation have been described in the literature.Traffic congestion reduction:Yongbin Han et al. (2008) [24] developed a mix integer programming model to reduce traffic congestion problem, with help of low-high workload balancing technique, to achieve this the model determines minimum number of yard cranes needed to handle the imported containers coming to the container terminal and for verification of model number of numerical experiments are done. Joseph J. M. Evers and Stijn A. J. Koppers (1996) [25] developed a hierarchical model for controlling the traffic of automated vehicles, model developed is enhancing the performance of the information system used for controlling automated vehicles in container terminal.

## 3. MATHEMATICAL MODEL FORMULATION

As discussed earlier TKD container terminal is the inland container terminal (ICD) which is located at Tughlakabad (TKD) in New Delhi and this project mainly focus on this terminal. ICD, Tughlakabad is a type of dry port functioned by trains and it is a container terminal comes under CONCOR. This terminal comprises of a railside area where trains with or without container arrive, acquire serviced, loading, unloading and departure from the terminal. There is a container yard, where containers are temporarily stored until they are transported to their desired destination. The container terminal handles the number of trains, and every train is attended by number of handling equipment that load and unload the containers to the train and from trains. Likewise, this container terminal have a variety of yard cranes in the container yard that performs the loading and unloading of containers to the trucks and from trucks.

Initially we start this project i.e. to facilitate efficient operation at TKD container terminal using RFID (Radio Frequency Identification) technology. It is a technology that allows automatic identification of objects, animals and people and it is the electronic version of Bar Code. It can operate on number of frequencies ranges such as: low range (100-150 kHz)-low data rate, cost, medium range (10-20 MHz)-medium data rate and high range (850-950 MHz)-high data rate, cost [36]. It has following component:

- **Tag** – It is a transponder that is made up of an integrated antenna and an electronic circuit. The information can be written and rewritten on a tag.
- **Reader –** It is a device that is used to interrogate an RFID tag. The reader has an antenna that emits radio waves; the tag responds back by sending its data.
- **Host Computer -** It reads /writes data from/to the tag through the reader. It stores and evaluates

**Problem Formulation**

To optimize the block size, we have to optimize number of bays, number of tier, and number of rows and these are optimize when we optimize the block storage capacity. In TKD the focus of management is to mainly increase the number of container transfer from terminal to the landside customer and to the sea ports. They basically want to increase the container transfer within available resources (available apace for storage), to increase the number of customers and to satisfy the customer demand. So to increase the number of container transfer yard should be designed in such a way that no customer wait for their service and without increasing the container congestion at the terminal. It is possible by designing the block size i.e. by increasing the block storage capacity (i.e. by increasing the number of rows, number of tier, and number of bays in a block).

But for optimizing the block storage capacity yard crane cycle time play important role because by increasing the block parameters YC cycle also increase. Basically YC cycle time is time required by the YC to perform the yard operations (i.e. loading, discharging, receiving, and delivery). YC cycle time basically include time require to handle container from or to truck/rail racks to or from block at specified location. So if we increase the any parameter of the block, the YC cycle time increase for handling the container. So, optimizing the block storage capacity we must consider the YC cycle time.

YC cycle time is varying in nature because if a YC perform a delivery operation at a block, then time require to perform the operation is different for delivery a container which is at the end of the a bay widthwise and it is different if the container is at the center of that block because, to delivering the central container trolley movement is more as compare to when container is at the end. So to optimizing the block storage capacity we consider the expected value of YC cycle time in constraint for the purpose of simplification.

For optimizing the block storage capacity we have done problem formulation by taking the help of Lee&Kim (2010) [17] and Lee&Kim (2010) [5].

For the problem formulation we model the operations as follows:

**For maximizing the block storage capacity we use following notations for problem formulation:**

The following notations are introduced:

$X$ block length (in the number of bays) (a decision variable)

$Y$ height of stacks (in the number of tiers) (a decision variable)

$Z$ block width (in the number of rows in a bay) (a decision variable)

$\alpha$ weight assigned to loading operations. The weight that is assigned to

$\gamma$ maximum cycle time available for YC to perform an operation on outbound block

$\beta$ maximum cycle time available for YC to perform an operation on inbound block

g gantry movement

t trolley movement

u moving spreader up or down

0 loaded movement of YC

1 empty movement of YC

R re-handling operation

$l_o$ number of operation perform at a bay

$u_{YZ}$ number of operation perform at a block

$t_w$ time duration for trolley to move from one end to another end of a bay

$t_l$ time duration for gantry travel from first bay to last bay of a block.

And, container also have three parameters which is shown in figure 6 and bay also have some parameters, which is shown in figure 6

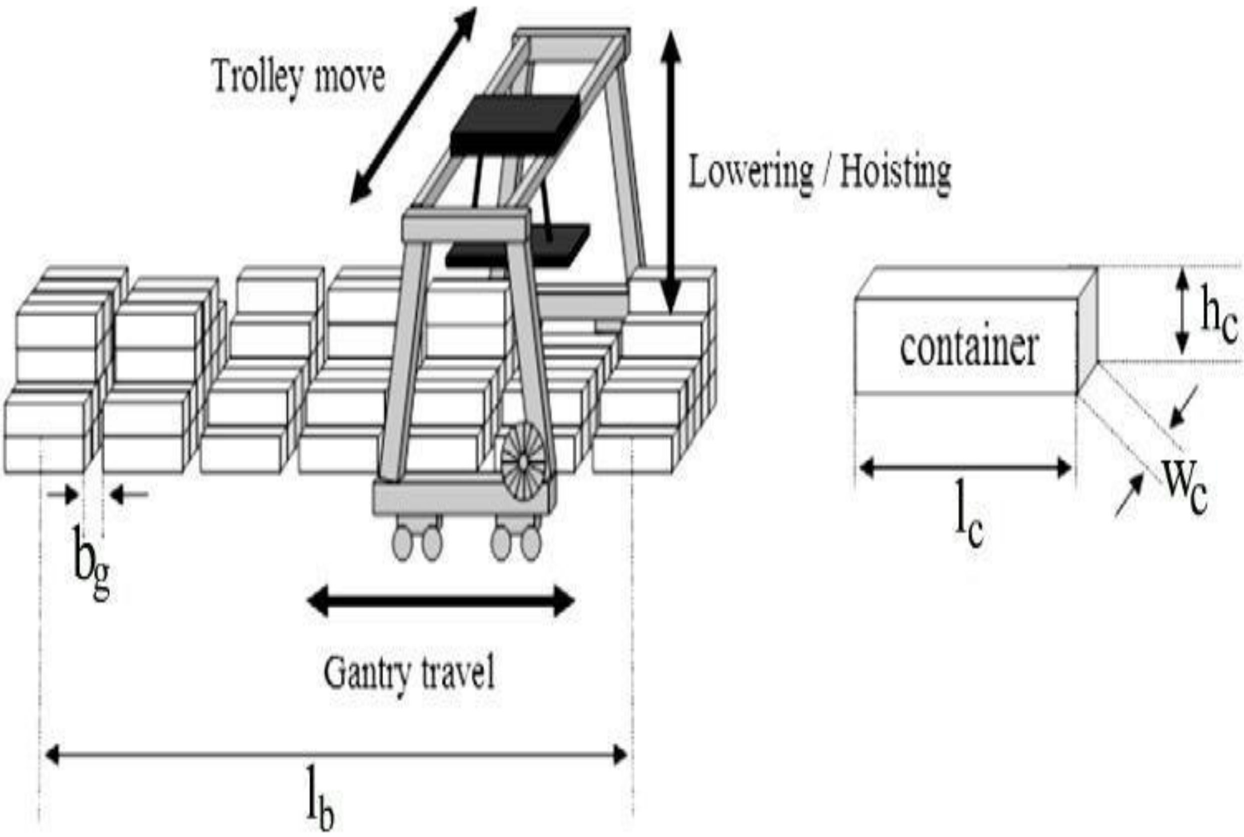


**Figure 6: Explanation of a block parameter notations [17]**

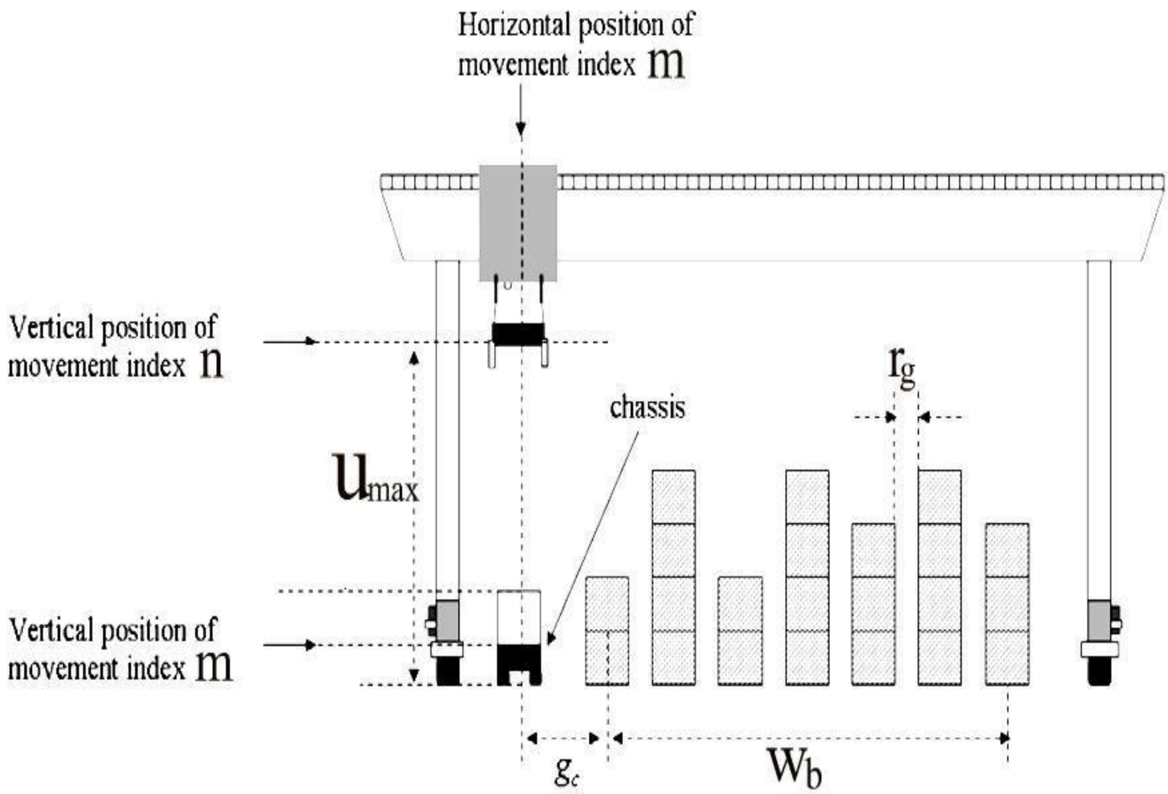


**Figure 7: Explanation of a** Optimization of problem

 

**For Outbound block**

Objective function:

Max. Capacity = $7\times X\times Y$

Subjected to constraint:-

$.5E[CTLo]+.5E[CTRe] \leq \gamma$ …… (1) $1\leq X \leq 40$ $1\leq Y \leq 5$

Where $X$, $Y$ are decision variables

**For Inbound block**

Objective function:

Max. Capacity = $7\times X\times Y$

Subjected to constraint:-

$.5E[CTUn]+.5E[CTDe] \leq \beta$ ………. (2) $1\leq X \leq 40$ $1\leq Y \leq 5$

After evaluation of expression for expected value of cycle time (Appendix A), the **expression of problem formulation becomes**:

**For Outbound block**

Objective function:

Max. Capacity = 7×X×Y

Subjected to constraint:-

$.5\times\{[(1+1C14)\times((-C9312\times C102\times(X-1)2)\times(C923\times C10\times(X-1))\times(C10\times(X-1)3))]+2C8+$
$C6+C7+[C3(3C14-1C14)]+2[((1+C11)\times(C4(Y+2)+C5))]\} \leq \gamma$ ………. (3) $1\leq X \leq 40$ $1\leq Y \leq 5$

**For Inbound block**

Objective function:

Max. Capacity = 7×X×Y

Subjected to constraint:- 28

$.5\times\{[(1+1C13)\times((-C9312\times C102\times(X-1)2)\times(C923\times C10\times(X-1))\times(C10\times(X-1)3))]+(C8\times(29Y+198112))+C6+C7+[C3\times(2+C12(C13-1C13))]+[(29Y+3056)((1+C11)\times(C4(Y+2)+C5))]+[(29Y-26112)\times((1+C12)\times(C2+C1(X-1)))]\} \leq \beta$ ……… (4)
$1\leq X \leq 40$ $1\leq Y \leq 5$

Where $C1= lc+bgVt1$ ,$C2= lcVt1$ ,$C3= gc+3(wc+rg)Vt1$ ,$C4= hc2Vt1$ , $C5= 1.5Vt1$ , $C6= (tu1nm+tu0mn)$ , $C7= (tu0nm+tu1mn)$ ,$C8=(tp+tr)$ ,$C9= gc+6(wc+rg)Vt0$ ,$C10= lc+bgVg0$ ,$C11= Vu1Vu0$ , $C12= Vt1Vt0$ , $C13= uYZ$ ,$C14= lo$ are constants.

For the solution of the above problem we need the specific optimization tool, but before that we need the value of all the constants, which is used in expression. After watching the expression we found that it is a non-linear problem and value of the X and Y should be integer because, X is the length of block in terms of number of bay and Y is the height of block in terms of number of tiers.

The value of constants can be determined only if the value of parameters on which they depend are known. The value of parameter, we can collect from the TKD container terminal, when we get the chance to collect data from terminal. For the initial phase of problem solution, we assume the value of these constants roughly.

**Optimization methods**

As it is observed from expression of problem that it has more than one power of decision variable, due to this it become non-linear mix integer program, for solving this nonlinear problem we use the two methods in M ATLAB (because it facilitate solution of all type of problem with easiest way of programming environment).

*Looping Method*: In this method we use the nested for loop to select the combination and use a numeric array for storing the value of capacity. Else if statement is also used for sorting the value of capacity according to the constraint provided. After that for selecting the maximum value of capacity, we use a variable which give us max value of the capacity.

## 4. Mathematical Model for Optimal Travel Distance of Internal Truck

As discussed earlier second part of this project is to optimize the container yard layout and for this, there is a need of understanding the container yard activities and operations. So that this section contains deep introduction about a container yard, problem formulation and their optimization.

At a container yard, types of containers and types of container terminal operations have great importance in deciding the optimized container yard layout. On the basis of container handling

at container yard, containers are classified into four types:

- Rail discharge containers: the containers which to be unloaded from the train racks
- Yard impromptu containers: the containers which is already in the yard and to be load on the external trucks.
- Yard indoctrinate containers: containers, which is come to the yard by external truck and stored in the blocks
- Rail loading containers: these are the containers, which are already stored in blocks waiting to be load on the train racks.

**Expression of problem formulation**

Objective:

**Minimize (distance travelled by internal truck):** $\sum_{i=1}^{T} \sum_{j=1}^{B} \sum_{k=1}^{S} Y_{ijk} d_{ijk}$

Subjected to:

$$\sum_{i=1}^{T} Y_{ijk} \leq V_{jk} \quad \text{.... (1) (supply constraint)}$$

For all j and k, where j϶ (1......B) and k ϵ (1......S)

$$\sum_{j=1}^{B} \sum_{k=1}^{S} Y_{ijk} = TC_i \quad \text{.... ..(2) (demand constraint)}$$

## RESULT AND ANALYSIS

**Result:**

This chapter refers to the result of models explained in detail in the previous chapter to increase the efficiency of container terminal operations in ICD (TKD), Tughlakabad. For obtaining the result in first model we assume data related to cycle time and in second model we assumed the data regarding distances between stacks and trains on the basis of observation done during visiting TKD container terminal. And, these models are solved by using different mechanisms. The mechanisms used are genetic algorithm, looping algorithm and transportation algorithm and they are solved on computers. Performance of these models are estimated separately and presented in next sections.

**Result of optimal block size model:**

In this section we describe about finding of optimal block size model, as discussed in section
3.2 after trying several times for getting value of constants, but we do not get any chance to get the data. Finally, we have no value of constants, so for solving the optimal block size problem using the genetic and looping algorithms we need value of constants. Therefore, we assume the value of constants for giving the initial result, but for final result we need the actual value of these constants.

**Using the Looping algorithm**:

After running the algorithm in MATLAB, we found following values of capacity of block and their parameters for:

*Inbound block*

Block storage capacity = 609, X (block length) = 29

Y (height of block) =3.

*Outbound block*

Block storage capacity = 840 X (block length) = 40

Y (height of block) =3.

**4.1.2 Result of optimal internal truck travel distance model**

In this section, we describe finding of optimal internal truck travel distance model. As discussed in section 3.3, this model's expression is linear and having number of variables and constraint, so we solved it using the CPLEX optimizer. After running the optimizer we found following result:

For getting the result we take following value of parameters; Number of train at terminal = 2

Number of blocks = 5

Number of stacks in each block = 10

And the value of decision variable (number of containers) at optimal location is given in the table 4.1

**Table 1: Value of decision variable**

| stack no. (size 50) | train no. (size 2) | No. of Containers |
|---|---|---|
| 1 | 1 | 0 |
| 1 | 2 | 0 |
| 2 | 1 | 10 |
| 2 | 2 | 0 |
| 3 | 1 | 0 |
| 3 | 2 | 5 |
| 4 | 1 | 0 |
| 4 | 2 | 0 |
| 5 | 1 | 0 |
| 5 | 2 | 0 |
| 6 | 1 | 0 |
| 6 | 2 | 0 |
| 7 | 1 | 0 |
| 7 | 2 | 4 |
| 8 | 1 | 0 |

| | | |
|---|---|---|
| 8 | 2 | 0 |
| 9 | 1 | 7 |
| 9 | 2 | 0 |
| 10 | 1 | 0 |
| 10 | 2 | 0 |
| 11 | 1 | 8 |
| 11 | 2 | 0 |
| 12 | 1 | 0 |
| 12 | 2 | 0 |
| 13 | 1 | 9 |
| 13 | 2 | 0 |
| 14 | 1 | 0 |
| 14 | 2 | 0 |
| 15 | 1 | 0 |
| 15 | 2 | 9 |
| 16 | 1 | 0 |
| 16 | 2 | 0 |
| 17 | 1 | 0 |
| 17 | 2 | 0 |
| 18 | 1 | 6 |
| 18 | 2 | 0 |
| 19 | 1 | 8 |
| 19 | 2 | 0 |
| 20 | 1 | 0 |

| Value of decision variable | | |
|---|---|---|
| Stack no. (size 50) | Train no. (size 2) | No. of Containers |
| 3 | 2 | 5 |

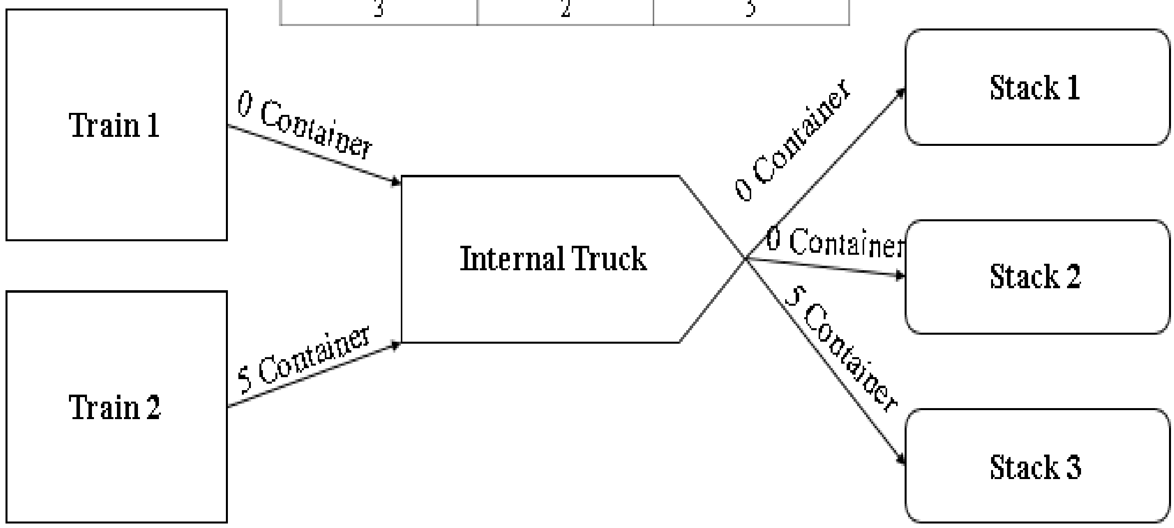


**Fig.4.1 Result description**

## CONCLUSION AND FUTURE SCOPE

This chapter basically summarizes work done in this report i.e. report summary and future work to be done to improve efficiency of TKD container terminal. As we know containerization of common goods have been increasing gradually over the last two decades. As an outcome of the rising volume of the ecosphere container turnover, nowadays container terminals have converted as a significant component of the universal transportation network. Due to and increasing competition, movement of huge volume of containers quickly and accurately is of dominant importance to a container depot. To achieve improved operations efficiency, a container depot needs to report the difficult process of transferring containers between numerous containers handling apparatus.

### 5.1 Report Summary

The project presented in this report describes the expansion and application of models to resolve internal truck travelling distance problem that is the problem of minimizing total distance moved by internal trucks during unloading of containers from trains to stacks into blocks and optimization of storage block size. A specific model is developed, which is based on non- linear mixed integer programming and its effectiveness in optimizing the yard crane cycle time by optimizing the storage block size of container yard has been done. In addition to specific model, two specific models depends on different type of storage block having different operations have been developed in this project. In addition to above model there is one generic model is also developed for the problem of optimizing the internal truck movement in the container yard, this model basically developed by considering it as transportation problem, so this model basically consist of concept of transportation model. The performance of above two models has been calculated in terms of the standard of solution attained by them. Solution obtained by first model is not quite good because unviability of data, but it shows that by keeping height of block above three, block length above twenty five and width seven enhance the operational efficiency of container terminal by optimizing their storage block size. But solution of second model shows that if we store containers after unloading it from trains to distance which near, total distance moved by internal truck in container yard gets minimized by significant amount and it leads to the decrease in transportation cost associated with

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