International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

Increasing the Production Rate by Introducing Vertical Storage Machine

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Accepted 30 Dec 2015, Available online 01 Jan 2016, **Vol.6, No.1 (Feb 2016)**

Abstract

The company Atlas Copco specializes in making the water well rigs. The main concern faced by the company was making the space available for the assembly of the water well rigs. The material stored in the warehouse of the company utilizes a lot of space. With the help of this project the space management of the company's warehouse is done and the floor area is made available. Mainly, on this project two machines TH10 and DB40K are considered. With increase in demand, the production rate was needed to be increased. For making this possible, the floor space was required to be managed accordingly. In the present research work, the Kardex shuttle system was introduced which is a vertical storage system and the increased the floor space from 35% to 71%, the production rate of the company was also raised and helped the company to increase their sales from 2.25Crores to 6.75Crores.

Keywords: *Assembly, Carousal System, DB40K, Kardex Shuttle System, TH10.*

1. Introduction

Atlas Copco is a Sweden based company established in the year 1873. It primarily concentrates its manufacturing in machineries that can easily use for underground processes. Machineries used for drilling and mining are the main focus of the firm.

Fig 1 Image Showing Assembled TH10

In this research, the main concentration will be on the drilling machines known as TH10 and Diamond Back 40K. The TH10 maintains the hard explosive tower structure, which helps in offering a sufficient place for executing such works like welding covering. The drilling speed of the drilling machine is very high along with other features like the good design, variable speed head, the input system, along with its rod handling technique. The input rate both upwards and downwards is around 191 feet every minute, i.e. 59 m every minute. Fig 1 shows how the assembled machine of TH10 looks like.

Fig 2 represents the inaction look of Diamond Back 40K. it is used for drilling the deep hole for water well and also many times used by oil and gas industries for extracting the natural gas and oil from the deepest parts of the earth.

Fig 2 Diamond Back 40K

1.1 Inventory Management

Basically the inventory management is an essential concept which represents the current status of the supply chain along with the financial status of the

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balance sheet. There are various types of inventories and at different stages of the organization.

In this research the main focus is on managing the space on the shopfloor of the company. Currently, the maximum space is occupied by the material stored along the floor area. In this research, the company is introduced with the vertical storage system which in return makes sufficient space for assembly of the water well rig machines TH10 and DB40K and increases the production rate three times per month. Also the pre management of all the inventories required for constructing the water well rigs is done. The material required for these machines requires sorting out and making the use of the Kanban system to make sure the production is not affected due to shortage in supply of the parts and material required for its construction.

1.2 Kardex Shuttle Concept

The concept used for this research is the Kardex shuttle concept. It is used for inventory management, which is the main focus of the research. It can be defined as modular structured computer managed robotic vertical lift, storing along with the recovery system. Every part works with its' own computer and electronically managed extractor which moves and provides the required tray or bucket to the small entrance of the location allocated for its storage in a very small duration of time. All the materials are stored on the plates or trays on the forward facing and backward facing side of the tower. This Kardex shuttle extractor does the work of getting the required material from their storage location to the trays and placing the material back to its previous location after use. This extractor is given the motion with the help of belts of two toothed type, which is also the latest technique and is noiseless working characteristics. Fig 3 gives clearer idea of the outline of the machine.

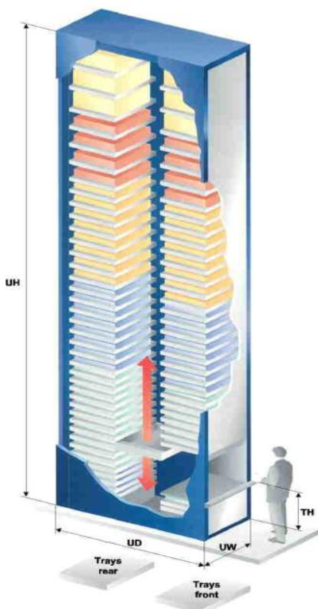


Fig 3 Outline of the Kardex Machine

2. Literature Review

In recent time, numerous firms have appeared as a classic of "finest rehearses" in supply chain management; for instance, Wal-Mart is commonly quoted as consuming exclusive approaches to top its marketplace. Single major task for Wal-Mart is handling records of goods that regularly *reaches expiry date*: A major share of Wal-Mart's item for consumption collection contains *consumable* goods such as foodstuffs (changing as of fresh products to milk products to bakery foodstuffs), medicines (e.g., drugs, vitamins, cosmetics), compounds (e.g., cleaning liquids used in homes), and etc. (Itir Z. Karaesmen *et al*, 2010).

The study that was grounded on the principle that RFID will be implanted in a transference chest or else pallet scattered in the Supply Chain (SC). The prototype presented that SC actions have optimistic associations with the RFID system, besides the initiation of RFID encourages data exchanges among SC actions, which in return allows the organization plus association of the entire SC management. After the consequences of this research, it stays predictable that the RFID scheme qualifies the SC associates to advance their benefits along with this; it encourages the competence of SC management completely. This is significant bearing in mind that here is till now an argument concerning the properties of RFID on SC management (Oh-Keun Ha *et al*, 2014).

The influence of RFID in warehouse organization of consumable foodstuffs and offers carefully worked-out outline to evaluate the assistances of RFID in warehouse organization. It aids organization in the several of methods comprising enhancement in the delivery besides transport methods, decrease in sequence calculating labors, decrease in store outs/additional account, reduced simulating, declined revenues, as well as decrease in account damage as a result of reduction plus uselessness. A compassion examination has been offered which displays the multiple consequences of RFID, drop in main time plus lead time inconsistency. Ultimately situations account level remains condensed by definite proportion by integrating RFID (Chandrakumar M. Badole *et al*, 2013).

A real manufacturing, warehouse demand picking issues, which where material is stockpiled at numerous places plus the pick position of material could be designated vigorously in immediate present period. The issues are overcome by means of a smart material created prototype. The demonstrating outline is amongst the dual limits of *categorized* plus *hierarchical* structures (Byung-In Kim *et al*, 2002).

The study to propose storing project, plus order gathering scheme by means of an advanced scientific model then stochastic evolutionary enhancement method in the motorized company. It is accomplished in two phases. In the initial phase, storing position task issue is resolved through a class dependent storing strategy using the purpose of reducing storeroom diffusions with the help of integer encoding. The next phase contains, grouping and steering issues stay measured, composed to decrease transport expense in warehouse processes (Seval Ene and Nursel Öztürk, 2012).

The properties of the order gathering scheme enactment for features like the number and arrangement kind of diagonal passages in a warehouse arrangement, storing consignment strategy, gathering method, normal gathering capacity consisted in passages, in addition to demand arrangement style, etc. A software, eM-plant, is considered as a imitation plus examination device, a warehouse strategy record will be introduced, which depends on the lowest complete migrant area by way of the finest routine guide, the diagonal passageway amount, warehouse design, storage consignment, picking direction preparation, picking amount plus demand grouping category will be properly combined and managed in the scheme of warehousing (Ling-feng Hsieh and Lihui Tsai, 2006).

The objective of improved recognized the impression of store administration rehearses on physical supplies treatment actions of warehouse supermarket workers. An ergonomic study was approved in two warehouse supermarkets of a prominent firm in the trade sector which concentrates in office provisions (D. Denis *et al*, 2006).

A thorough study of the investigation on warehouse project, presentation assessment, first-hand information collected case studies, plus atomized provision gears. This study on warehouse setup offers a complete assessment of current theoretical inquiry outcomes in the background of a methodical organization. Every exploration region inside current background is discoursed, counting the documents of the restrictions of earlier study plus of possible forthcoming exploration orders (Jinxiang Gu *et al*, 2010).

A particular sub-conditions for the ordered assembly of the issue, like excise enticements plus excise assemblies, convenience of employment strength, excellence plus dependability of manners of conveyance, in addition nearness to clients. The conservative methods to the warehouse site assortment issue have a tendency to be not as much of operative in distributing with the inaccurate or imprecise nature of the language calculation. In various states, the values of the qualitative conditions are repeatedly vaguely distinct for the decision-makers. Coquet essential is an appropriate numerous-criteria technique to imprisonment this inaccurate or unclear environment. In this paper, it is shown a positive presentation of numerous-criteria Choquet essential to an actual warehouse site assortment issue of a vast Turkish logistic company (Tufan Demirel *et al*, 2010).

A mixed-integer software design prototypical to resolve the warehouse remodel issue, the helpfulness of the prototype was authorized by its fruitful presentation of an actual situation issue besides by its understanding investigates once used with varying situations inside a warehouse linkage formation (Emanuel Melachrinoudis and Hokey Min, 2007).

An investigative prototype for the selecting and transferring system by recitation the process of selection as a Markov Chain for the approximation of the predictable space moved of the selection in a selected line. Depending on the projected logical prototype, this research originates assets of storing consignment plus recommends three procedures that optimally assign materials to storing for the gears of a unit selection area, a selection line with varied dimension areas, plus a selection line through similar dimension regions in a selection and transfer system (Jason Chao-Hsien Pan and Ming-Hung Wu, 2009).

The scientific prototype plus two effective processes for the combined replacement also supplies planning of the warehouse. Consequently, they have established the fusion, genetic algorithm (GA) then relate that one by way of dual effective experimental algorithms on behalf of widespread atomized tests. Additionally, they have demonstrated the benefits of our GA in production simply with supply limitations (B.C. Cha *et al*, 2008).

The theory of Supply Hub in Industrial Park (SHIP) is a capable method speaking this experiment. SHIP is explained as a community supplier of warehousing plus logistic facilities for industrial initiatives positioned inside a manufacturing park. The study described in this paper concentrates on assessing the price of carriage union, one of the classic profits of relating the SHIP method (Xuan Qiu and George Q. Huang, 2013).

Warehouse organization acting an essential part in effective steel resource chains, in specific, optimum planning used for entirely warehousing actions is a stimulating job in this environment: Management entering winds as of the steel capability, assigning these winds in their animatedly allocated positions in the warehouse, defining an arrangement in which the retiring coils, equivalent to the present client demands, must be stayed by the crane so as to shield all provision provisions on time (Günther Zäpfel and Michael Wasner, 2006).

The entire rate assistances that could be accomplished by dealers and warehouses over the improved universal reflectivity delivered through a combined system. They improved a distinct affair imitation model of a numerous-product source chain to inspect the possible welfares to be added from universal register perceptibility also preview patch shipping and arranging methods. Experimental outcomes determine the probable aimed at this combined example to progress client facility over better competences, compact prices, plus less lead-duration unevenness (Scott J. Mason *et al*, 2003).

3. Research Methodology

3.1. Floor Space

In most of the companies the main issue faced is the space management on the shop floor. The area available is to be utilized for material storing as well as the production of the machine. Both are required to be on the same floor so that the time required for moving the material to the required site is less and production rate is higher.

Considering the case of DB40K, it can be seen in the tables 1 and table 2 that how the area required for the storing the material and assembly is very less and the demand is very high.

- The total number of parts required for it is 1415.
- Components that can go into the yard are 51.
- Components to be kept on the pallets are 313.
- Bin containing the components is 882.
- Hydraulic hoses required are 205.

Table 1 Pallet and Forklift Area

Calculation for Pallet Rack Area 105 cells required considering 3 pallets per cell 21 columns needed considering 5 cells in each column				
	Pallet Rack	Forklift access		
Length	63	63		
Depth	1	4	Sq. m.	Sq. ft.
Area	63	252	315	3389.4

Table 2 Bin and Access Area

Calculation for Bin Rack Area 126 Cell required for 7 bins / cell 18 columns required for 7 cells/ column				
	Bin Rack	Access Area		
Length	37.8	37.8		
Depth	1	2	Sq. m.	Sq. ft.
Area	37.8	75.6	113.4	1220.2

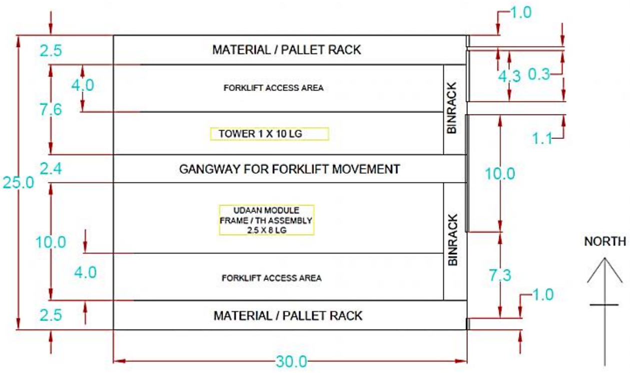


Fig 4 Present Layout of the Company

When the Table 1 is studied it can be seen that the total number of pallets per row kept are three and total number of rows in one column are 5. The area required for the forklift is same in front of every pallet and so that much area is also required to be kept empty and free of any obstacles. The similar situation is in the area occupied by the bins placed on the racks that is given in Table 2. Currently, the space available is only sufficient for manufacturing one water well machine per month, whereas the requirement is almost 3 to 4 machines per month. This is a huge difference experienced by the company and would let down the company's reputation if the demand of the customers is not met on time. The current layout of the company's shop floor can be seen in the line diagram as shown in the Fig 4 gives the detail information of the present layout of the shop floor and the area that is utilized for storing and area utilized for production.

3.2. Material Sorting

The parts and units required for manufacturing of the machines TH10 and DB40K were around 1500 each. All the parts were studied in deep to understand its nature. These parts after studying deeply were divided according to the size, dimensions, cost, sturdiness, frequency of using during the manufacturing of machines and cost. Every single part has a different nature and different behavioral properties. Total there were 3500 parts to be sorted out. There were four divisions made which were Kardex, yard, rack and paint shop in which these parts were distributed. Fig 5 represents the bins arrangements and utilization of the floor space and as it can be seen, the entire shopfloor space is consumed only for storing the material.

Fig 5 Image Showing the Bins Arrangement on the Shop Floor

The Kardex contained the maximum number of units since it is the most convenient and consists of the biggest storage system. The parts having smaller dimensions, high cost, high frequency of use and delicate in nature, were put in the Kardex. On the other hand, materials having larger dimensions which would not fit in the bucket size of the Kardex yet delicate were put in the racks. The larger parts that could bear the harsh weather conditions were shifted to the yard. The material like the pipes, oil barrels, water barrels, trucks etc. the paintshop consisted of the materials related to the painting of the machine like the paints, thinner, coating liquids etc.

3.3. Kanban Quantity

After the floor area was studied, the next task was to find out the Kanban quantity. This was done to make sure, the flow of material is right in time and the production should not get affected due to any kind of delay in the availability of the material. For deciding the Kanban system, the two bin system is followed. The quantity of material in each bin is to be calculated and accordingly the order is needed to be placed. For calculating the quantity, the parameters required are:

1) Lead time: Lead time indicates the time required from placing the order to the supplier's manufacturing time along with the time required for transportation and placing the material in the right location. Every supplier requires different lead time, according the nature of the part being manufactured along with the travel distance.
2) Monthly production: The number of machines being assembled every month comes into this category. The machines that are being manufactured here are TH10 and DB40k. in one month, the number of TH10 being manufactured are 2, and that of DB40k is 3. While considering the number of kanban quantities, these quantities are required to be considered and decided accordingly.
3) The daily requirement of the material: Once we have the monthly production rate of the machines, we can then calculate the daily requirement of every part. This can be calculated by multiplying the part required for every machine and dividing it by 30 days.

The formula derived for calculating the Kanban quantity can be given as:

Kanban quantity = (daily requirement) x (lead time)

4. Results

4.1 Space Management

For assembling the machines simultaneously, the main hurdle faced was the space management. The available space was not enough for assembling more than one machine. It was observed that the height of the shop floor is very high and can be utilized for storing instead of storing the material along the floor. For making this possible, the Kardex shuttle concept was introduced.

In the Table 3, the comparison can be seen. The dimensions and the working of the kardex system are seen in details in the section of research methodology and its comparison is done with the current material storage plan. In comparison, the utilization of the height of the shop floor is done more than its length. The area utilized for the storage of racks for pallets and racks for bins is completely eliminated and only the area required for the maintenance that is electrical output and plugs utilize a small amount of area. This helps in making the area available for assembly is 71%. Almost double the area is available as compared to the current layout on the shop floor. This will help in doubling the speed of assembly and meet the requirements.

Table 3 Comparison of Space Utilized

	Existing			Proposed		
	L (m)	W(m)	Area(sq.m.)	L(3)	W(m)	Area(sq.m.)
Total Space (A)	**30**	**25**	**750**	**30**	**25**	**750**
Maintenance access (No crane)area (north)	30	1.5	45	30	1.5	45
Maintenance access (no crane) area (south)	30	1.5	45	30	1.5	45
Pallet rack south	30	1	30	0	0	0
Pallet rack North	30	1	30	0	0	0
Forklift access area North	30	4	120	0	0	0
Forklift access area South	30	4	120	0	0	0
Bin Rack North East	5	2	10	0	0	0
Bin Rack South East	8	2	16	0	0	0
Gangway	30	2.4	72	30	2.4	72
Carousel System				8	7	56
Storage Area (B)			**488**			**218**
Assembly Area (A-B)			**262**			**532**
% utilization			**35%**			**71%**

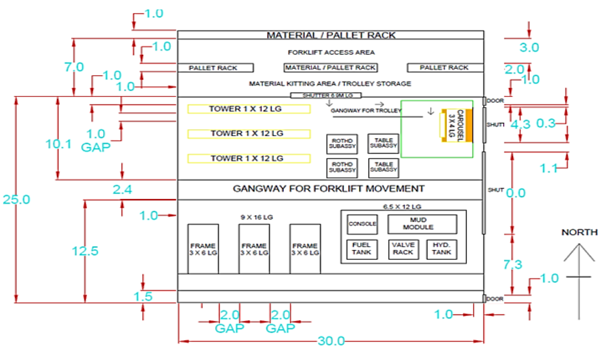
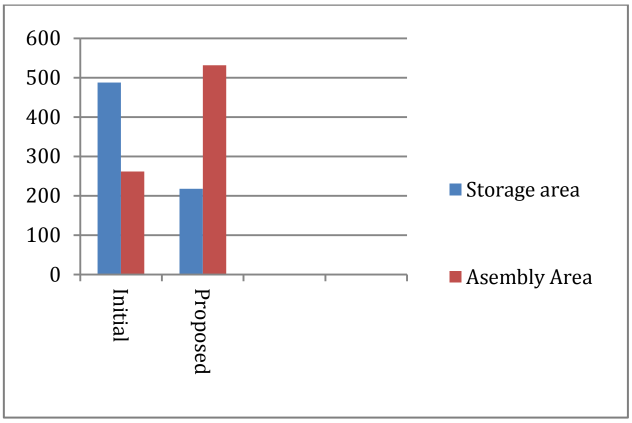


Fig 6 Diagram Showing Proposed Layout

Fig 6 helps to understand the layout of the floor when the carousel system is introduced. Where in the current case only one tower could fit is the available area, the proposed system could make almost three towers at one time to fit in the same area. As represented in the graph 1, it becomes very clear the utilization of the area for assembly as well as the area used for storing the material.



Graph 1 Area Comparison

4.2. Cost Optimization

Currently there are technical people who are assigned for assemblies of the machine are also working for pulling the material from their location. The rate of these persons per hour is **Rs.1450/-.**

Approximately for every assembly, the time required for material pulling only is 30 hours.

Therefore, the total cost required for only pulling the material can be calculated in rupees as:

1450*30 = 43500/-.

Since the current proposed work was undertaken for working on space management for assemblies of three machines at one time.

Therefore, the total cost required for material pulling of three machines can be given in rupees as:

43500*3 = 130500/-.

Whereas, in this proposed technique, non-technical persons can be employed for pulling the material since there will be only the need of knowing the location and number of trays to be pulled out. The rate of these people is around 500 per hour. When the total cost is calculated for these workers in rupees we get:

500*30 = 15000/-.

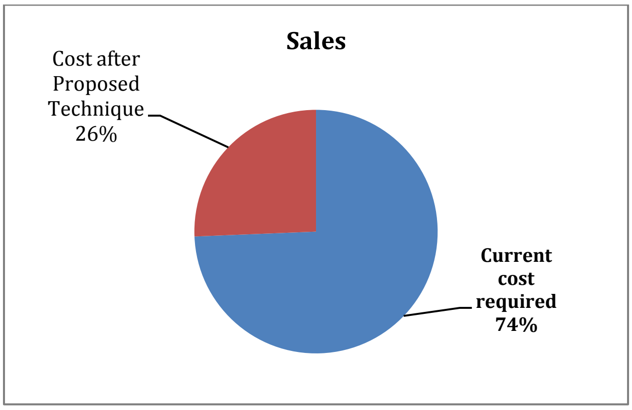
And for three machines in Rupees we can get:

15000*3 = 45000/-.

When these costs are compared, it can be seen a drastic difference is observed which can be found out by:

130500-45000 = 85500/-

Therefore the amount saved is **Rs. 85500/-.**



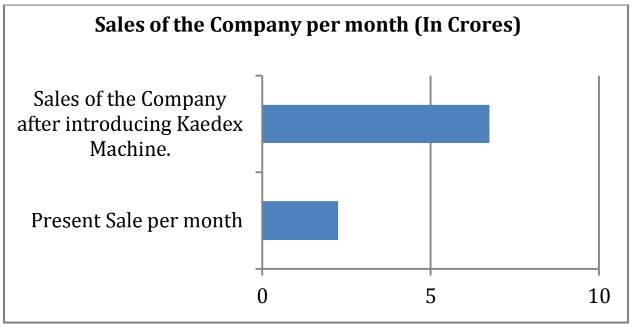
Graph 2 Comparison of Costs Required

On the other hand, the technical persons engaged in pulling out the material can now be assigned to doing some other technical work as per their caliber which in return would help the company to enhance their performance and productivity.

4.3. Company Sales

As discussed earlier, the company was able to assemble only one machine every month. So the sales were restricted to only that much. As each machine costs Rs.2.25 Crores, the sales were the same. After introducing the kardex system machine to the company, the assembly rate increase from one machine to three machines per month. The cost of the kardex system machine is around Rs.38 Lakhs excluding the taxes and shipping costs, this cost is much less as compared to the increased sales cost of the company. Per month sales of the company would go up to Rs.6.75 Crores every month as represented in the graph.

This has helped in proving that the proposed work has given a positive result which would help the company to grow and prosper more.



Graph 3: Company Sales per Month

Conclusion

When the vertical storage system that is Kardex machine was introduced, with some amount of investment, it was possible for the company to increase their production capacity from one machine per month to three machines per month. This also has helped the company to increase their sales accordingly.

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