Inventory Optimization in Manufacturing Industry

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Abstract: Inventory optimization is a method of balancing capital investment constraints or objectives and service-level goals over a large assortment of stock-keeping units (SKUs) while taking demand and supply volatility into account. Inventory optimization can be done through Just in Time (JIT). KANBAN is one such method to achieve JIT.

KANBAN is first introduced in Toyota. The very first step in Kanban is to study the demand of the component and adding buffer to it. A Buffer is the extra quantity which is maintained to sustain in the dynamic market. Then arrangements are to be made to store the components. According to the demand along with the buffer storage, certain limit has to be defined. We should ensure that the available stock should not fall below the lower limit. When it falls below the limit, item should be ordered immediately. In two bin system, two bins are used where if one of the bins falls vacant, the worker has to trigger the barcode. Then the supplier will get the order details automatically which is already stored in the barcode. Then they can place the order, without manually ordering it. It reduces the time consumption. In Kanban system, we have to study the market and set some demand so only required amount of components are ordered. Extra inventory can be eliminated.

Keywords: Inventory Optimization, SKU, Just In Time (JIT), KANBAN System

I. INTRODUCTION

In a construction equipment manufacturing company, there are 7000 components used and they are divided into four categories based on the importance namely A, B, C and D. Aand B categories are less in number but contributes 85% of the inventory cost. These includes chases, engines etc., and C and D categories are more in number and it contributes almost 15% of the inventory cost. These include nuts, bolts etc. Since they are small in size, they require more space to store and difficult to order each and every

The components were not easy for the workers to locate and also the availability of the components fluctuates sometimes they may be more and sometimes they may be scarcity of the components. If any one of the components is missing, the entire assembly will be delayed.

Hence the inventory was fluctuating. Time consumption for searching the required component while assembly was more. Space consumption was more. We should overcome these problems and also to make sure that the component should be there at the time of its usage.

Inventory is the cost associated with the goods. For any company, profit is the main target and it can be increased by reducing the expenditure. Inventory optimization is a method to reduce the cost of the order and it reduces the storage cost as well. When the demand is well defined, then production should be done to satisfy the demands. Excess production will lead to loss of money and the products cannot be sold as a result money will be deadlocked. So in order to avoid that situation, inventory should be optimized [2-3].

So it is essential for any company to maintain the inventory as low as possible and it should not affect the production. So we should balance the inventory and the production. Excess inventory will lead to extra expenditures like for storage, space consumption, security, and it affect the availability of money.

Market is very dynamic in nature and it changes with respect to time. So it is very important for any company to maintain the inventory keeping volatility of the market demand in concern [5].

Just in time is one such method to optimize the inventory cost.Just in time manufacturing, also known as just-in-time production or the Toyota Production System (TPS), is a methodology aimed primarily at reducing times within production system as well as response times from suppliers and to customers. Its origin and development was in Japan, largely in the 1960s and 1970s and particularly at Toyota [4-6].

Kanban is a visual signal that is used to trigger an action. The word Kanban is Japanese word which means “card you can see.”Toyota introduced and refined the use of Kanban in a relay system to standardize the flow of parts in their just in time production lines in the 1950s. In Kanban system, the demand of the market has to be studied, and adding some buffer storage to the market requirement we need to fix a lower limit of the stock to ensure the production continues. And we have to ensure that the stock availability should not go below the limit [7].

As one of the lean manufacturing principles, Kanban system emphasized minimum level of inventory by producing only what is needed. It ensures the supply of the right product, at the right time, in the right quantity and at the right place. Kanban system becomes practical; it synchronizes all manufacturing activities entire manufacturing with customer demand [3]

II. METHODOLOGY

2.0 Procedure to Implement KANBAN System

i)Validation of Bill Of Materials (BOM).

A bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities of each needed to manufacture an end product.
The details of the bill of materials is prepared by the company.
ii) Publish physical stock details at the company: The quantity of the stock is to be listed out.
iii) Article validity and conform final sales price.
Through the list of the stock needed, and based on the price details given by the supplier, cost will be estimated.
iv) The supplier to give the stock status of the each article.
After sending the details of the required articles from the company, the supplier will give the availability of the articles in that company. And announce the details of the delivery date.
v) KANBAN contract finalization:
After the negotiation of price, the company gives the contract to supply the components continuously without fail and to implement KANBAN system.
vi) Installation of racks: To arrange the bins, racks have to be installed.
vii) Installation of bins
Bins are the one which are used to store the components and there will be a capacity given by the supplier.
Based on the capacity of the bins, they are three types,
a) Small
b) Medium
c) Large
The three kinds of bins will have different capacities based on volume of the component to be stored.
The capacity of the bin will be mentioned on the bin
Based on the requirement of the component which include 15 present buffer, the number of bins will be calculated.
viii) Bin labelling
The label of on the bin gives some information about the storage location, component stored, capacity of the bin,barcode to scan etc.,
ix) Status of stock details of empty bin.
x) Empty bin triggering starts.
xi) Starts implementing the system.

2.1 Kanban sizing formulae- what they can and can't do

The number of Kanban needed to implement a project can be found out by using formula. There are many formulae which are used to find out the number of Kanban required some of them are quite complex, which inherently contradicts the simplicity of the Kanban. Based on the required accuracy, one should select the Kanban formula. We cannot select exact number of Kanban but while selecting, we should make sure that production should not be disturbed.no matter how sophisticated the formula may be we have to consider all the factors which can affect the production. Every process or project are dynamic and continuous improvement can be done. Kanban has a great quality that it is flexible and can continuously be improved.

2.2 Kanban Size Formula Fundamentals in Lean and JIT Manufacturing

Kanban can be used in Lean Six Sigma, whichrelies on data to drive towards improvement and values the prevention rather than detection of the defects after the process is done. To improve the results and customer satisfaction, it is about reducing variation, cycle time and wastewhile promoting the use of work standardization and flow.

Like Lean Six Sigma, Just in time manufacturing is an inventory strategy used to decrease wasteand increase efficiency. Just in time organizations receive goods on an asneeded basis in the production process to reduce inventory costs, and then use Kanban to signal when inventory replenishment is required.
The purpose of formulas is to reduce Kanban quantities in the spirit of the Toyota six practices:

1. Never send defective products downstream to the next process
2. Each process only orders what it currently needs from the upstream process
3. Each process only produces the quantity ordered by the downstream process
4. Maintain a level rate of production
5. Use Kanban to fine-tune the rate of production
6. Work to reach a stable rate of production

2.3 Factors That Influence Kanban Card Formulae

It is important to think about already existing formulas or maybe creating your own formula to determine the number of Kanban you need. When it comes to formulas, in manufacturing or other organizations where there are parts that move downstream, you need to consider the following factors:

1. **Customer tact -** Derived from the German word Taktzeit (and then adopted into Japanese), it means "measure time" and refers to cadence. Think about how many parts/deliverables a customer requires in a specific time frame.
2. **Regular time of replenishment system -** Consider how long it takes to restock items.

3. **Changes in replenishment system -** If problems occur, identify which items are most important to cover if there are fluctuations in restocking.
4. Customer changes **-** If the customer orders more quantity or the same overall amount but less frequently, consider what are the important changes that need to be covered.
5. Buffer/safety margin **-** Decide whether additional Kanbans are needed so team members can feel more comfortable with the system.

2.4 KANBAN Formula Used

One of the tendencies in the practice of Kanban is to make the formulas much more complex than needed. Here are basic Kanban formulas you can apply to your work situation to help keep estimating less stressful and time consuming:

Number of Kanban = DT (1+x)/C

- D: Demand per unit of time
- T: Lead time
- C: Container capacity or bin capacity.
- X: Buffer, or safety factor

III. EXPERIMENTAL RESEARCH

Kanban is of many types. It is different from one company to another. It can be formulated based on our need in a construction equipment company (VOLVO) located in Bangalore, where wourth company is a supplier. It sends around 630 different components.

3.1Problems faced without Kanban system

1. Ordering the components was very difficult.
2. Shortage of hardware for line which impacts production.
3. Frequent follow up of supplier for procuring material at right time.
4. Excess inventory of hardware at the RM stores at times which was of no use.
5. Excessive Space consumption for storing the extra inventory.
6. Additional cost was involved with extra inventory.
7. Problems were encountered while binning, such as wastage of time in searching the right material in the received pallets.

3.2 KANBAN Setup

There are many types of Kanban systems implemented in many companies. Firstly, the demand has to be studied. It is worthy to note that the market will not be the same and it fluctuates according to the inflation and many other situations [8].

3.2.1 Demand

Demand is very important thing we should firstly look upon. We should make sure that the components are delivered to the company right before their assembly starts. There will be 4 pavers, 5 excavators, 6 Single drum (RM), 4Double drum(RM) on an

average were manufactured every week and it will vary from time to time sometimes if the demand of the products are more, then the demand of the components will be increased.
The market is very dynamic and therefore to sustain in that unfavorable situations, buffer storage is added and it is fixed to 15%. Buffer storage is basically extra stock more than the required amount maintained to meet the fluctuating demands.

3.2.2 Bin Selection

Bins are used to store the components. There are 3 types of bins based on their size. Large, medium, and small. Each bin has its own capacity and it is given by the manufacturer. Based on the demand and size of the component, the type of bin is selected. 6Majorly, medium bins are used.

3.2.3 Two Bin System

Since there are more number of components involved in Kanban system, it is very much difficult to count the components to order. Hence we choose two bin system where the demand along (with the buffer) is studied and it is kept in two bins. For processing, they use first bin components. Whenever the bin becomes empty, they will trigger the barcode on the bin. And the barcode contains the details of the component and the quantity. Then the supplier automatically gets the details of the components to be delivered. So the worker will order the component without manually counting them. Now, there no manual work involved in ordering the component as soon as the worker trigger the empty bin, the supplier gets all the information regarding the details[7-10].

Table: 3.2.4 Kanban simulation

Sr No	Scan part no.	Wuerth Part	BIN	Description	Filled	Empty
1	12760163/B3RGZ06F10	02548 20	500	SCR-CUPPT-ISO4029-45H-IH4-M8X20		12760163/B/1
2	12760163/B3RGZ06F10	02548 20	500	SCR-CUPPT-ISO4029-45H-IH4-M8X20		
3	12783800/B3RGZ09E02	1905500716	70	WSH-WO-DIN440-R-(35-45HRC)-(A2C)-22X72X6		12783800/B/1
4	12783800/B3RGZ09E02	1905500716	70	WSH-WO-DIN440-R-(35-45HRC)-(A2C)-22X72X6		
5	12792325/B3RGZ09E05	010536 150	15	SCR-HEX-ISO4014-10.9-WS55-(A3C)-M36X150		12792325/B/1
6	12792325/B3RGZ09E05	010536 150	15	SCR-HEX-ISO4014-10.9-WS55-(A3C)-M36X150		
7	12792325/B3RGZ09E05	010536 150	100	SCR-HEX-ISO4014-10.9-WS55-(A3C)-M36X150		
8	12814824/B3RGZ07E07	006716 50	250	SCR-DIN961-10.9-WS24-(A2C)-M16X1,5X50		
9	12814824/B3RGZ07E07	006716 50	250	SCR-DIN961-10.9-WS24-(A2C)-M16X1,5X50		
10	12814824/B3RGZ07E07	006716 50	250	SCR-DIN961-10.9-WS24-(A2C)-M16X1,5X50		
11	12814824/B3RGZ07E07	006716 50	250	SCR-DIN961-10.9-WS24-(A2C)-M16X1,5X50		
12	12816118/B3RGZ09C01	4128420180	70	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M20X180		
13	12816118/B3RGZ09C01	4128420180	70	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M20X180		
14	12816118/B3RGZ09C01	4128420180	70	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M20X180		
15	12816118/B3RGZ09C01	4128420180	70	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M20X180		
16	12816118/B3RGZ09C01	4128420180	70	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M20X180		
17	12816118/B3RGZ09C01	4128420180	70	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M20X180		
18	12822985/B3RGZ07F10	4128424180	40	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M24X180		12822985/B/1
19	12822985/B3RGZ07F10	4128424180	40	SCR-HEX-ISO4014-10.9-(GE3A/VL)-M24X180		

The above table 3.2.4 indicating the status of the stock in Volvo. Whenever the empty bin is triggered in Volvo, the parts will be highlighted to the supplier in red color.

- Kanban simulation which was shared by supplier is as shown.
- It contains the red coloured cells which were empty at the company and were triggered.
- And the green once indicated the bins which are full with Kanban quantity.

IV. RESULTS AND DISCUSSION

As a result of implementation of Kanban system, we could able to reduce the inventory cost. The number of parts located in the company is reduced. Only the required quantity of the components are stored.

4.1 Reduction of quantity of the components in storage location after implementation of Kanban system

Table: 4.1.1 stock details of few components before and after implementation of Kanban system.

Component	Component Description	Total Qty now	stock before	Reduced Qty
RM95055265	HSHCS 3/8-16 X 1.25	300	1274	974
RM96742416	HEX. SOCKET SCREW; M5x12-8.8; ISO4762	5487	10000	4513
RM96720115	HEX. SOCKET SCREW; M5x16-8.8; ISO4762	1000	7200	6200
RM95920377	HEXAGON SCREW; 1/4-20x1.00-GR 8, PARTIAL	400	1914	1514
RM96747464	WASHER FLAT M8 -OD 16.0 CL 20	2000	7652	5652

The above table 4.1.1 gives the details of quantity of the components present in the company before and after the Kanban system Implementation. We can see after implementation of Kanban system, the excess storage is eliminated. Therefore, the storage Space is reduced.

4.2 Inventory reduction

Table: 4.2.1 Inventory details of few components

Component	Component Description	Inventory cost after KANBAN (in IND rupees)	Inventory cost before Kanban(in IND rupees)	Reduced inventory cost (IND Rupees)
RM95055265	HSHCS 3/8-16 X 1.25	4566	11978.14	7412.14
RM96742416	HEX. SOCKET SCREW; M5x12-8.8; ISO4762	3401.94	6200	2798.06
RM96720115	HEX. SOCKET SCREW; M5x16-8.8; ISO4762	4970	20377	15407
RM95920377	HEXAGON SCREW; 1/4-20x1.00-GR 8, PARTIAL	1620	4685.85	3065.85
RM96747464	WASHER FLAT M8 -OD 16.0 CL 20	6780	16360.14	9580.19

The above table 4.2.1 gives the information regarding inventory and it is clear that after implementation of Kanban system, the inventory cost has reduced significantly. And the difference in the inventory cost is shown in below graph.

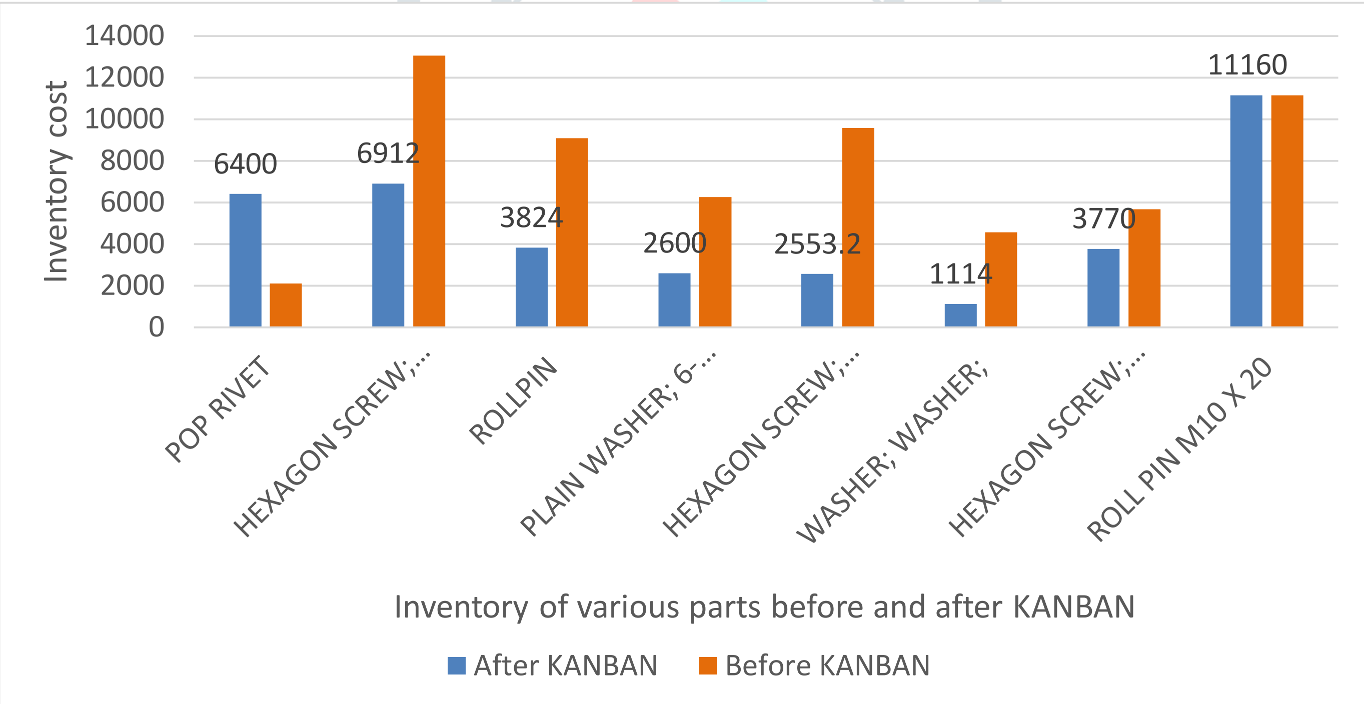

Fig: 4.2.2 variation in inventory cost for various components.

The figure 4.2.2 represents the details of the inventory before and after the implementation of the Kanban system for few samples. The samples are selected randomly from all the 560 components. The orange color indicating inventory before Kanban system, and the blue color indicating inventory after Kanban system implementation. And we can see from the above graph that the inventory cost is reduced. For few components, the inventory even got increased but only for few.

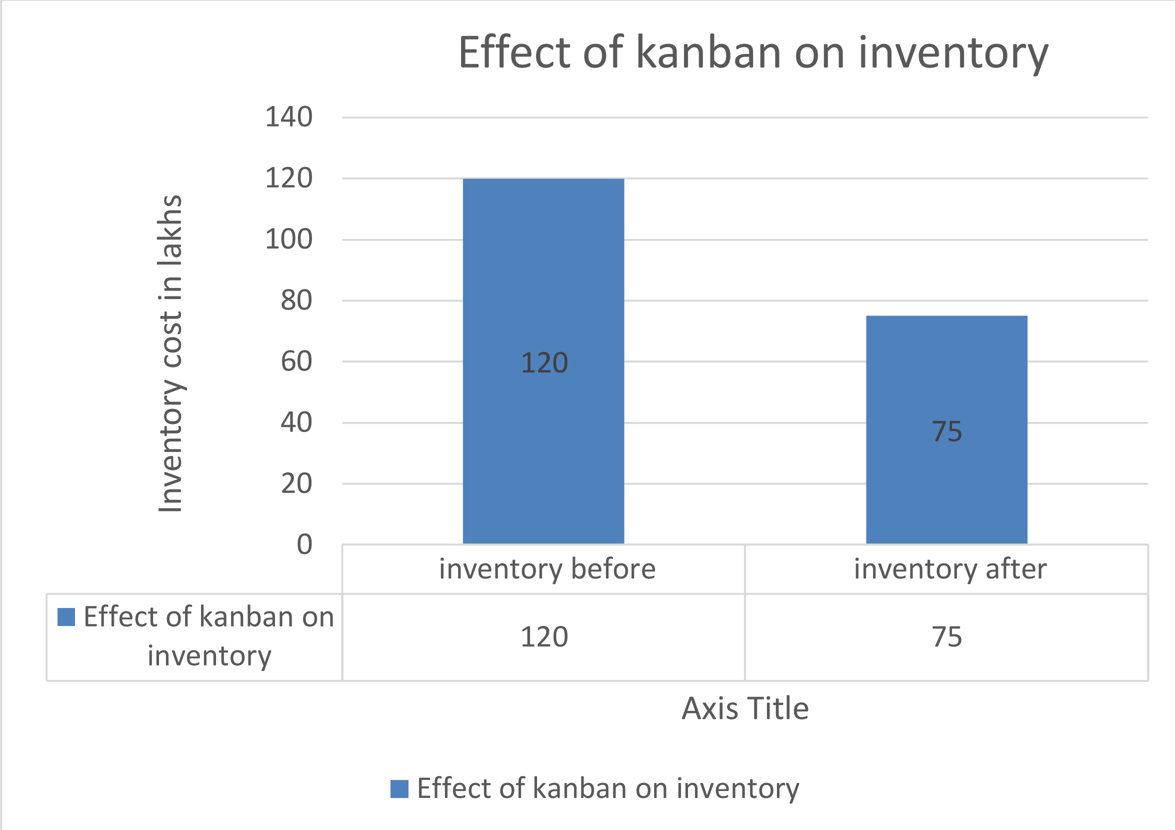

Fig: 4.2.3 Inventory reduced from 1.2 crores to 75 lakhs.

The fig.4.2.3 gives the information about inventory cost of few components. And the trend continues for all the 530 components, the inventory has been reduced from 1.2 crores to 75 lakhs. Almost 37% of inventory cost is reduced.

4.3 Time consumption

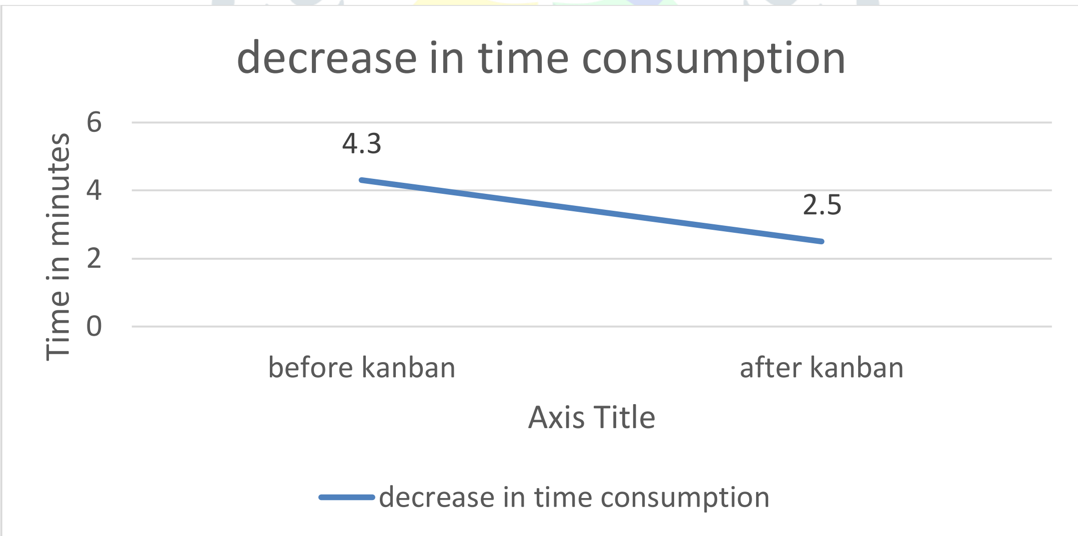

Fig: 4.3.1 Time consumed for the worker to search the required component among 560 components.

The above figure 4.3.1 represents time consumption of the worker to search the component from the location.

- The very important thing in any industry for effective performance, time consumption should be less.
- The time consumed for the worker to search for the required component was reduced by 50%.

4.4 Data and Sources of Data.

The data is collected from a construction equipment company (VOLVO) which is located at Bangalore.

5. Conclusion

This paper presented a real industrial case study of Kanban system implementation in a manufacturing industry. The research findings show that Kanban system is essential in ensuring the success of Just In Time production and create smooth flow of part throughout manufacturing system. Systematic and full commitment in implementing Kanban system is crucial in ensuring its effectiveness and ultimately meeting customer satisfaction. The implementation of the Kanban system shows that lead time, inprocess and finished goods inventory and also finished good area will certainly improve. Subsequently manufacturing pace will be controlled and synchronized with market demand. Therefore, it can be concluded that implementation of Kanban system has improved manufacturing system and this should be a part of the core task of JIT practitioner.

As a result Kanban system has achieved in reducing the following parameters

The outcomes of the implementation of the Kanban system are as follows. The miscommunication between the workers and suppliers has been eliminated .Ordering of parts has been reduced. Ordering the components made automated.Supplier delivery performance is improved. Time has been reduced from 4.3 minutes to 2.5 minutes in searching of parts. Confusion is avoided among the workers because the sub locations are made very clear. The inventory cost has been reduced from 1.20 crores to 75 lakhs excess inventory got reduced. Excess inventory has totally eliminated. Procurement of hardware has been reduced as compared to previous months.Space consumption of parts is reduced by introducing two bin concept (Kanban system).

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