IMPLEMENTATION OF KANBAN SYSTEM FOR INVENTORY TRACKING AND ESTABLISHING PULL PRODUCTION (A CASE STUDY)

Vignesh Ravichandran[1], N.Ganesh Kumar[2]
[1]UG Scholar, Dept. of Mechanical Engineering, PSG College of Technology, Coimbatore.
[2]Assistant Professor (SG), Dept. of Mechanical Engineering, PSG College of Technology, Coimbatore.

Abstract— **The purpose of this paper is to analyze and implement kanban system to a pressure vessel manufacturing facility in order to manage its subcontract inventory. The facility manufactures air receivers and air-oil separators for compressors. The plant is not able to meet the demand of its customer due to production line stoppages. The facility experiences production line stoppages due to non-availability of the raw material (subcontract) inventory. This was primarily due to the absence of a proper model of inventory management and a system to track the status of on hand inventory. Tracking of raw material was difficult, as the variety of models manufactured in the facility was high. The problem of raw material non-availability was addressed by setting up a model of inventory to determine the required inventory levels for all the models. The issue of tracking the status of on hand inventory was addressed by implementing the Kanban system, which ensured raw material availability and also helped in establishing pull system.**

Keywords—kanban; inventory; subcontract; pull production; lean manufacturing;

I. INTRODUCTION

This case study addresses the application of kanban to the continuous production/process sector with a focus on the pressure vessel manufacturing industry. Company ‘X’ is a leading air compressor manufacturer with a broad line of innovative and technologically superior compressed air systems. The Pressure Vessel Division (PVD) of company ‘X’ manufactures air receivers and air-oil separators for compressors. The only customer of this division is their head office. The fabricated receivers and separators are sent to their head office based on the demand. PVD buys cut and blanked sheets from a sister concern of company ‘X’. The cut and blanked sheets are preprocessed and sent for subcontracting. The sheets are formed into dishes and rolled into shells by the subcontractor. These shells and dishes are fabricated into air receivers and oil separators at PVD. Rolling of shells whose outer diameter is less than 300mm is only subcontracted.

II. LITERATURE REVIEW

A. KANBAN

Kanban means signboard. A kanban can be a variety of things, most commonly it is a card, but sometimes it is a cart, while other times it is just a marked space. In all cases, its purpose is to facilitate flow, bring about pull, and limit inventory [1]. Implementation of Kanban system in an auto industry has been discussed in [2], which demonstrates the application of Kanban to implement lean manufacturing. The impact of kanban on inventory management is demonstrated in [3]. The method for development of electronic kanban has been discussed in [4], which is the next step after successfully implementing the manually operated kanban system. Traditional-manufacturing strategy is driven by ‘Push system’, which is aimed to keep large inventory of product according to customer forecast. However, this has created big problem to people on floor in dealing with high of WIP inventories, unsynchronized production processes and producing unnecessary stock. Due to that, established company like Toyota Motor Corporation has moved to next level of manufacturing approach or strategy by adopting Kanban system [5]. The number of kanban is calculated by [5]

$$\text{Number of Kanban} = \frac{\text{Demand} * \text{Lead time } (1 + \text{safety stock\%})}{\text{container quantity}} \quad (1)$$

III. ANALYSIS OF THE INVENTORY PROBLEM

The Pressure Vessel Division (PVD) follows a subcontracting model for forming the blanks into dish ends and rolling the blanks into shells. The sheets to be rolled into shells require being edge beveled before being sent to the subcontractor for rolling process. The blanks that are to be formed into dish ends do not require any processing. The blanks are then sent to the subcontractor for forming. The formed dishes and shells are then withdrawn from them and stored in PVD for fabricating them into air receivers and air-oil separators. It is to be noted that the blanks that are supplied by the raw material supplier arrive inside PVD with the raw material part number and the formed dishes and shells arrive inside PVD with another part number. The inventory process flow is depicted in a flow chart in the figure 1.

According to the current practice, the materials department receives the firm demand for the current month and forecast for the next two months from its customer, at the beginning of every month. Based on this, the materials department issues the plan to its raw material supplier for the receipt of blanks. Presently, there is no proper model of inventory followed at PVD with respect to the subcontracting process. As a result, raw material availability for fabrication could not be ensured, leading to line stoppages. Also, there are situations when unnecessary inventory is piled up at PVD leading to the capital being locked in inventory. Most of the times there have been friction with the subcontractor as pressure is exerted on them for the supply of formed dishes and shells, leading to weakening of the relations. As a result, to avoid tensions, the subcontractor tends to process more than what is required, leading to over production. This is problem with the runner models when the materials department dumps inventory at the subcontractor's end. There are no fixed batch sizes for the shells and dishes, leading to arbitrary batch sizes. As a result, raw material tracking at the supplier end becomes difficult. It was found during one of the supplier visits that dishes of a particular model were lying around the subcontractor's facility without being sent back or accounted. Tracking the inventory becomes difficult because the number of models to be tracked is 61.

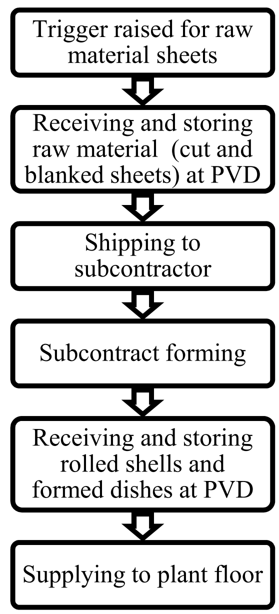

Fig 1 Inventory process flow

IV. INVENTORY MODEL

The inventory model, which is suggested for the subcontract inventory, resembles the classical EOQ model with certain differences. The demand is constant for the subcontract inventory as the materials department receives the firm plan from its customer at the beginning of every month. The quantity will not be altered and hence we are safe in assuming that the demand is constant. Safety stock has been provided in this model to account for the uncertainties. This model of inventory is the fixed order quantity model or the 'Q' model. The order quantity is arrived based on the following equations.

Order quantity = Lead time demand + safety stock (2)
Safety stock = lead time variation * demand (3)

The order quantity, which found according to equation (2), is not the Economic Ordering Quantity. The EOQ was not determined due to certain constraints in determining the various cost factors involved in the determination of EOQ. This model when implemented will ensure material availability. The diagrammatic representation is given in fig 2.

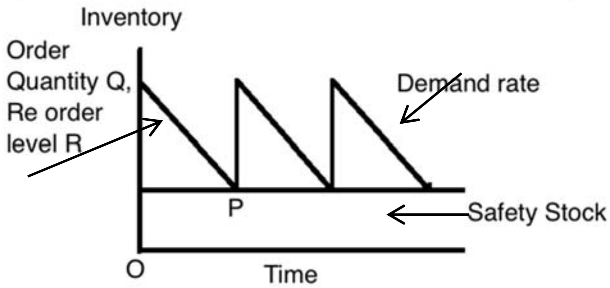

Fig.2 Inventory model for subcontract inventory

V. KANBAN SYSTEM FOR INVENTORY TRACKING

One of the major problems in PVD regarding subcontract inventory is the tracking of the status of inventory. This is a major issue as the raw material sheets are bought out and then sent for subcontracting. There was not any fixed batch quantity for the subcontracting models and was dealt in arbitrary quantities. For example, the raw material sheets might be dumped at the subcontractor's facility and might be withdrawn in smaller units. The major constraint is that the sheets occupy significantly less volume when compared to the formed dishes or shells. As the withdrawal was in arbitrary batch sizes, the materials department could not precisely track the raw material inventory at the subcontractor's facility. To enable the tracking and to curtail overproduction, kanban system has been implemented.

A. KANBAN QUANTITY

Number of kanban was calculated using equation (1). The safety stock was fixed at one day's production demand. The container quantity was fixed in consultation with the store. The demand is constant and is known. The lead-time is also known for all the subcontractors. Based on this the kanban quantity was determined for all the models. It was also decided to follow two-card kanban system. The success of this system lies in the strict adherence to the kanban quantity specified in the card. The suppliers are strictly asked to adhere to the quantity mentioned in the card. The kanban quantity has been determined so as to be in multiples of the bin quantity of the corresponding raw material sheet.

Kanban boards have been designed and erected at PVD plant floor. Another set of kanban boards have been given to the subcontractors to be placed at their facility. Figure 3 shows the kanban board erected at the plant floor.

Fig 3 Kanban boards erected at the PVD

Fig 4 Kanban cards

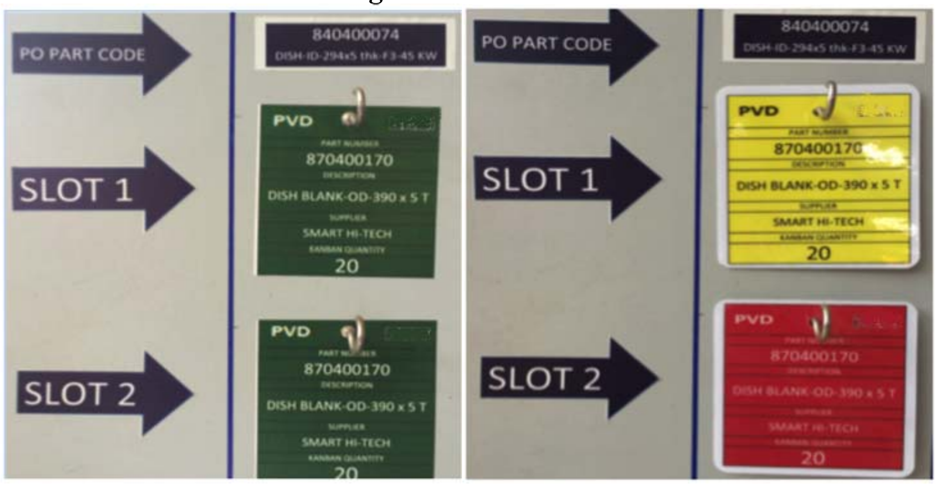

Fig 5 Kanban cards hanging on the kanban board

B.KANBAN CARD

Figure 4 shows the kanban cards designed to track inventory. Three colors are used for this purpose. Green color card is stuck on the kanban board permanently. Yellow and red cards are circulated between the subcontractor and PVD. These cards are hanged on the kanban board with the help of a hook. Figure 5 shows the yellow and red cards hanging on the kanban board. When yellow or red card is hanged, the green color is hidden.

C. INTERPRETING THE COLORS

For a single model of dish or shell, four green cards, one yellow and one red card are used for tracking. One set of green cards is stuck on the kanban board erected at PVD and another set at the subcontractor's facility. Two cards represent the two-kanban quantities, indicated by slots 1&2. Green color card indicates the presence of material at the other end. The cards have different interpretations depending on where they are present. When yellow color card is present at PVD, it indicates single bin raw material stock out at the subcontractor's end. Presence of red card at PVD indicates two bins stock out at subcontractor's end. When yellow color card is present at the subcontractor's end, it indicates two bins raw material stock availability at the subcontractor's end. Presence of red card at subcontractor's end indicates the availability of single bin raw material for the forming process. At any given point of time, the two kanban boards will be complementary in nature, that is, if two green cards are present for a particular model at PVD, the corresponding yellow and red cards should be present the corresponding subcontractor's facility. At any given point of time both PVD and the subcontractor will try to maintain their kanban boards with green color cards. Presence of red card is undesirable at PVD and the presence of red card is desirable at the subcontractor's end. The legends, which are stuck on the kanban boards, are shown in figures 6 and 7.

	Finished material available at customer, further material yet to come
	Two-bins raw material available for processing
	Single bin raw material available for processing, another bin yet to come

Fig 6 Legend on the kanban board at subcontractor end

	Raw material available at supplier end
	Raw material 1st bin stock out at supplier end, need to send
	Raw material 2nd bin stock out at supplier end, need to send on top priority

Fig 7 Legend on the kanban board at PVD

VI. WORKING OF KANBAN SYSTEM

The working of the kanban system is explained with the help of figure 8. The sequence of operations is explained below.

- Let us assume that initially PVD and the subcontractor have material for both the bins. This means that, the kanban board at PVD will be full of green cards and the yellow and red cards will be available with the subcontractor.
- The subcontractor then forms the corresponding quantity and sends it to PVD along with yellow color card, as the subcontractor will exhaust raw material blanks of a single bin.
- The yellow card along with formed dishes or shells is received at PVD, the card is hanged in the board in its place and the bin is transferred to the store.
- Presence of yellow card indicates single bin stock out at the subcontractor's end. So, the corresponding blanks are sent to the subcontractor along with the yellow card.
- When the raw material blanks are exhausted at PVD, trigger is sent to the raw material supplier via the supplier
- Now, formed shells and dishes are withdrawn for fabrication by the production department. The shells and dishes are issued when the materials department receives the production order.
- When a single kanban quantity has been withdrawn for the production process, trigger is sent to the subcontractor via the supplier portal.

  portal and the raw material blanks are replenished at PVD.
- There might be some situations wherein both the bins are consumed by the productions department and two triggers sent to the subcontractor. In this case, the subcontractor will send material for both the cards along with the yellow and red cards. Now both the cards will be present at PVD, which is undesirable.
- At any given circumstance, the yellow card needs to be operated first. When both the cards are operated by the subcontractor, PVD should replenish raw material for red card first or both the cards simultaneously.

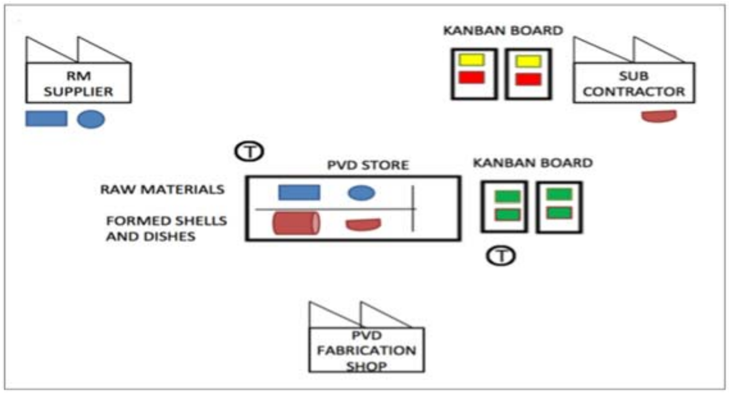

Fig 8 Working of the kanban system

VII. RESULTS

Table 1 shows the major differences prior to and after implementing the kanban system. The implementation of kanban system has ensured raw material availability and hence prevents production line stoppages that were occurring prior to implementation due to non-availability of subcontract inventory. The kanban system has also helped in preventing over production and dumping of inventory. The sub contractor will process the raw material only if he receives a trigger from PVD. The implementation of kanban system has brought about pull production in PVD, which was following push production system earlier. The subcontractor will process the raw material only if he receives the trigger in the supplier portal or when the formed inventory has been consumed at PVD. Hence the implementation of kanban system has not only helped in providing complete visibility of inventory but also implementing pull production.

Before implementation (Dec ’14 – Jan ’15)	After implementation (Feb – Mar ’15)
Withdrawal of inventory from subcontractor in arbitrary batch sizes.	Withdrawal of inventory in fixed batch sizes.
Dumping of raw material at subcontractor’s facility.	Shipping raw material according to the kanban quantity.
Push production process.	Pull production process.
No visual control.	Visual control by means of the kanban board.
Over production.	Production only made to the required inventory specified in the kanban card.
Unnecessary waiting.	Waiting time has been reduced as only required amount of inventory is processed.
Dumping of inventory for runner models.	Supermarket system is implemented where inventory is replenished only if it falls below a certain level.
No proper system for tracking inventory at the subcontractor’s end.	Kanban cards are used to track inventory at the subcontractor’s end.
Low levels of inventory turnover ratio, 2% for dish ends and 3% for shells.	Improved inventory turnover ratio of 6% for dishes and 5% for shells.
Production line stoppage due to material non-availability.	No production line stoppages due to material non-availability.

Table 1 Advantages of implementing kanban system

VIII. CONCLUSION

This case study explains how PVD has benefited in terms of ensuring material availability and tracking subcontract inventory at the supplier end. This case study demonstrates how Kanban can effectively used to exert control on inventory, which contribute substantially to costs. The implementation of kanban system has helped PVD in knowing the status of subcontract inventory. The kanban boards erected at PVD and at the subcontractor's facility help in visually managing the information as well as material flow. The suppliers and the materials department at PVD are now able to communicate in the language of lean, which is a drastic change in the way they were dealing with each other prior to the implementation of the kanban system. This has improved their relations substantially. Future work may be aimed at converting the kanban cards and boards from being operated manually to being operated electronically.

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