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Improvement of Process Productivity through Just-in-Time

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Abstract

Just in time (JIT) is a production strategy which helps the organisation to achieve and improve the return on investment by reducing material inventory plus the associated carrying costs. It is a logistics philosophy which is practiced in many manufacturing companies with an aim of reducing inefficiencies and unproductive time in the production process. However, earlier research and experience suggest that the interrelationship between JIT and other manufacturing system's components such as product design and business strategies are more complex than it is suggested by the traditional JIT studies. This paper deals with the modelling and simulation in the manufacturing industry where assemblies are made as per the production forecast. The main objective of this paper is to observe how the Finished Goods Inventory of the assembly process using System Dynamics methodology and how it can be improved by considering the lead time and the manufacturing cycle time.

Keywords: Assembly line, cycle time, fabrication shop, inventory, just-in-time system, system dynamics.

Introduction

Just-in-time JIT, as the name implies, is to produce goods in the right quantities and at the right time, which is followed by Japanese manufacturing company in 1970s, so as to develop better and efficient technique capable of rebuilding their economy after the 2nd World War. Up to now or then, enormous defects existed in the manufacturing system are related to inventory problem, product defects, rising cost of production through wastes and production delays. Indeed, JIT is described as a philosophy which attempts to incorporate all aspects of the operation processes starting from incoming material, actual manufacturing to deliveries[1]. The operation of a just-in-time (JIT) production control system mainly depends on the performance and availability of the resources[2]. It also utilizes a system called as Pull System, where the products are produced according to the orders from the customer and the products produced are pulled out of assembly process. The final assembly line then pulls or withdraws the necessary parts in the necessary quantity at the necessary time. The process will continue until each process pulls the desired parts from the preceding process to complete the assembly process. The whole process is coordinated through the use of Kanban system[3].

The basic benefit of this technique is to reduce production costs through increased efficiency within the production process as it reduces waste of materials, time and effort, thus the JIT system of production control has the natural ability to compete with the others in the business and remain relevant as they can develop a more optimal process for their firms.

Literature Review

The approach of SD was created and developed by a group of researchers led by J. Forrester at the Massachusetts Institute of Technology (MIT) in the late 1950s. It is a study of information-feedback, which is a characteristic of industrial activity to show how organization structure, amplification and time delays interact with the system to influence the success of the enterprise[4]. The basic objective of this approach is to understand the structural causes that trigger system performance. SD provides symbols for mapping business systems in terms of diagrams and equations, and a programming language for making computer simulation.

Chan Kah Wai, and Chooi-Leng, developed a system dynamics model considering supply chain events from order to ship out for a semiconductor company and observed that with better policy settings helps in achieving an average saving of about one million units of inventory per week with an increase of efficiency of inventory by reducing the cycle time by 27.5%[5].

Arunprakash, and Nandini, studied the inventory control practices by using survey method. However, in this study, the authors have used SD methodology[6]. Mathew et al. highlighted that use of System Dynamics (SD) methodology helped the modelers to view a problem situation by considering the system as a whole rather than focusing only on the current problem in hand. This view point is particularly important because when the holistic picture comes in front of people, they can look for fundamental solutions instead of focusing on symptomatic solutions[7]. Inventory management is very crucial in case of perishable items like fruits, vegetables and food stuff because, these may decay or their quality may deteriorate over time. However, this research work focuses on manufacturing industries and the inventory items are nonperishable goods[8].

S. Shyam Sunder Rao, K. Vizaya Kumar, developed a model for medium size industrial iron foundry where important issues relating to the demand, inventory, and production rates are considered and concluded that by maintaining good vendor relationships helps in reducing the lead time and can improve the quality of services, customer satisfaction which improves supply chain efficiency and also concluded how much to keep as the inventory level. Inventory reductions generated by just-in-time (JIT) and lean manufacturing policies, implemented by one firm are often offset by increases in inventories held by suppliers or customers[9].

When a manufacturer moves to JIT materials delivery, its suppliers must deliver more frequently and with much higher reliability. To meet these more stringent requirements suppliers often carry additional inventory[10].

Orders are processed with JIT (just-in-time) systems in minimum amounts and with the manufacturing priorities defined by the delivery date[11]. This approach, which emphasizes simple control systems, has brought about changes to the manufacturing process with shorter cycle times and improved customer service[12].

Through the philosophy of JIT - materials delivery systems, the suppliers must deliver material more frequently and with much higher reliability. To meet their demand, suppliers often carry additional inventory so that the production is not affected[10]. Production comprises ‘made-to-order’ from the building up of stock. The order rate is based on the observation of the customer behaviour for a certain period of time. Amplification behaviour in inventory is usually the result of increased orders in each stage of the supply chain. The delays in the customer order to delivery, further add up to the piling up of the orders[13].

Ashish Agarwal and Ravi Shankar, (2005), developed a system dynamics model to understand the dynamic behaviour of customer satisfaction, cost minimization, lead-time reduction, service level improvement and quality improvement which plays a major role in improving the performance of supply chain and also observed that with the improvement rate for delivery speed, data accuracy, centralized and collaborative planning, market sensitiveness the behaviour was very slow initially and later increases. Similarly the value of inhibitors such as lack of trust, uncertainty and resistance to change is quite high in the beginning but gradually decreases and concluded that as the impact of inhibitors reduces the influence of enablers on SP Index gradually improves[14]. Increase in supply chain performance Index indicates the performance improvement of the supply chain. According to Manjunath, 2013, cost cutting is crucial to reduce the variable costs so as to maximize the profits[15].

Ramprasad, 2013, identified that one of the major factors for effective inventory management is the motivation and efficiency of the workforce[16]. This paper primarily focuses on studying the process productivity through JIT systems with an objective of studying the behaviour on finished goods inventory both for the assembly process and the fabrication process considering the delays in the raw material supply for assembly and fabrication. Since there is comparatively lesser research undertaken on the study on JIT application in a manufacturing sector, by considering the raw material inventory and production process, an effort is made in this paper to move in this direction.

Construction of the model

The model is developed for a Multi-national Company based in India, which imports the components from its supply chain spread across the globe. The model is developed both for the Assembly process (figure-1) and Fabrication process (figure-2a and figure-2b). Both the processes are based on the forecasted demand quantity. The endogenous factors of study are Work in Process, Supply of raw materials, Finished goods inventory, and Raw material inventory.

The forecast is made based on the production schedule by considering the availability of workforce and supplier constraints for a period of two months. The model is developed for the compactor assembly, for which the initial input (order rate) will be considered as per the production schedule i.e. for the assembly process and the order rate for the fabrication material is considered depending on the quantity required building one compactor assembly. Therefore, the order rate for fab shop components is considered as 4 times the rate of order given to the assembly raw materials.

For example: Building one Single Drum compactor assembly requires 4 components (i.e. Main frame, Drum frame, Swivel frame and Drum) from the fabrication process which should be delivered to the assembly shop for the assembly process. In process, the finished goods from the fabrication inventory and components from the assembly store are delivered as an input for starting the assembly process.

Simulation Results and Analysis

The model was simulated for 20 months under different scenarios of IAT and CT and the impact of this on the Finished goods inventory both for the fabrication shop (figure-3) and assembly process (figure-4) were studied. The initial consideration here was CT = ST, which represents the JIT principle.

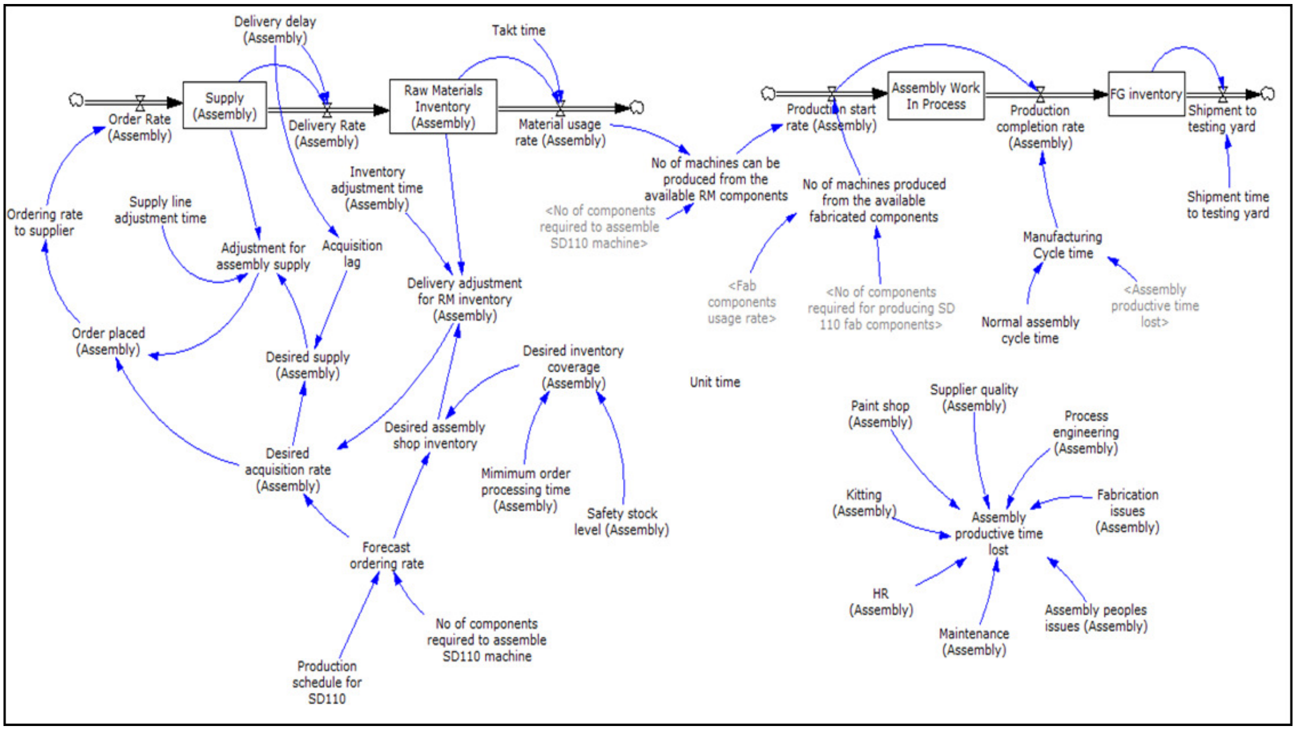

Figure-1

Stock and Flow diagram for JIT production system (Assembly process)

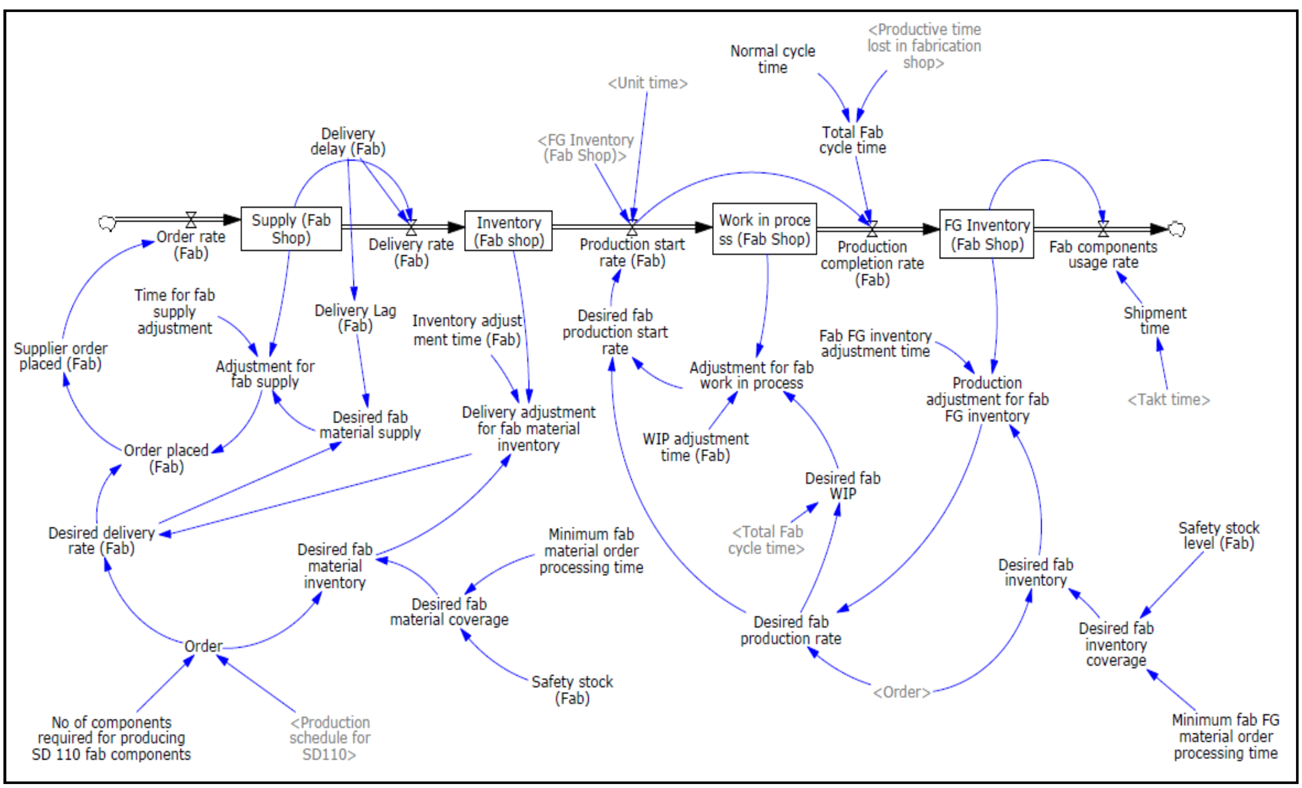

Figure-2a

Stock and Flow diagram for JIT production system (Fabrication process)

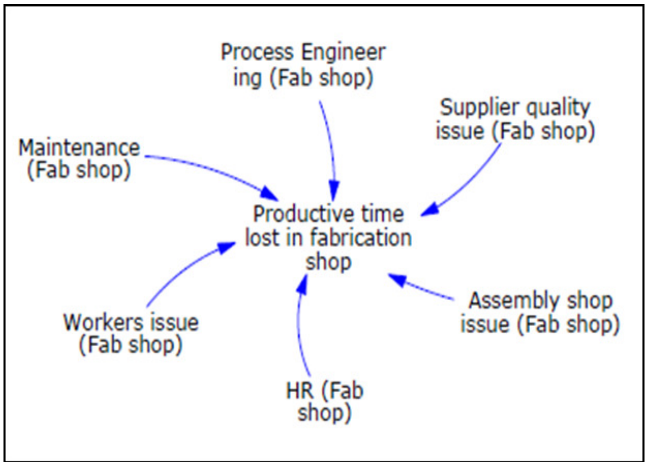

Figure-2b
Productive time lost (Fabrication Shop)

Hence, the different scenarios inventory policies are:
Scenario i: IAT < CT (Figure-3a and Figure-4a)
Scenario ii: IAT = CT (Figure-3b and Figure-4b)
Scenario iii: IAT > CT (Figure-3c and Figure-4c)

Fabrication

It can be observed that when the IAT is less than the CT, the finished goods (FG) inventory of the fabrication shop (Fab Shop) will follow a distortion type of pattern (figure-3a). The continuous oscillation observed decreases over a period of time and gets stabilized after a period of time. This means that in order to cope up with the customer orders this scenario takes more time than compared to other two scenarios.

Further, it can be observed that when IAT is equal to the CT, the inventory level witnesses a sudden drop in its level and then in order to regain stability it overshoots to a threshold value and finally gets stabilizes at around 24th month (figure-3b). This indicates that the company will achieve a well-controlled inventory and the lower holding cost from the second year. The same can be said when the IAT is higher than the CT (figure-3c).

Assembly: It can be observed that for all the three scenarios the pattern of finished goods inventory remains the same (figure-4a, 4b, and 4c), however, the time taken for the inventory to reach the minimum value varies. By analysing the graphs, it can be observed that when IAT > CT, the settling time to reach the minimum level is much faster when compared to the other two cases i.e. when IAT = CT and IAT < CT, but the number of units produced in the finished goods inventory is less than compared to that of other two cases because more time is consumed in preparing or adjusting the components for the assembly process than that of time taken to complete the assembly i.e. cycle time.

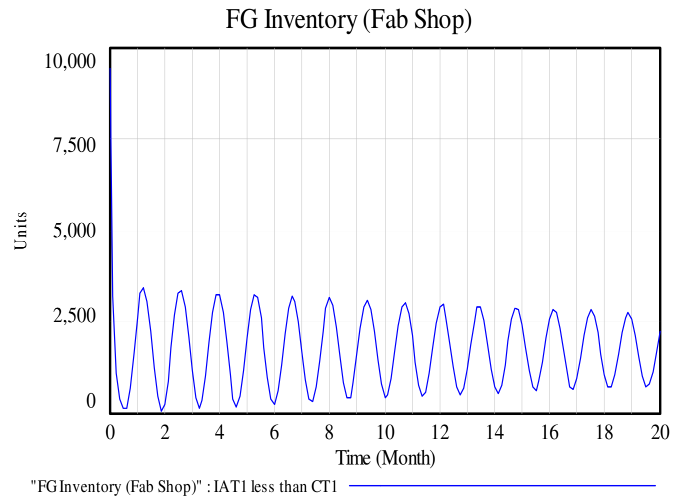

Figure-3a
IAT < CT (Fabrication Shop)

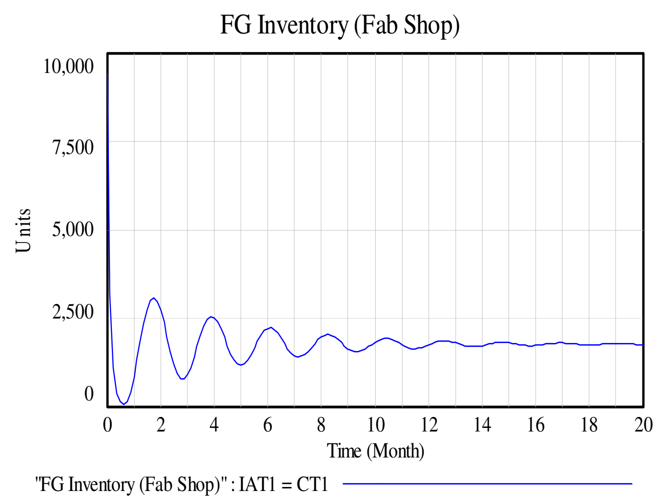

Figure-3b
IAT = CT (Fabrication Shop)

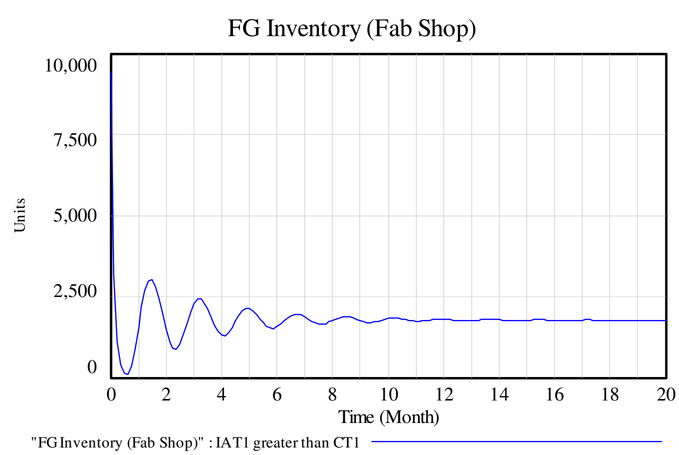

Figure-3c
IAT > CT (Fabrication Shop)

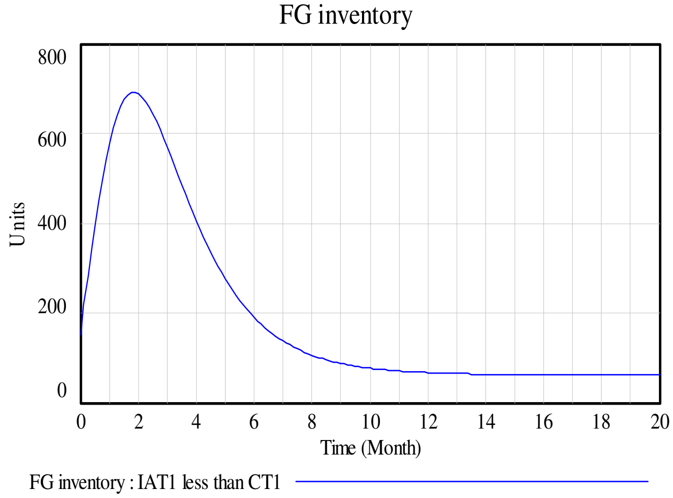

Figure-4a
IAT < CT (Assembly shop)

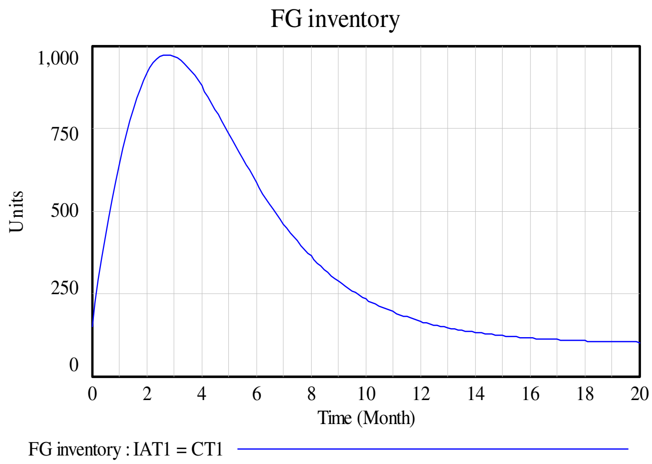

Figure-4b
IAT = CT (Assembly Shop)

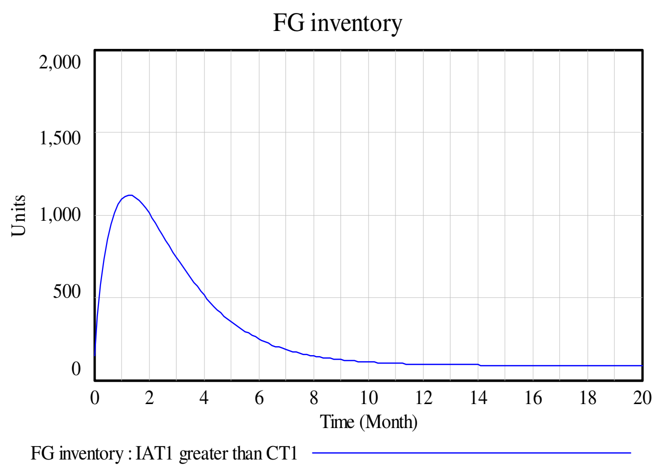

Figure-4c
IAT > CT (Assembly Shop)

Model Validation

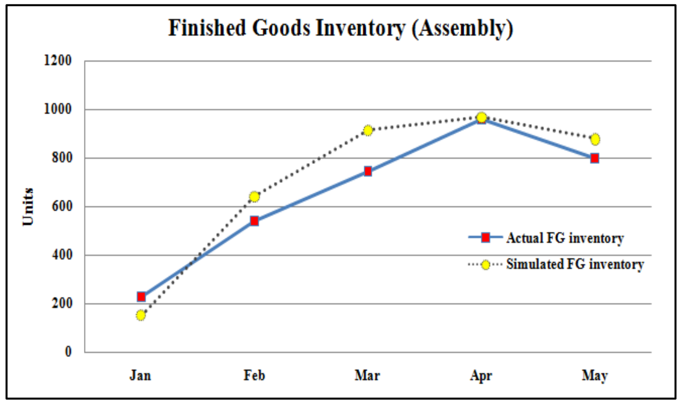

Figure-5
Finished Goods Inventory (Assembly)

As this model has been developed from the earlier robust model of "Computer Simulation to Manufacturing Lean Manufacturing Systems" by Ahmed Deif (2010), the model has already passed the standard tests of validation[17]. However, as the context of application in the present case is a manufacturing company and also the addition of parameters can induce instability in the model structure, the simulation pattern has been superimposed with the empirical data obtained from the industry for a period of five months for the sake of validation (Figure-5).

It can be observed that the simulation follows the trend to a considerable extent even though there is deviation which could be due to the extraneous factors not considered in the model.

Conclusion

It can be observed that for the traditional manufacturing systems, the inventory adjustment time should be set lesser than or equal to cycle time so that the production process will not get interrupted with the material shortage and the customer orders can be met without any delay of materials from the suppliers.

This paper proposes a system dynamics methodology using Vensim software to study the process productivity through Just in Time[18]. On successful implementation of the suggestions, there will be continuous and accurate flow of materials at the right time and in the right quantity. A balance must be maintained by using a system of Kanban, where it contains two containers consisting of components along with the cards called as Kanban cards indicating the maximum quantity of materials to be ordered by scanning the bar code present on it, the main purpose of scanning is, as the components is getting consumed the barcode is scanned by the person in the material department which acts as a signal which acts as placing an order to the supplier.

This work has considered the JIT scenario, where cycle time and shipment time are equal and inventory adjustment time is varied. The future work can be focused on implementing the Kanban system for ordering the components from the suppliers and also by extending to different product lines which improve the performance of manufacturing system by reducing the scrap rate, minimizing the inventory costs and improving the quality of the products.

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