



International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)

www.iasir.net

Guideline to decide Safety stock for Number of Kanban & Kanban quantity: A Review & Methodology

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Abstract: Lean manufacturing has been the buzzword in the area of manufacturing for past few years especially in Japan. The Kanban system is one of the manufacturing strategies for lean production with minimal inventory and reduced costs. Kanban system is essential in ensuring success of Just in time practice and to create smooth flow throughout manufacturing system. Kanban system mainly deals with smoothing production schedule. Number of kanban and kanban quantity are the main design parameters of kanban system. It is important to state that there is a significant relationship between the design parameters of kanban system such as the number of kanbans, kanban quantity and factor of safety i.e safety stock. Safety stock is important parameter which is responsible for deciding number of kanban and kanban quantity. Kanban system requires more elaboration and fine tuning under different conditions where demand may be variable, setup time may be high and system may be balanced. The paper reviews various literatures and forms methodology for deciding safety stock for number of kanban and kanban quantity which will be useful for research in current field.

Keywords: Just in time philosophy, Kanban system, lean manufacturing systems, Kanban system methodology.

I. Introduction

‘Just in time’ approach is based on lean manufacturing system which develops to optimize and improve manufacturing efficiency by reducing manufacturing lead time through waste elimination and kanban. It was derived from Toyota Production System as a principle to minimize inventory and improve throughput [1-2]. Now a days, Lean production aims at incorporating multiple management practices to create a streamlined, high quality system that produces finished products at the pace of customer demand with little or no waste. As one of the lean manufacturing principles, Kanban system emphasized optimum 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 [2]. Kanban system becomes practical when it synchronizes all manufacturing activities of product with customer demand. Every process on the floor is controlled by kanban system which is designed to respond to actual demands. The Kanban system is basically an inventory stock control system that triggers production signals for product based on actual customer’s requirements and demand [1].

The system is controlled by the kanban card which dictates the optimum production parameters allowing production with smaller quantities with minimal waste of human and natural resources, and utilize only when they are needed [1]. Kanban system generally preferred for batch type production system. Batch production is maintained as well as the implement of kanban system. It is used to authorize production of any product to replenish those already consumed by the customer or subsequent process. Number of kanban and Kanban quantity are main decision parameters of kanban system [2]. This paper is organized as follows: Section I describes kanban system. Section II describes Present status of kanban system in manufacturing industries. Section III describes various literatures related with kanban system. Section IV introduces new proposed methodology. Most of researchers had concluded that Kanban system could lead to reduction of lead time and manufacturing excellence [3-5]

II. Present status of kanban system in manufacturing industries

Kanban system has proven to be effectively at meeting production goals in environments with high process reliability, low setup times and low demand variability. There is a limit to the extent that kanban can be usefully applied in many industries. For the smooth operation in a Just in time environment the stages should be balanced and the suppliers should be reliable. When setup times become considerable system performance declines, since large setup times require large lot sizes. System performance declines with following factor like variable demand, high setup times, long lead times, multiple machines to multiple assembly lines, number of part families [2]. If the demand cannot be predicted accurately and product variety cannot be constrained, it may not be possible to implement kanban effectively. Kanban system needs more elaboration. So evaluation of performance of kanban system is needed. For the evaluation and analysis of parameters the decision variables are mainly kanban sizes, number of kanban and safety stock levels. Determining the number of kanban is

essential to the performance of the system, and keeping the buffer size constant by increasing the kanban size and decreasing the number of kanban accordingly increase the inventory [3]. Factor of safety i.e. safety stock level is important parameter which is responsible for deciding kanban quantity and number of kanban which depends upon average demand, high setup times. Also increasing the product variety and decreasing product standardization reduces the performance of kanban System. At present, company decides factor of safety arbitrarily not sequentially which effects on deciding number of kanban and kanban quantity. Proper guideline to decide factor of safety for number of kanban and kanban quantity is necessary because kanban system mainly deals with smoothing production schedule.

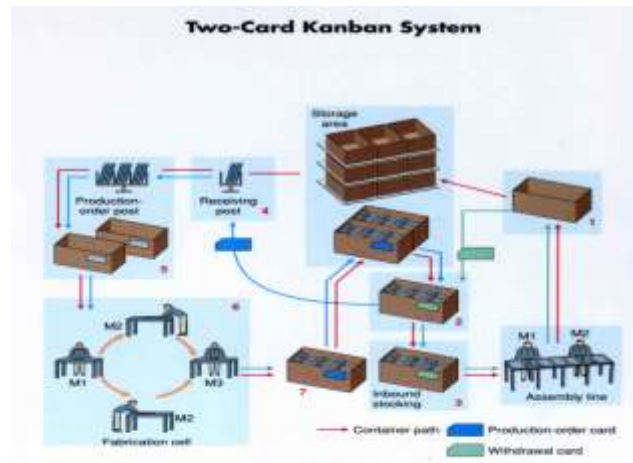


Figure 1

Figure 1 shows flow of two types of kanban cards are used which are mainly used in manufacturing industries which are production kanban and withdrawal kanban. A withdrawal kanban defines the quantity that the succeeding stage should withdraw from the preceding stage. A production kanban, on the other hand, defines the quantity of the specific part that the producing stage should manufacture in order to replace those which have been removed. Even though the dual-card kanban system provides strong control on the production system due to its strict assumptions and prerequisites, such as design of the manufacturing system, smoothing of production and standardization of operations, it is difficult to implement it. Therefore, a variant of this system, called single-card kanban system, is sometimes used as a first stage to develop a dual-card kanban system [2-4].

III. Literature Review

Ahmad Naufal *et al.* [1] develop implementation activities in manufacturing site prior to kanban system. The paper concludes that implementation of kanban system would reduce lead time, minimize inventory on floor and optimize storage area. Successful implementation of the kanban system furthermore reduces operational costs, consequently increases market competitiveness for this research work methodology was developed which includes activities like gathering relevant parameters, calculating kanban quantity, establishing pull mechanism and rule, the research study demonstrate kanban system is essential in ensuring success of Just in time practice and to create smooth flow throughout manufacturing system.

M. S. Akturk and F. Erhun [2] develops an experimental design to evaluate the impact of operational issues, such as sequencing rules and actual lead times on the design parameters also models on determining design parameters are explained by using tabular format to compare different models. The study reports on classification of techniques to determine design parameters and kanban sequences for just in time manufacturing system. One of the main assumptions of JIT is repetitive manufacturing. Therefore, factors that adversely affect the repetitive nature of the system, i.e. increasing the product variety and decreasing product standardization, reduce the performance of kanban systems.

M. Apreutesei *et.al* [3] describes briefly presentation of kanban system & how company can use this tool for managing inventory, In this article they describes why company have inventory, why they need inventory and reasons why a company strive to reduce inventory and how inventory was reduced by implementing and using different rules of kanban system. On the other hand author conclude that the determination of Kanban is important step in cell design process because Kanban is limiting factor for inventory levels, inventory and lead time has a major influence on continuous improvement within cellular operation.

Sheikh Rizwan Hussain [4] describes briefly operation of Kanban system which is preparation for evaluation & analysis. In the research work, SWOT analysis was used as main analysis tool since analysis is very open, Main objective of implementation is to do overall analysis and adopt steps and activities to reduce problems which are faces by company at main assembly areas, for Routines purpose, it is necessary to document the overall analysis and evaluation of Kanban. Results like limited work in process inventories, limited FIFO (First in First out), Continuous flow of material achieved with implementation of kanban system.

M. Gallo *et al.* [5] utilized an approach based on system dynamics simulation model. The objective of work is to contribute to the understanding of the dynamics enacted by the demand variability and influencing decision-makers with their manufacturing strategies. In order to maintain system productivity and to limit queues in system, a management of model for cell operation called as Virtual kanban strategy has been proposed. The problem of a variable demand in a kanban cell has been studied and analyzed using simulation software based on system dynamics approach, Power sim Studio 5. It is possible to say that the experimental results obtained showed that the constructed model can be used as a valid tool for strategic decision support for manufacturing systems that want to be able to react appropriately to the variability of the market using pull logic.

Yvonne Iejtman *et al.* [6] reports on design of a suitable production management system (PMS) for a manufacturing company located in Western Australia. The company was experiencing problems in scheduling and plant layout leading to further problems in material flow, labour control, inventory & purchasing, material handling system and production space. Group Technology concept was used to design a new layout. A G.T algorithm was developed to minimize machine duplication. Advantage to company has been adoption of scientific approach to problem solving and data collection organization and analysis which will be of continuing benefits in future

B. Vijaya Ramnath *et al.* [7] develops implementation of lean manufacturing in Engine valve machining cell in a leading auto components manufacturing industry in the South India. Objective of this paper is to provide a background on lean manufacturing, present an overview of manufacturing wastes and introduce the tools and techniques that are used to transform a company into a high performing lean enterprise. The steps involved in the implementation of lean manufacturing include choosing a product or product family, study of manufacturing methods and sequence of operations, value stream mapping and elimination of waste and analysis of economical benefits associated with proposed concept. The elimination and or reducing of wastes is by making the process improvements in the current manufacturing line by adopting some lean tools like JIT, set up time reduction, etc. Hsu-Tung Lee, Michael H. Wang [8] presents a model to determine the workstation arrangement and kanban number for pull production systems. To determine the allocation, the optimal number of kanban for each work stage has to be defined first. Several practical production line characters are considered, and evolutionary algorithms are utilized to obtain the optimal/near-optimal result. An evolutionary algorithm, genetic algorithm, is used to obtain the allocation of workstations in the production line. With the model developed, the unreliable workstation-line-balancing problem can be easily adopted without much of the efforts in calculation.

Nor Azian Abdul *et al.* [9] presents case study whose the objectives are 1) to determine how does the Kanban system works effectively in multinational organization; and 2) to identify factors hindering Malaysian small and medium enterprises (SME) from implementing Kanban. Findings of the study suggest that top management commitment, vendor participation, inventory management and quality improvement are important for Kanban deployment and towards lean manufacturing. Kanban system implemented in this manufacturing company was found to be adequate due to the many benefits such as the operational costs, wastes, scraps and losses were minimized, overproduction stocks were controlled with flexible work stations

Shaojun Wang and Bhaba R. Sarker [10] study the assembly-type supply chain system controlled by kanban mechanism. A composite formulation of the assembly-type supply chain system is developed by appropriately aggregating the individual branch models as a whole system. The batch size, the number of batches, and the total quantity over one period in the mainline and each branch line are determined. A heuristic is developed which divides the ATSCS into several small size problems, and then conquers them individually.

Baris Selcuk [11] provides guidelines for setting design parameters such as the number of kanbans and the frequency of updating the lead time are provided through numerical tests. In this paper, a single-stage single-class kanban controlled manufacturing system is considered, where the problem is quoting accurate lead times for orders that are generated by an MRP system. The objective is to establish a cost effective lead time quoting procedure.

P. Shabudeen *et al.* [12] studies the simulation model and designs single card system which used for analysis. A bi criterion function consisting of throughput and aggregate kanban queue has been employed to obtain solution that maximizes value of objective function.

Katsuhiko Takahashi, Nobuto Nakamura [13] proposes a decentralized reactive Kanban system. In the proposed system, the time series data of the demand from the succeeding stage are monitored at each stage individually, and unstable changes in the demand are detected by utilizing control charts. The results show that the proposed system, as well as the previous systems, can react to unstable changes in product demand, and that the proposed decentralized reactive Kanban system needs smaller work-in-process inventories to satisfy the required level of mean waiting time of product demand than the centralized reactive systems.

Qi Hao, Weiming Shen [14] proposes a hybrid simulation approach, using both discrete event and agent-based technologies, to model complex material handling processes in an assembly line. A prototype system is implemented using a commercial multi-paradigm modeling tool. In this prototype, JIT principles are applied to both the production and the material handling processes. The system performance is evaluated and system optimization directions are suggested.

F.T. Schan [15] investigates effect of kanban varying size on performance of Just in time manufacturing environment. Two types of JIT production systems are analysed using computer simulation models. Parameters

are fill rate, lead time, kanban size are taken into consideration. Through simulation production planner improves their understanding about system performance of JIT manufacturing system.

S.M. Moattar Hussein et al. [16] Proposed a method using an integer linear programming technique, to flexibly determine the number of Kanbans for each stage of a JIT production system, minimizing total inventory cost for a given planning horizon, the comparison proved a cost advantage for the proposed method over the conventional method in fluctuating demand situations while the cost advantage increases with increase in demand fluctuations. The proposed method incorporates practical limitations for changing the number of kanbans in any stage of production

Muris Lage Junior, Moacir Godinho Filho [17] reviews the literature regarding variations of the kanban system, i.e. the aim is to study only the modified kanban systems. Thirty two different systems were studied and classified according to six categories: the publication year of the paper, the number of original characteristics conserved in the variation, the operational differences between each variation and the original kanban system, the advantages in relation to the original kanban, the disadvantages in relation to the original kanban, and the way those systems were tested. Our analysis of the papers, using the proposed classification method, provides useful insights on the anatomy of the literature about variations of the kanban system.

IV. Proposed method for research work

1. An exploratory literature review shall be done to study the issues in details and to identify the gaps based on the literature review and the requirement of the industries.

2. Development of a methodology to integrate Kanban and JIT is proposed which intends to further develop a methodology to integrate inbound and outbound logistics and lean related issues also.

3. Data collection

Data collection helps in achieving objectives by providing clear and accurate information. It also ensures that data is representative of process and sufficient to enable conclusions and decisions to be made.

a) *Gathering relevant parameter*

Relevant production parameter to be collected such as a) number of parts produced by the process b) changeover times c) downtime d) scrap levels e) cycle time f) withdrawn time g) time for waiting kanban h) time to replenish i) safety stock and j) container capacity. All the parameters to be taken directly from production shop floor and history record. Another important parameter is customer demand. Further required data like supplier list, forecasted demand will be obtained from ERP systems, which rely on an IT resource of the industry. Where ERP data is not available, appropriate tool such as check sheet will be used for data collection. Forecast demand is to be collected to determine the highest volume within the period. This to ensure that kanban system is capable to cater the highest demand from customer. Factor of safety is selected which is based upon average demand, high setup times, all the data collected from ERP system. Gathering of accurate and appropriate parameter to be done prior to kanban calculation to ensure that kanban numbers are optimum and sufficient to cater customer need.

b) *Determination of factor of safety (Safety stock)*

1. Factor of safety (Safety stock) = Standard deviation x service level provided by company. This is calculated by using statistical calculation method.

a) Figure 2 shows that If actual demand > expected demand, we stock out then Service level is determined using following formula, Service level = 1- Probability of stock out.



Figure 2

b) Standard deviation is calculated by following formula:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

c) Calculation of kanban quantity:

Kanban Quantity = Daily or weekly part usage x Lead time x no. of locations x smoothing factor.

Input variables for deciding kanban quantity

1. PFEP (Plan for every part) which is cornerstone of kanban card implementation.
2. Part MOQ (Minimum order Quantity.)
3. Lead time decided by supplier.
4. Container quantity.
5. No. of locations: - Tells us how many locations should have a full container to begin with.
6. Smoothing factor: - Used for seasonal fluctuation in demand

V. Conclusion

Each of literature review provides good techniques that can be applied in my work. Reading the literature reviews helped to clarify my understanding of kanban system parameters. Literature review gives the best idea to formulate new methodology for proposed work and which will be best suitable for further research in current field. This review gives motivation for my research work to generate new methodology to find out Safety stock for number of kanban and kanban quantity under different conditions.

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Acknowledgments

I would like to acknowledge and extend my sincere gratitude to Prof. S.R.Jadhav for his constant assistance and much needed motivation to publish paper.