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Development of kanban system for valve manufacturing industries using Just in time principles

Sagar M.Patole[#1], Prof.Subhash R.Jadhav.[*2]
[#1]Research scholar (M.E), [*2] Professor, Mechanical Engineering
K.B.P.College of Engineering & Polytechnic, Satara, Shivaji University, Kolhapur

Abstract: Just in Time (JIT) is a management philosophy used to eliminate sources of production waste by producing the right amount in the right place at the right time which should improve profits and return on investment. It also helps in reducing variability, improving productivity, reducing lead time, and reduces costs associated with machine setup and equipment breakdown through waste elimination and kanban. Kanban is one of the primary techniques of JIT philosophy which is a card based control system which signals a cycle of replenishment for production and materials. It maintains an orderly and efficient flow of materials throughout the entire manufacturing process which improves a manufacturing system. This study covers pre-requisite activities in establishing a Kanban system, starting with gathering manufacturing data, calculating optimum kanbans in the systems, determination of safety factor based on manufacturing capability in order to ensure that delivery to customer .This paper studies the development of the kanban system with implementation of Just in time policies for valve manufacturing industries. This paper concludes that development of the Kanban system minimise inventory on floor and optimized storage area. The objective of this study is to show that Kanban system improves a manufacturing system as well as achieving Just in Time (JIT) practice which provides a background on lean manufacturing.
Keywords: **Just In Time, Kanban system, determination of factor of safety for inventory level**

I. INTRODUCTION

Excess work in progress (WIP), costs of labour, demand variations, unreliable deliveries of raw materials, defects, machine breakdown, processing time variations, and excessive set up times are the main problems with the traditional push systems in manufacturing. As an alternative to the traditional push systems Just in Time (JIT) is best solution which eliminates problems associated with traditional push system. Kanban is one of the primary techniques of JIT philosophy which signals a cycle of replenishment for production and materials [1]. It is one that meets high throughput or service demands with very little inventory. Kanban is a card based control system to transfer instruction based on logic that nothing will be produced until needed. The Kanban system is a pull system approach that gives authorization to produce at a required rate and specific time in order to replenish part that already consumed by the customer [2, 8].

This paper focuses on steps and activities carried out to develop of Kanban system for valve manufacturing industries for an existing product. Steps and activities include gathering relevant parameters, calculating optimum kanbans in systems, determination of safety factor based on manufacturing capabilities. Nowadays, many companies have faced customer pressure to produce products with high value, to deliver quality product at a competitive price. They have to focus to meet these needs as a requirement to remain and stay successful in today’s market. [3] The process of producing product is more efficient and effective when Kanban system is implemented [2]. A comparative study was made between push and pull systems in order to justify the benefits of Kanban system. 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 [6]. Card is used to regulate pattern of material flow throughout process. It was driven from downstream need and trigger upstream production. Upstream production is then initiated to replenish those parts that have been withdrawn. Cards that contain information such as the job type, the quantity of parts to carry, and the Kanban type, have become crucial in production management. With the movement of the cards, information becomes tangible and easily understood.

There are two types of kanban system which are single card kanban system and two card kanban system [5]. Single card kanban system uses only 1 type of kanban card to trigger upstream production when it needed. This card called Production Instruction Kanban (PIK). While two card kanban systems are using two types of card which are Production Withdrawal Kanban (PWK) and Production Instruction Kanban (PIK). PWK card is used to withdraw needed goods from preceding process and PIK card is used to give instruction to preceding process to produce what is needed for inventory replenishment. In order to achieve lean goal, essentially kanban system is established on factory floor to align flow of material by removing all waste and source of waste. Waste is anything that customer not willing to pay for and it could be categorizes into seven elements which are transportation, over inventory, excess of motion, waiting, over process, over production and defect [3, 5, 10].

II. METHODOLOGY OF WORK

In this section, method to develop kanban system is presented. The method contains following activities which are important from research point of view.

The Activities are
Gathering relevant parameter.
Calculating number of kanbans to determine optimum level of inventory.
Determination of safety factor based on manufacturing conditions**.**

As a started, relevant production parameter was gathered such as cycle time, withdrawn time, time for waiting kanban, time to replenish, part variant, safety stock and container capacity. All the parameters were taken directly from production floor and history record. Another important parameter was customer demand. Basically, 9 months customer forecast demand was collected to determine the highest volume within the period. Next, kanban calculation was carried out to determine optimum number of kanbans in system. Toyota formula (derived by UMW Toyota) was used to determine kanban numbers. Due to current manufacturing system, two kanban cards system was suggested to suit with current condition. The cards are Production Instruction Kanban (PIK) and Production Withdrawal Kanban (PWK). The calculation was carried out by:

$$PIK= ((Wk+Tw+TL/Tt+\alpha)/C \quad (1)$$

Where PIK = number of production instruction kanban,
Wk = withdrawal time
Tw = time for waiting kanban,
T_L = time to replenish part
Tt = takt time
α = safety stock
c = container capacity

Time to replenish part:

$$TL = \text{Setup time} + \text{Processing time} + \text{Waiting 1 container complete} \quad (2)$$

Withdrawal time:

$$Wk = (\text{Part interval} * \text{Part demand}/c)*2* \text{Part demand} / \text{total demand} \quad (3)$$

Time for waiting kanban:

$$Tw = (\text{Part interval} * \text{Part demand}/c) - 1 + Wk. \quad (4)$$

Production withdrawal kanban is calculated by following formula,

$$PWK= (D+Kw+\alpha)/C \quad (5)$$

Where PWK= number of withdrawal kanban
D = customer demand quantity,
Kw = quantity of kanban waiting.
α = safety stock.
c = container capacity.

The total numbers of kanban must be tally with inventory to achieve smooth circulation of kanban card in the system. Therefore accuracy and reliability of parameter is important for kanban calculation.

III.DEVELOPMENT OF KANBAN SYSTEM TO MINIMISE INVENTORY AND OPTIMISE STORAGE AREA

A. Gathering relevant parameter.

Product*:* KB-Spare 250 B/A-CI with non rising indicator (Diaphragm Valve Family)
As a start gathering of production parameter and forecast demand was carried out as shown in table 1 and table 2. This data is based on current condition of manufacturing process line. Forecasted demand is collected to determine highest volume within period.

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1	Number of product variant	20
2	Number of working days	26
3	Working hours	12.5
4	Changeover time(in minutes)	5
5	Cycle time (in minutes)	11.35
6	Container capacity	5

Table 1: KB-Spare 250 B/A-CI with non rising indicator (Diaphragm Valve Family)

Item Code	Forecasted demand	Item Code	Forecasted demand
C30140	145	CA2501014	112
C30528	168	CA-2509015	112
C30689	145	CKB2001034	257
C32038	278	CKB2501035	112
C34087	278	CKB2501053	112
C34091	514	CKB2501055	112
C34600	278	D154525B250	112
C34602	224	CKB2501052	112
C34603	266	CKB2509010	112
D154493	278	CKB2509021C	112

Table 2: Forecasted demand for parts associated with
KB-Spare 250 B/A-CI with non rising indicator (Diaphragm Valve Family)

B. Calculating number of kanbans to determine optimum level of inventory.

It is essential to determine the number of Kanban and inventory level in the Kanban system. The Kanban number should tally with inventory in order to create smooth Kanban circulation. Hence, Toyota formula was used for calculation of optimum number of Kanbans in the system. In the first step, batch factor or part interval was defined. Possible number of change-over was defined according to a few factors such as available time for change-over activity, current capability of machine to switch production and as well as company policy. The Method to determine possible number of change-over has been described by Art Smalley in his book [8]. For this case, possible number of change-over for final assembly is 23. Therefore, part interval at final assembly line was defined as follows;

Batch factor (Part interval) = number of parts/ possible number of changeover a day.

= 20/23 = 0.869565217

Production line	Part interval
Final assembly line	0.8695

Table 3: Part Interval

Following on from table 3, the amount of batch or lot size for each part could now be determined. The value shows lot size factor, in which the smaller the value of part interval, the smaller the lot size has to be produced. Takt time was then determined for basic parameter in kanban system [9].The calculation of takt time for C30140 as follows;

Takt time = Available time in day (in seconds)/Part demand

= (12.5*3600)/ (145) = 310.344827 seconds/unit

Part Number	Takt time	Part Number	Takt time
C30140	310.3448276	CA2501014	401.7857143
C30528	267.8571429	CA-2509015	401.7857143
C30689	310.3448276	CKB2001034	175.0972763
C32038	161.8705036	CKB2501035	401.7857143
C34087	161.8705036	CKB2501053	401.7857143
C34091	87.54863813	CKB2501055	401.7857143
C34600	161.8705036	D154525B250	401.7857143
C34602	200.8928571	CKB2501052	401.7857143
C34603	169.1729323	CKB2509010	401.7857143
D154493	161.8705036	CKB2509021C	401.7857143

Table 4: Takt time

Table 4 shows takt time for every part, then next step is calculation of PIK and PWK using Eq. 1 and 5. A few parameters, however, has to be defined using Eq. 2, 3 and 4 prior to PIK calculation. Hence, the appropriate number of PIKs was obtained. On the other hand, calculation of PWK was done by referring Kanban waiting point in Kanban flow. The determination of optimum kanban waiting has to be made in order to justify the necessity in the system. The calculation of PIK and PWK for C30140 which is as follows,

$$PIK= ((Wk+Tw+TL/\ Tt+\alpha)/C$$

Where TL (Time to replenish part)

=Setup time + Processing time +Waiting time parts equal to container capacity

= 60 + 60 + 240 = 360

Withdrawal time

Wk = (Part interval* Part demand/c)*2* Part demand/total demand

= (0.869565217 * 145/25)*2* 145/268

= 5.457495133

Time for waiting kanban

Tw = (Part interval* Part demand/c) - 1 + Wk.

= (0.869565217 * 145/25) - 1 + 5.457495133

= 9.500973394

Hence, PIK = ((Wk+Tw+TL/ Tt+α)/C

= ((5.457495133+9.500973394+360 / 310.3448276 +0.2)/25

= 5.514215133 ≈ 6

PWK = (D+Kw+α)/C = (145+ 25+ 0.2)/25 = 6.808 ≈ 7.

Part Number	PIK	PWK	Part Number	PIK	PWK
C30140	6	7	CA2501014	9	10
C30528	1	2	CA-2509015	27	29
C30689	1	2	CKB2001034	17	18
C32038	1	2	CKB2501035	109	113
C34087	3	4	CKB2501053	9	10
C34091	6	7	CKB2501055	4	5
C34600	11	12	D154525B250	11	12

C34602	4	5	CKB2501052	3	4
C34603	5	6	CKB2509010	7	8
D154493	27	29	CKB2509021C	22	23

Table 5: PIK and PWK number for parts associated with. KB-Spare 250 B/A-CI with non rising indicator (Diaphragm Valve Family)

IV. RESULT AND DISCUSSION

A. Determination of safety factor based on manufacturing condition.

Based on table 5, the numbers of PIK and PWK are different for every part. Here Numbers of PWK for each part number was higher than PIK because due to current manufacturing capability. Therfore the company had decided to use 1 day of inventory for safety factor in order to ensure that delivery to customer was not affected when machine breakdown or short supply of component occurred. So in time delivery is possible to customer within specified time.

V. CONCLUSION

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. Therefore, it can be concluded that development of kanban system has improved manufacturing system with determination of factor of safety for inventory level based on manufacturing capabilities of shop floor. Development 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

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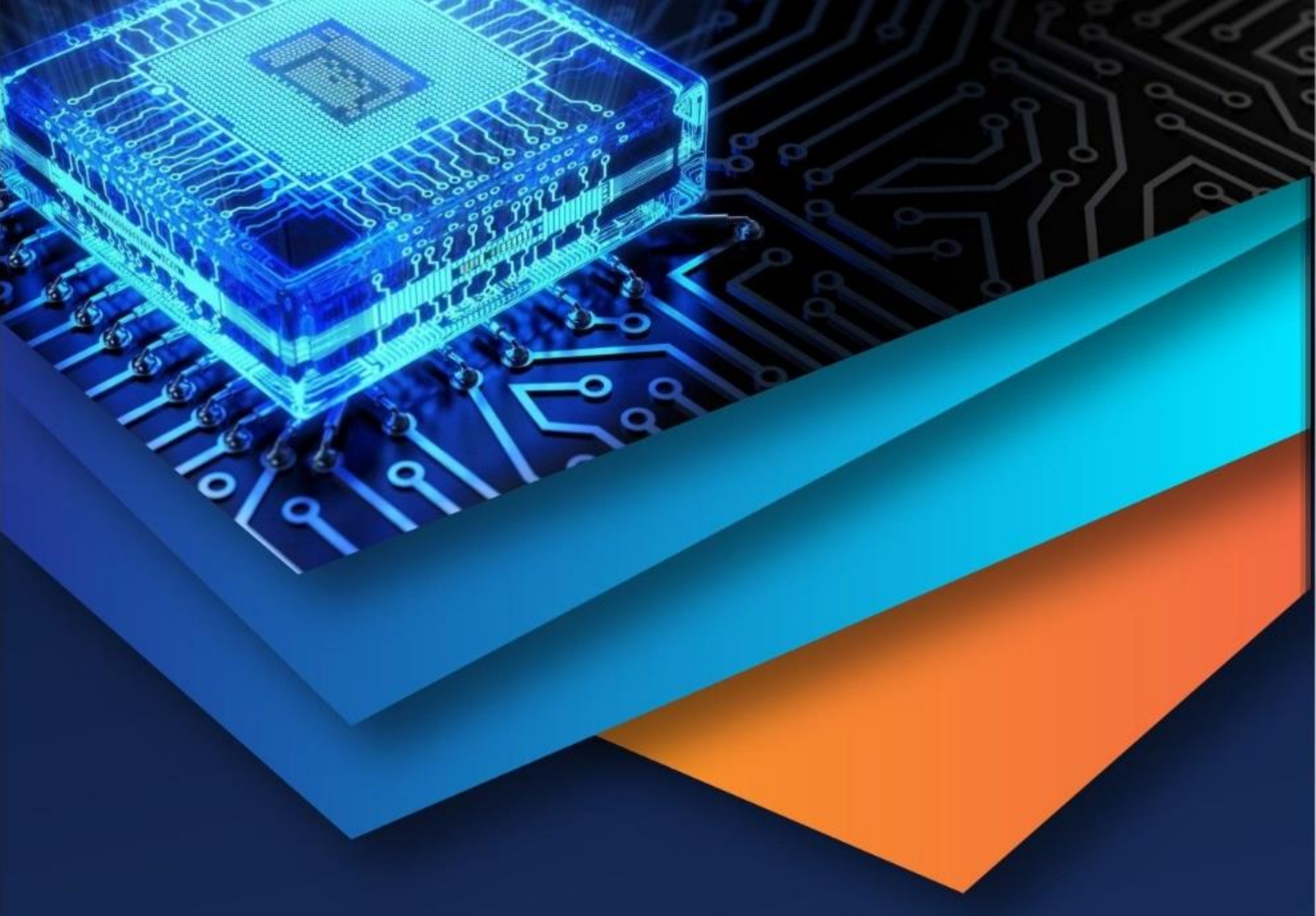

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