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Kanban and VSM Analysis of Butterfly Valve Production Using Simulation

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Abstract: **This project focuses on three lean manufacturing techniques which are Kanban production system, setup time reductionin a valve manufacturing industry. The project was conducted in a manufacturing unit. The methodology can be simply expanded to other industries as well. Kanban is implemented as the main subject for just-in-time (JIT) production systems, while value stream mapping (VSM) is utilised to focus more on the streams in the production processes. The three main causes for work-in-process (WIP) are selected based on the cause and effect diagram in the company. Kanban and TPM are recognised as the two most significant techniques in comparison with the setup time reduction technique which has the least significance. Furthermore, the study signifies that the Kanban system widely stimulates the reduction of WIP inventory.**

Keywords: **Lean Manufacturing, (Just-in-time) JIT, VSM, Kanban, Simulation.**

1. INTRODUCTION

Lean manufacturing was initially created as a tool for reduction of costs involved in administrative and engineering activities.It is defined as a systematic elimination of non- value-added activities and as the name implies

Kanban is an efficient and easy way to implement a JIT production system in a supply chain. Kanban is a pull production system which serves both transaction and communication purposes.First, a card is attached to a completed container. The container accompanied by its Kanban card is then transported to the next production staging area that requires the material. At that time the Kanban card is detached from the container to signal consumption.

A value stream is defined as all necessary actions, either value-added or non-value added activities that take place in manufacturing a single product or a family of products in the production flow.Both information and material flows are considered, beginning from raw materials and ending with finished goods in order to identify all types of waste and ultimately try to remove them.

The application of simulation involves specific steps in order for the simulation study to be successful. Regardless of the type of problem and the objective of the study, the process by which the simulation is performed remains constant. The following briefly describes the basic steps in the simulation process.

2. LITERATURE REVIEW

Lean manufacturing was initially created as a tool for reduction of costs involved in administrative and engineering activities. It is defined as a systematic elimination of non- value-added activities and as the name implies, its focus is on cutting 'fat' from production activities(Anand and Kodali, 2019; Meanwhile, some information modelling strategies are also essential in order to have a full control over the lean manufacturing processes (Sabaghi et al., 2018).

Many tools and lean manufacturing techniques originate from Japanese manufacturers, particularly Toyota. Most of these techniques were largely matured and emerged as a global approach, applicable to many manufacturing sectors(Abdulmalek and Rajgopal, 2017). Following the Second World War, Japanese auto manufacturers faced a delicate situation with respect to their ability to access resources, i.e., capital, land, a skilled workforce, and so on. These inherent limitations led them to develop techniques to manage a business in a very disciplined environment known as the 'Toyota production system' or 'lean manufacturing'. The system focuses on identifying the main sources of waste, and then tools such as just-in- time (JIT), production smoothing, reducing configuration and other waste disposal techniques are used. As mentioned in the introduction, some of the most common lean manufacturing tools are named as follows;

Kanban system is one of the tools under lean manufacturing system that can achieve minimum inventory at any one time. Kanban system provides many advantages in managing operations and business in the organization. Using Kanban system is a strategic operational decision to be used in the production lines. It helps to improve the company's productivity and at the same time minimize waste in production. The Kanban system requires production only when the demand of products is available. Manufacturing companies especially in Japan have implemented Kanban system successfully as this system originates from this country. However, it was found that not all companies in Malaysia, particularly, among the small and medium enterprises (SME) in manufacturing sector, are deploying the Kanban system. Even though there are small medium enterprises (SMEs) using the Kanban system, they are facing problems in making the system effective. Thus, understanding the Kanban system is crucial in lean manufacturing.

One of the predominant indicators of JIT effectiveness, a made to order or pull-based system (Yeh, 2014), is related to inventory reductions. In this sense, Lieberman and Demeester found that raw materials tend to exhibit an immediate reduction. At the same time, the reduction of WIP lowers the costs of inventory holding and related activities. Finally, the level of finished goods inventory should be reduced as a result of improvements in process reliability and reduced cycle times.

Company produces various Valve products through different cellular manufacturing stations. The manufacturing cells include Cutting, Welding, Drilling, grinding, lining, Testing, Assembly and packing. The ultimate goal of the company is to produce high quality products within the time of delivery in order to meet the client needs and customer satisfaction to be a leading valve manufacturer in India.

3. PRESENT METHOD

The current time details of the production process are given below:

Total Cycle time: 43.25 hours

Total Setup time: 7.05 hours

Total WIP Inventory time: 82 hours Total Lead time: 132.3 hours

Currently they are meeting 80% of their demand with given time period.

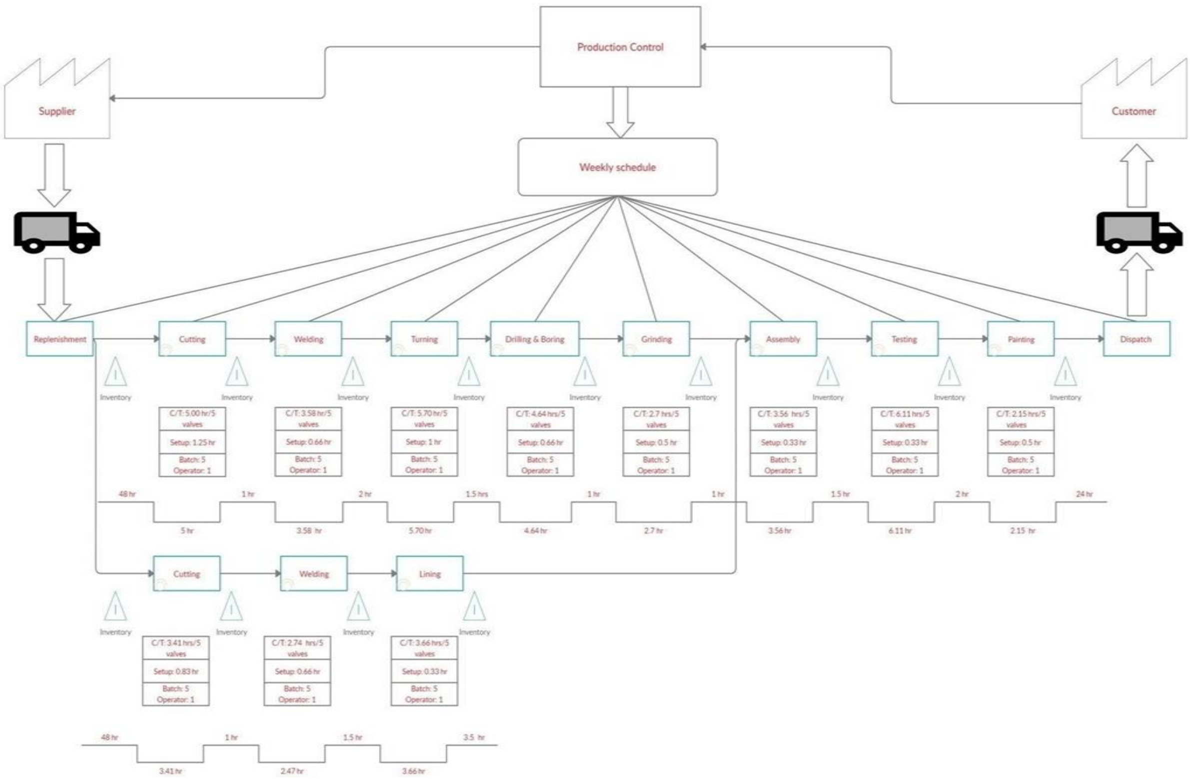
3.1. CALCULATION OF PROCESSNG TIME

In order to find the processing time we studied on the manufacturing floor first, a time study using stop watch was carried out (ten times). Then, to see whether the current sample size is reliable or not, t-test was utilized and 'n', the number of required data for each machine was estimated based on the collected data, according to equation (1) (Groover, 2006):

$$n = \left(\frac{t_{\alpha/2} \cdot S}{E}\right)^2$$

where 'S' is the standard deviation for the sample and 'E' is the maximum error of the estimate which defined as 5% of the x . If 'n' is bigger than 10 the test should be repeated again with respect to the 'n'. If the value is smaller or equal to 10, the current x is the number for machine processing time with 95% confidence. $t\alpha/2$ came from the t-distribution table which in our case equals to 2.262.

4. CURRENT



VSM

A current state map was created using the information collected for Butterfly valve as shown above. As shown on current state map, order are taken by customer service and entered into the MRP system. A significant portion of the total lead time promised to customer is used in the order entry process. There appear to be improvement in the areaHowever, the focus of this study will concentrate on the production of butterfly valve on the shop floor. The order are then sent to production control each morning, planning and scheduling activities are performed by the plant supervisor, planner and department leads. Job direction is communicated to each person at every machine daily. This is represented by the arrow pointing from production control box to the individual operation boxes on the current state map. A work order and traveler are printed and sent along to each operation with the job.

5. CALCULATION FOR KANBAN

The Kanban system supports level production. It helps to maintain stable and efficient operations. The question of how many kanbans to use is a basic issue in tuning a kanban system. If your factory makes products using mostly standard, repeated operations, the number of kanbans can be determined using the formula.

$$K= DR* RT*(1+ \alpha) / NC$$

Where

DR= Average demand per day RT= Replenishment Time (days) α= Safety factor

NC=Number of parts per container

K =1.53 *2*(1+1) / 5

K = 1.25 = 2 cards

Inventory Level = Production requirement * Replenishment time* (1+α)

= 1.53*2*(1+1)

= 6.12 = 7

No. of Kanbans = Inventory Level / lot size

= 7/5

= 2 cards.

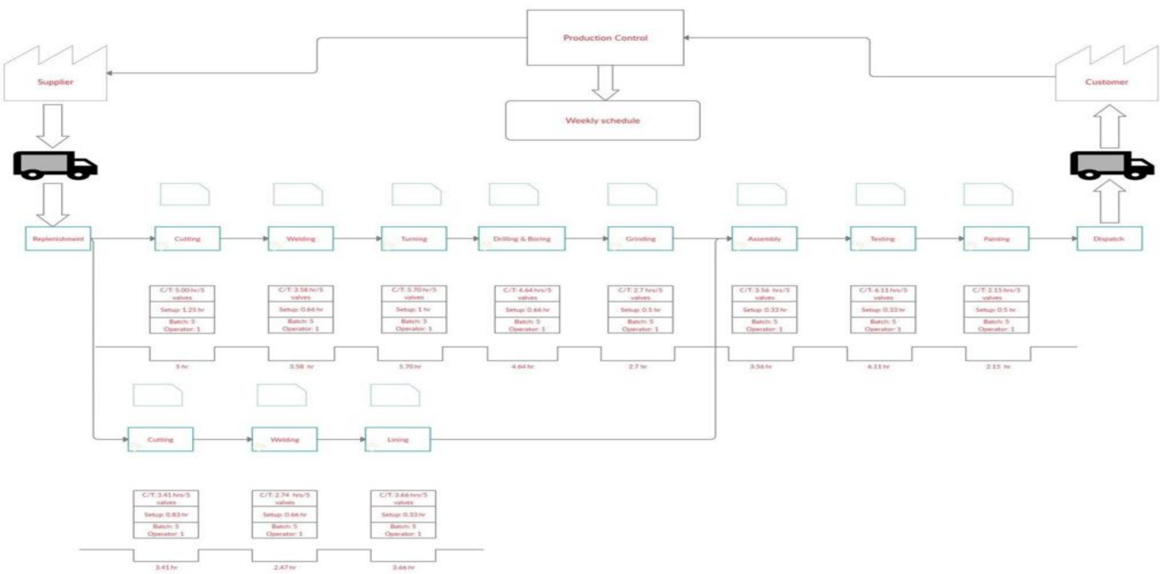
So we can add 8 kanban cards to the current system.

6. ASSUMPTIONS

1. Batch production- after completing each batch size, only the production is moving to another station.
2. External Conditions won’t apply to inner production ie, climate, forces, reordering point, Strikes of workers etc.
3. Machines are working fine, No breakdown of machines.
4. Production requirements are met.
5. Average Demand is taken as constant, ie vary in the demand is negligible.
6. Price Fluctuation is Zero.
7. The project is based on the collected data in the time period.
8. The kanban is making level production in the production line, ie kanban is removing the WIP inventory time between each station.
9. The output can vary in real situations.
10. Downstream process withdraws items from upstream processes.
11. Upstream processes produce only what has been withdrawn.
12. 100% defect free products.
13. Work in progress is Zero.

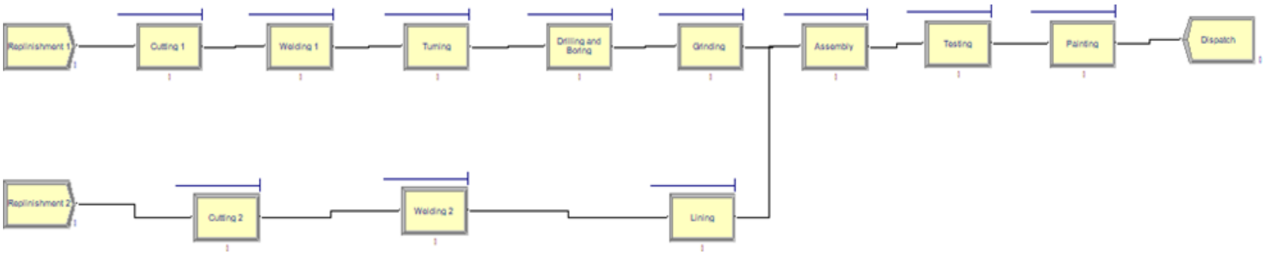
7. VSM FOR FUTURE STATE

Implementation of kanban in the future map made a resolution to reduce the total lead time. This arrangement increased the company capacity, thereby helping the company to consistently meet customer orders on time all the time.



8. SIMULATION FOR FUTURE STATE

As mentioned in the preceding subsection, the simulation model for the current system was verified and validated. This simulation model was used to evaluate the future state mapping of the system as well as to assess the qualified impact of adopting the lean approach.



6:55:20PM **Category Overview** June 6, 2020

Values Across All Replications

Simulation

Replications: 10 Time Units: Hours

Key Performance Indicators

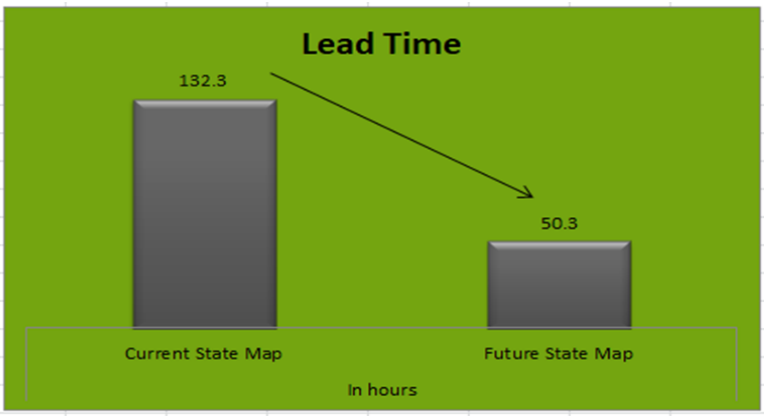
System Average

Number Out 10

9. RESULT

Implementation of future state resulted in reduction of total lead from 132.3 hours to 50.30 hours, giving a 61% reduction in lead time.

	Current State Map (in hours)	Future State Map (in hours)
Total Cycle Time	43.25	43.25
Total Setup Time	7.05	7.05
Total WIP inventory Time	82	0
Total Lead Time	132.3	50.30



10. CONCLUSION

Making appropriate decisions regarding lean technique adaptation in process sectors which possess a combination of continuous and discrete elements is a critical issue. Due to reduced knowledge of lean techniques in this sector and lack of documented applications, managers are reluctant to commit to these improvement programmes. The current study has taken a case-based practice in a valve manufacturing productions. Value stream mapping as well as cause and effect diagram were utilised to identify the problems in the production floor. WIP was recognised as the most potential opportunities for improvement and it was successfully investigated through the proposed improvement tools.

As mentioned in the literature, a number of tools are available to implement a lean approach, however only Kanban and value stream mapping were studied here.The study showed that the effect of Kanban was more significant. In addition, there might be uncertainties about the potential outputs for managers who are seeking to implement lean techniques.The study performed a detailed simulation model to evaluate the basic performance measures, as well as analysing the system configurations. The Information obtained from the simulation could effectively facilitate and validate the manager's decision on implementing lean principles, and as a result to motivate the company during the actual implementation in order to achieve the desired results. With the new improvements at the company,the downstream process pulls the Kanban from the waiting area after receiving a signal that improves the machine reliability and consequently resulted in reduction of machine breakdowns, minor stoppages, and etc.

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