A Review on Lean Manufacturing Implementation Techniques

Dinesh[1],
[1]Department of Mechanical Engineering,
Ganga Institute of Technology and Management,
Kablana, jhajjar

Monu Malik[2]
[2]Department of Mechanical Engineering,
Ganga Institute of Technology and Management,
Kablana, jhajjar

The concept of lean manufacturing was developed for maximizing the resource utilization through minimization of waste, later on lean was formulated in response to the fluctuating and competitive business environment. Due to rapidly changing business environment the organizations are forced to face challenges and complexities. Any organization whether manufacturing or service oriented to survive may ultimately depend on its ability to systematically and continuously respond to these changes for enhancing the product value. Therefore value adding process is necessary to achieve this perfection; hence implementing a lean manufacturing system is becoming a core competency for any type of organizations to sustain. The majority of the study focuses on single aspect of lean element, only very few focuses on more than one aspect of lean elements, but for the successful implementation of lean the organisation had to focuses on all the aspects such as Value Stream Mapping (VSM),Cellular Manufacturing (CM), U-line system, Line Balancing, Inventory control, Single Minute Exchange of Dies (SMED), Pull System, Kanban, Production Levelling etc., In this paper, an attempt has been made to develop a lean route map for the organization to implement the lean manufacturing system. Analyses of the exploratory survey results are summarized in this paper to illustrate the implementation sequence of lean elements in volatile business environment and the finding of this review was synthesized to develop a unified theory for implementation of lean elements.

Index Terms: Manufacturing, production, implementation

I. INTRODUCTION

Lean concepts are mostly evolved from Japanese industries especially from Toyota. Lean Manufacturing is considered to be a waste reduction technique as suggested by many authors, but in practice lean manufacturing maximize the value of the product through minimization of waste. Lean principles defines the value of the product/service as perceived by the customer and then making the flow in-line with the customer pull and striving for perfection through continuous improvement to eliminate waste by sorting out Value Added activity(VA) and Non- Value Added activity(NVA). The sources for the NVA activity wastes are Transportation, Inventory, Motion Waiting, Overproduction, Over processing and Defects. The NVA activity waste is vital hurdle for VA activity. Elimination of these wastes is achieved through the successful implementation of lean elements. Various Survey demonstrate that most of the researcher focus on one or two elements for finding out the existence of wastes and suggest their views on implementing these elements

II. REVIEW OF LEAN IMPLEMENTATION

The perfect strive of the manufacturing system can be achieved through successful implementation of lean elements. Majority of the survey on lean elements focuses on only one or two element or combination of two or three elements. For successful implementation of lean, practically need incorporation of all lean elements and sequencing of implementation task. This literature review explains the incorporation and sequencing of lean elements during implementation period along with implementation issues.

Scheduling:-

By defining a clear production plan any organization can start initializing the manufacturing system implementation. The production plan generated by scheduling decides service order, allocation of resources and manages queue of service request. This review does not focus the scheduling due to readily available scheduling software's.

Employee perceptions:-

Survey on Employee Perception helps to identify the influencing factors on employees' perceptions for successful lean transitions. Losonci et al. [7] suggest that the organization must understand the new shop floor work environment and analyze the cultural change of workers' in everyday lives. The detailed study and survey helps to determine which factors make workers feel that lean transformation was successful in order to reveal the building blocks of successful lean transformations. The conclusion of this surveys stratify the perception factor into critical intrinsic factors (commitment, belief) and external factors (lean work method, communication) which affect the success of the lean implementation from workers' point of view and suggest that the possibility of the lean transformation success, is on the hands of employees' commitment levels, beliefs, communication and work methods. [7] Armenakis et al. [8] suggested that the belief is an opinion or a conviction about the truth of something that may not be readily obvious or subject to systematic verification. David et al. suggest that employee perceptions can be influenced by Belief, Commitment, Work method and Communication. Work methods can strengthen worker identification and involvement, particularly commitment. The employee perception can be achieved through training and awareness by defining road map, metrics and measurement [9].

A. *Value stream mapping (VSM)*

Value Stream is defined as “the set of all the specific actions required to bring a specific product through the three critical management tasks of any business: Problem Solving, Information Management and Physical Transformation”. Value Stream Mapping (VSM) is the process of mapping the material and information flows required to coordinate the activities performed by manufacturers, suppliers and distributors to deliver products to customers. Initially a current state map was drawn from which the source of waste identified and its finds the opportunity for implementing various lean techniques. Rother et al [10] suggest that the Visual representation of VSM facilitates the identification of the value-adding activities in a Value state map based on improvement plan. The availability of the information in the VSM facilitates and validates the decision to implement lean tool and can also motivate the organization during the actual implementation in order to obtain the desired results. VSM clearly indicate the inventory, process time, Lead time, waiting time, etc and process flow from which we can sort out bottleneck cycle time against Takt time. Fawaz et al. case study investigate the ‘‘before’’ and ‘‘after’’ scenarios, through simulation which helps to illustrate the potential benefits such as reduced production lead-time and lower work-in-process inventory. Fawaz et al. [10] concluded that simulation model can be used to evaluate basic performance measures before lean implementation. The systematic continuous improvement starts with the bottleneck area. The prediction of levels throughout the production process is usually impossible with only a future state map, because with a static model one cannot observe how inventory levels will vary for different scenarios, so simulation tool is necessary for predicting the inventory level during demand uncertainty [11].

B. *Takt time*

Takt time refers to the frequency of a part or component must be produced to meet customers’ demand. Takt time depends on monthly production demand, if the demand increases the Takt time decreases, if the demand decreases the Takt time increases which mean the output interval increases or decreases. Rahani et al.[12]Suggested that the importance of measuring Takt time due to the costs and inefficiency factors in producing ahead of demand, which includes Storage and retrieval of finished goods, Premature purchasing of raw materials, Premature spending on wages, the cost of missed opportunities to produce other goods, Capital costs for excess capacity.

C. *Bottleneck process*

Bottleneck process/constrain in the line is identified by determining the maximum cycle time in the line. The line/ plant capacity is decided by this bottleneck cycle time. Line Capacity is the product of Bottleneck Cycle time(C/T) and Total Available time, If Bottleneck C/T <Takt time, then Customer demand met, If Bottleneck C/T >Takt time, and then Customer demand is not met. With the past projected production delivery or from the expected future demand, the takt time is identified for the manufacturing system. With the known Takt time the bottleneck process are identified from the Value stream mapping (VSM), the gap between the capacity and demand is calculated and based on this gap the lean implementation plan is executed [12].

D. *Group Technology*

et al. [13] suggested that the successful implementation of flexible manufacturing system need grouping of parts using similarity among the design and manufacturing attribute which make the production plan and manufacturing process flexible. Based on the grouping of parts through similar process, dissimilar machines are grouped together to form a cell concept as suggest by lean concept. Cell formation is purely based on the nature of the process which varies from organization to organization.

E. *Cellular manufacturing (CM)*

Cellular Manufacturing is the grouping of miscellaneous equipment to manufacture the family of parts [10]. VSM provide route map for every part family, based on the route map the dissimilar machine are grouped together to form a cell. Wemmerlov et al. [14] suggest those dissimilar machines are clustered in sequential manner in order to meet process need of a family of product. Metternich et al. [16] suggested that the effective and efficient clustering of machine or cell is improved by moving employees, Workstations, or both into a U-shaped line which improve the employees’ interaction. CM inducing multi skill process knowledge through implementing U-shape manufacturing line, many of the research and literature survey suggest that the U-line manufacturing is special type of Cellular Manufacturing system which improves flexibility in manufacturing system [15]. The Cellular Manufacturing system success depends on the successful implementation of U-Line manufacturing system, Line balancing, and Flow manufacturing.

F. *U-line manufacturing system*

Monden et al. [18] In his overview the entrance and the exit of the U-line, are placed on the same position. A rather narrow U-shape is normally formed since both ends of the line are located narrowly together. U-shaped lines line reduces number of work station, improve line balancing, visibility, communication, quality, flexibility, material handling.

G. *Line balancing*

Monden et al. [18] suggested that the consideration of task time variability is due to human factors or various disruptions which leads to U-line balancing problem. The task time variability is mainly due to the instability of humans with respect to work rate, skill and motivation as well as the failure sensitivity of complex processes. Becker et al. [19] and Chiang et al. [20] suggested task itself a sources of variability and explains the worker performing the task, and the environment where the task is performed. These sources of variability are controlled by minimizing the moving cost of men and machine. The operator walking time and fluctuation of man and machine cycle time leads to line imbalance. Also the change over time creates imbalance in the line for mixed model line which is necessary for lean. Based on demand, the number of worker and machine within the workstation are increased or decreased in order to overcome the line imbalance. Man-machine flexibility is achieved through free flow of material and information in the manufacturing process [18].

H. Flow Manufacturing

The principle offlow manufacturing is producing an item at a time at a rate equal to the cycle time, the successful implementation of flow manufacturing needs U-line layout, multi-skill operator, standardized cycle time, designing operator work as standing and walking manner and the equipment/machine should be standard and less expensive user friendly . Miltenburg et al. [21] Suggested that the break-through or tedious process flow can be balanced by introducing the customized machine in the workstation in order to balance the machine with the workstation cycle time [21].The mixed model flow is smoothened by designing the workstation with Quick changeover and Small lot size.

I. Quick Changeover/Single Minute Exchange of Die

The quick change over time was introduced and developed by Shingo [5] which is popularly called as Single Minute Exchange of Dies (SMED).Based on time/video study Shingo separated the changeover (C/O) time into internal and external-up set time. The activities performed by stopping the machine are called internal set-up time and the other hand the activity are performed without stopping the machine, these activity are called external set-up time. Yamazumi chart is used to analyze the internal (on-line activity) and external (off-line) set-up time. Based on these analysis possible internal set-up time are converted to external set-up and internal set-up time are streamlined by introducing multi operator working parallel during On-line activity and one touch set-up adjustments to convert the C/O time to single minute. Finally the sustainability of these set-up time improvements is achieved by standardization. Shingo [5] proposed rules for standardization of set-up time and they are Visualizations and standardization rule for overcoming adjustment and trial run and Machine with multiple productions tooling system. One of the critical task in C/O is setting parameter for first good product during initial trial run after C/O. The first good product setting parameter for initial trial run can be achieved using Taguchi experimental design .As a result of the Taguchi experimental design the trials needed to start mass production is reduced and also it reduces the wastage of material during initial production phase. The factors that affect the decision-making process of SMED are cost, energy, facility layout, safety, life, quality and maintenance. Almomani et al. [22] research on Multiple Criteria Decision-Making Techniques (MCDM) and provide a systematic procedure for selecting the best setup techniques such as Analytical Hierarchal Process (AHP), Preference Selection Index (PSI) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) by considering the above factors. The integration of MCDM with SMED leads to greater system flexibility and increase the productivity. C/O time play vital role in sequencing the batch in cellular manufacturing. Cheng et al. [23] suggest that the makespan of the part family in cellular manufacturing depends on set up time [24].

J. Small Lot size/Small Batch

A batch is a set of parts of the same part family. While part families are supposed to be given in advance, lot sizing is a part of the decision making process. Conventional manufacturing systems are run based on buffer production system. Built-in buffer system was introduced to overcome the material flow interruption in case of for equipment break down, machine C/O, absenteeism which lead to high quality problem and lead time. In order to smoothen the material flow and to overcome the quality and lead time issues, buffer quantity should be optimized. In practice, Lean is associated with zero inventories to increase the visibility of product flows and optimize the utilization of capacity [25].

K. Inventory

Survey from various articles indicates that 60% of wastes in manufacturing system are due to inventory. These Inventories are classified into Raw material (RM), Work-in-process (WIP),Finished goods (FG). Increase in inventory of RM, WIP or FG leads to less inventory turnover. Inventory plays a vital role in firm's turnover, detailed literature from 1000 world class manufacturing firms revealed that 34% firms try to increase inventory turnover for at least 10 years [26]. Sakakibara et al. [27] suggested that the excess RM is due to poor projection of product plan, availability of raw material, defective parts, waiting for processing leads to more WIP, and unnecessary transportation between working stations or plants increases WIP inventory, overproduction of parts beyond the plan leads to FG inventories which wait long time in the warehouse or might never be sold. Inventories are reduced by improving the quality levels, rejection rates, delivery rate, lead time and customer satisfaction. RM is controlled by ordering material against the demand or ordered only after the design is accepted by the customer in case of new product. Demete et al. [28] suggested that WIP is controlled by implementing cellular manufacturing/dedicated line Assemble or manufacture the parts against the customer order reduces FG which means FG goes to customer without unusual delay. Imperfection due to lack of process control in the manufacturing system creates the WIP requirement in workstation. In order to reduce the impact adjacent process, the decoupling buffers is placed between processes to overcome the imperfection. The buffers allow each of the teams to make decisions regarding stopping the line to fix problems. Buffer violates the lean system but in practice safety buffer is necessary in case of system fluctuation. If certain workstation run worse than others and the buffers are stripped, individual workstation can run overtime in order to build back up the inventory.

As a result manufacturing lead time increase which in turn increase the WIP. Kanban and Pull systemare the lean elements that control the WIP.

III. SUMMARY AND DISCUSSION

Case study from various literature surveys demonstrates the lean element deliberation and the implementation process. In practice, the organization focuses on only few aspects of lean elements such as Cellular Manufacturing, Pull System, Production Levelling etc., for driving their manufacturing system towards the success. In reality, long term success of manufacturing system in the competitive business environment depends on elimination of dreary issue such as lack of direction, lack of planning, lack of sequencing and interdependency factors of lean elements. To overcome this dreary issue, the lean elements are implemented in sequence in-line with corresponding interdependent factors with proper plan. The finding of survey proposes the Lean Road Map which gives the detailed guide line for Lean Manufacturing System implementation. Detailed survey of Lean concept also summarizes some of the other important aspect such as buffer stacking in case of imbalance / tedious process/ C/O, design the Pull System with One-Piece flow / One Set Flow to implement Every Part Every Interval Concept.

IV. CONCLUSION

Conclusion of this survey reveals that the successful Lean Manufacturing System implementation needs integration and simultaneous implementation of Lean elements along with proper sequence. The survey also proposes the detailed implementation Road Map which gives a unified theory for Lean Manufacturing System implementation. Thus the proposed implementation structure reduces the implementation duration and reduces manufacturing system divergence. As a result it is proposed that the Lean Manufacturing System can be sustained in competitive business environment. Future research should try to find Scheduling structures in-line with EPEI pull system by considering the whole lean elements.

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