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Research Article

Value Stream Mapping in an Automotive Industry

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Abstract

Value stream is a creative process for a part product. The concept of Lean has been introduced and popularized by the Toyota by the name Toyota Production System. Lean is a systematical approach to identify and eliminate waste through continuous improvement. The value stream initiates at the concept and ends when delivered to consumer. Value Stream Mapping (VSM) is an important tool for implementing lean philosophy. VSM is a method to describe the flow of material and information through the production system. The ratio of value added to total lead time is determined by documenting the current lead time, inventory levels, and cycle times. Value added activities make the product more closely to the customer requirement. Non Value added activities do not create customers value, and anything that does not constitutes to value is defined as Waste. In the present work, an attempt has been made to identify and eliminate different types of wastes with the application of Lean tools in an automotive industry. Gearbox Case machining has been selected due to high economic value and complicated processing cycle resulting into excessive rework, longer lead time, and high rejection rate.

Keywords: *Lean Manufacturing; Value Stream Mapping; Gearbox Case Machining.*

1. Introduction

Lean Manufacturing is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, value is defined as any action or process that a customer would be willing to pay for. Lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as Lean only in the 1990s.

TPS is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved . The steady growth of Toyota, from a small company to the world's largest automaker, Bailey, David (2008) has focused attention on how it has achieved this.

While the elimination of waste may seem like a simple and clear subject it is noticeable that waste is often very conservatively identified. This then hugely reduces the potential of such an aim. The elimination of waste is the goal of Lean, and Toyota defined three broad types of waste: *muda*, *muri* and *mura*; it should be noted that for many Lean implementations this list shrinks to the first waste type only with corresponding benefits decrease. To illustrate the state of this thinking, Shigeo Shingo observed that only the last turn of a bolt tightens it – the rest is just movement. This ever finer clarification of waste is a key to establishing distinctions between value-adding activity, waste and non-value-adding work. Non-value adding work is waste that must be done under the present work conditions. One key is to measure, or estimate, the size of these wastes, to demonstrate the effect of the changes achieved and therefore the movement toward the goal.

2. History

After World War II Japanese manufacturers were faced with the dilemma of vast shortage of materials, finances, and human resources. The problems that Japanese manufacturers were faced with differed from those of their Western counterparts. These conditions resulted in the birth of the lean manufacturing concept. Toyota Motor Company, led by its president Toyoda recognized that American automakers of that era were out-producing their Japanese counterparts; in the mid-1940s' American companies were outperforming their Japanese counterparts by a factor of ten. In order to make a move toward improvement early Japanese leaders such as Toyoda Kiichiro, and Taiichi Ohno devised a new, disciplined, process-oriented system, which is known today as the Toyota Production System, or Lean Manufacturing. After some experimentation, the Toyota Production System was developed and refined between 1945 and 1970, and is still growing today all over the world. The basic underlying idea of this system is to minimize the consumption of resources that add no value to a product.

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The term Lean Manufacturing or Lean Production first appeared in the 1990 book, The Machine that Changed the World. Concepts in Lean Manufacturing originate from the Toyota Production System (TPS) and have been implemented gradually throughout Toyota's operations beginning in the 1950's. By the 1980's Toyota had increasingly become known for the effectiveness with which they implemented Just-In-Time (JIT) manufacturing systems.

The arrival of Japanese automotive companies in the UK in the 1980s and 1990s highlighted the uncompetitive nature of UK automotive components suppliers. Strategies were therefore developed to improve the product quality, cost and delivery (QCD) performance of UK companies. In 1996, the Society of Motor Manufacturers and Traders (SMMT), in collaboration with the Department of Trade and Industry, created the Industry Forum (IF). This was supported by Honda, Nissan, Toyota, General Motors and Volkswagen. They provided 'master engineers' who were world experts in manufacturing process improvement. The master engineers trained a cadre of UK engineers in the use of best practice manufacturing tools and techniques. The implementation of lean manufacturing techniques and methodologies requires the transfer of explicit and tacit knowledge.

Table 1 Comparison of Traditional and Lean Manufacturing

	Traditional batch manufacturing	**Lean Manufacturing**
Orientation	Supply driven	Customer driven
Planning	Orders are pushed though factory based on production plan/ forecast	Orders are pulled through factory based on customer/ downstream demand
Batch size	Large	Small
Quality inspection	Checking of samples by QC inspectors	In-line inspection by workers
Inventory	Buffer of work-in-progress between each production stage	Little or no work-in-progress between each production stage
Handoff of works-	Materials after each stage accumulate	Materials handed off directly from one
in-progress	into works-in-progress storage areas before being retrieved by next production stage	production stage to the next
Production cycle time	Total production cycle takes significantly longer than actual time spent processing the materials.	Total production cycle shortens to approach time spent actually processing the materials.

Table 1 above depicts the basic difference between the traditional manufacturing and Lean Manufacturing. From TPS to lean enterprise and lean supply chain, engineers easily find plenty of tools for improvement projects. For this purpose, the lean training, value stream mapping, and lean assessment are three major activities to initiate. Lean training helps the engineers to learn the basic knowledge and skills for improvements. Value stream maps envisage the product and flow of information and, hence, locate the problems and wastes. These three activities are the guiding tools that lead the lean engineers in compiling the projects and moving forward along the lean journey. Among them, VSM and lean assessment are the main tools that provide decision-support information.

Maike Scherrer-Rathje, et al (2009) implemented two lean implementation projects within the same company: a global manufacturer of food processing machines and equipment. The first project was a failure, while the second is viewed as a success. Examining these projects in detail, the major criteria and conditions that led to either lean failure or lean success are identified.

Ulf K. Teichgräber, Maximilian de Bucourt (2010) utilized VSM to eliminate non-value-adding (NVA) waste for the procurement of endovascular stents in interventional radiology services by applying value stream mapping (VSM). The Lean manufacturing technique was used to analyze the process of material and information flow currently required to direct endovascular stents from external suppliers to patients. Based on a decision point analysis for the procurement of stents in the hospital, a present state VSM was drawn. After assessment of the current status VSM and progressive elimination of unnecessary NVA waste, a future state VSM was drawn.

Krisztina Demeter, ZsoltMatyusz (2011) discussed how companies can improve their inventory turnover performance through the use of lean practices. According to his main proposition, firms that widely apply lean practices have higher inventory turnover than those that do not rely on Lean Manufacturing. However, there may be significant differences in inventory turnover even among lean manufacturers depending on their contingencies.

Zoe J. Radnor, Matthias Holweg, Justin Waring (2012), adopted process improvement methodologies from the manufacturing sector, such as Lean Production. In this paper we report on four multi-level case studies of the implementation of Lean in the English NHS. Our results show that this generally involves the application of specific Lean 'tools', such as 'kaizen blitz' and 'rapid improvement events', which tend to produce small-scale and localised productivity gains. Although this suggests that Lean might not currently deliver the efficiency improvements desired in policy, the evolution of Lean in the manufacturing sector also reveals this initial focus on the 'tool level'. In moving to a more system-wide approach, however, we identify significant contextual differences between healthcare and manufacturing that result in two critical breaches of the assumptions behind Lean .

3. Methodology

One of the largest Manufacturing unit of tractors in North region of India. Machine shop of this company are facing problems of delay in high rejection rate, improper utilization of machines, and delivery process which lead to poor quality and more input cost and hence loss in profits. The problem consists of an existing traditional manufacturing system of Machine shop. Machine Shop has Radial Drills, Reaming, Boring Machines, Milling Machines, CNC's, etc. with Lower Quality, Less labor productivity, more waiting times, large work-in-process, and longer material movement.

To overcome the above mentioned limitations there is a need to identify the key areas which are producing Wastes (seven wastes) and to identify the bottleneck operations at shop floor. VSM tool is purposed to introduce in machine shop to locate the source of waste in value stream by the lean concepts and techniques to improve the productivity, quality of existing traditional manufacturing system and hence increase the profits. These steps explain work done in machine shop for Gearbox case, drawing and using VSM to visualize the waste.

3.1Takt time calculation

The rate at which the customer requires a company to manufacture products. Takt time is the number of work minutes per day divided by the number of orders per day. Takt time is calculated as 75 for this work, taking available time of machines per day as 450 minutes (for total 7hours, 30minutes excluding lunch time of 30 minutes from total 8 hours), and demand of 6 pieces per day. Figure 1 shows the control chart of Gearbox Case Machining Shop. From the chart we observed that few operations are taking more time than the takt time of 75 minutes.

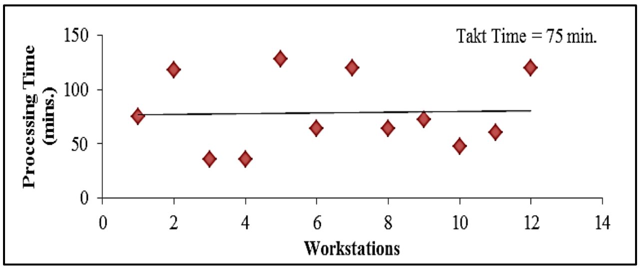

Fig. 1 Control chart for Gearbox Case Machining

The operations with time above takt time are Milling, Drilling, and Boring at machines 2, 5, 7, and 12 with cycle time 118, 128, 120, and 120 minutes respectively.

4. Methodology

After calculation we found the takt time is Seventy Five (75) minutes. Operator of machine 2 consumes 118 minutes. Daily production of this machine is working for 4 pieces but we require 6 pieces per day to adjust working time table of operator of CNC machines. Operator of machine 3 takes quite very less time and works only for 36 minutes, and his production is of 6 pieces, as it is clearly seen from the inventory table, and has 7 hours of time idle, which can be utilized for the operations of machine 2. Similarly, operator of machine 5 works for 4 pieces at the rate of 128 minutes. The drilling machine thus remains busy for longer durations and also does not constitute to the daily order capability. Drilling machine 6 works for just 64 minutes in a day, and thus on this analysis, we suggest company to plan the man-to-machine combination in such a manner that both machines can be utilized accordingly and operators can be thus call on shifts basis.

For machine 7, operator works for 120 minutes, for fine drilling operation, and works again on only 4 units. As mentioned earlier, machine 6 works for only 64 minutes, can be used for the same fine drilling operation with the adjustment of the operators to get the task completed without any rework required. Operator of machine 12 works for 120 minutes, whereas machine 11 works only for 2 hours (120 minutes). Machine 11 can be used to do the same work as it has 5 hours and 30 minutes spare in the machine available working hours.

Also, the point of consideration is with the operators doing Drilling and Reaming process twice. The operation 14 and 15 are operations of Ø17mm drill for Small and Long Hole, and 16, 17 operation highlights the reaming operation of Ø18mm for Small and Long Hole. These two operations can be done in one go, and the time utilized in tool changing can be obsolete, and thus can be used for production only.

The operation 21 and 22, for Ø7mm Rough Boring and then Ø0.3 mm fine boring respectively. This constitutes to a rejection cause due to ovality of holes aroused from the overheating cause by boring operation for removal of 7mm material. This problem of overheating can be rectified by increasing the step of boring, first we use the Ø5mm boring tool and then followed the Ø7mm tool for bore and this will be done in a manner such that first hole after utilizing Ø5mm bore tool, will be left for cooling down and then second hole will be bore with that Ø5mm bore tool, and this also will be left for cooling and so on till the fifth hole. Now, tool change for Ø7mm bore and this will be done in the same manner as for the Ø5mm boring. This will be then followed by the Ø0.3mm fine bore tool. After analysis of this, we suggested company to change the plan of work for these particular operations; this directly reduces the rejection rate due to holes dislocations or rework.

From all the above analysis, the operator working on machine 2, shares work with the machine 3, which is working only for 36 minutes, and producing 6 pieces can easily accommodate and increase the production cycle of 4 pieces to 6 pieces on machine 2.

The Machine 5, producing only 4 pieces per day. Machine 6 utilized for the same operation can easily raise the production to 6 pieces as machine 6 is being used for 6 hrs. 30 mins., and remains idle for 1 hour of machine available time.

Machine 7 also producing 4 pieces of actual 6 pieces required per day. Machine 6 can be utilized for the same operations. If the same machine 6 cannot be producing the required 6 pieces, the machine can be run for another shift or for over time to achieve the target 6 pieces per day in order to maintain the takt time.

The operator of machine 5 works on machine 5 and then goes to machine 6 for the same work, and utilizes the machine in the morning shift. Operator of machine 7 in the second shift works on machine 7 and then goes to machine 6, and finishes the work. The work of machine 6 can be done by operator 5 in the morning shift and rest in the second shift by the operator 7. If required overtime can be call for in order to meet the takt time.

Machine 12 producing 4 pieces per day in 120 minutes, machine 11 is working for the half time as of machine 12. Machine 11 easily can take the load of machine 12 and thus takt time can be maintained for each machine.

After the time study, we suggest that the company should adjust the working times of operators of machine 2, machine 5, machine 7 and machine 12 with the machine 3, machine 6 and machine 11.

The operators shall be intended responsible and flexible enough to achieve the targets in shifts and in overtime. After the adjustments suggested, we met the takt time of machine 2, 5, 7 and 12. Now as far as operators are concerned same operators working on machine 2 can work on machine 3.

Operator 5 work on machine 6 and operator 7 work on machine 6. Thus eliminating the operator 6, reduces the cost to company for producing the part.

4.1 Incorporating the proposed change in current state VSM

From the all above findings, Current State VSM, calculations and discussions, we propose a change for current state VSM as follows.

The comparison of proposed operation cycle with the existing operation cycle for Gearbox Case machining reflects the decrease in Cycle time as well as Number of operators engaged at the workstations.

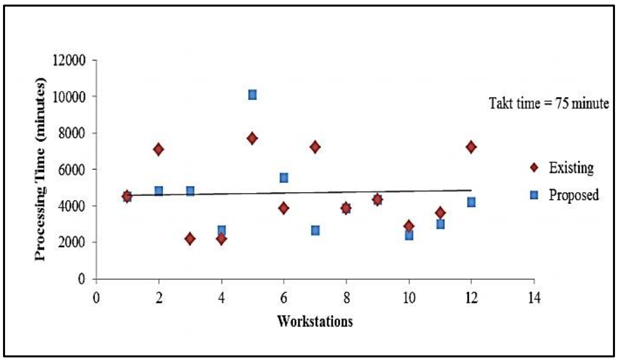

Fig.2 Comparison chart for the existing and proposed operations on workstations

The above cycle times for gearbox case machining clearly indicates the approximate 7 minutes of time saving. For current production of 4 pieces per day means saving of approximate 28 minutes which directly can be utilized for the value added process.

A scatter chart reflecting the comparison of proposed with the existing operation cycle (fig.2) depicts easily the reduction in operations above takt time.

5. Results

It is revealed that Cycle Time has been reduced from 50 days to 40 days on prorate basis, as the proposed cycle of movement on workstations has been reduced by approximate 21%.

Number of Operators involved in, shown a reduction of 3 operators, from 16 to 13.

Also, Rejection Rate due to ovality caused by overheating in Ø7mm Bore has been eliminated. Moreover, waiting time has reduced to a low value.

For inspection process, gauges are provided to check the visual boring operations or drilling holes. The gauges are utilized to check the sizes and takes less time as compared to previous inspection timings. The Inspections has been reduced to (from 3840 secs. to 960 secs. only).

Conclusion

As discussed above, the Internet can facilitate the movement to lean production systems, for many reasons. For a lean approach, a logical target is supply chain management, which has been proven by the organizations adopting lean manufacturing. The study on Lean system design describes some advantageous characteristics production systems for control. However, it does not offer enough support for making congruent decisions on the structure of both systems.

The Lean tool implemented to manufacture the Gearbox Case machining at company. A VSM technique is introduced to control the production and raw material delivery using some processes, where it is possible are linked within a single cell to ensure continuous production between them.

Value Stream Mapping (VSM) proves to be a distinguished technique which provides a company with a blueprint for strategic planning to organize the principles of Lean Thinking for their transformation into a Lean Organization

Future scope

The Lean strategy of VSM can also be implemented to the other divisions, manufacturing components, not only their process cycle, in addition to the machines, manpower, and thus Work-In Process, Inventory, Rejections are reduced.

Value stream mapping tools can further be used with advanced tools or automations for simulating the existing parts under production to derive and analyze the results before implementation. This work can be extended by adding some more variable like set up reduction, workers attitude and working environment.

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