ISSN: 2278-0181
AMASE - 2016 Conference Proceedings

Implementation of Lean Manufacturing Technique with Matlab Simulation Software in An Automobile Industry–A Case Study

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***Abstract*—Today's automobile industries are high competitive, volatile and fluctuation in demand in market. So these industries are planned how to improve their performance. A common technique lean is followed to reduce the wastage, cost and increase the productivity of the industry. The main aim of this project is using the lean principle to reduce the overall cost and increase the percentage of value addition. The objective of this article is to draw the current state value stream map and identify the waste area of the project. The batch processing is converted into lean manufacturing method. The various lean tools JIT, kanban card, value stream mapping methods are used to reduce the non value added time, lead time and increase the percentage value addition. The future state value stream mapping indicates the improved status of the lean manufacturing method. The matlab simulation software method is used to check the values within the range. The overall efficiency of the manufacturing industry is gradually increased.**

Keywords—Value stream mapping, 5s, jit, matlab simulation, value addition.

I. INTRODUCTION

The lean manufacturing concept was first used in toyota production system, japan. In traditional manufacturing, inventory is made in manufacturing, but lean manufacturing there is no inventory. Now the markets are more competitive, so lean manufacturing is important principle to satisfy the customer, worker and improve the productivity and efficiency of the industry. Lean is defined in 5 ways, define customer value, define value stream, make it flow, establish pull, strive for excellence [1]. The various industries are surveyed and improvement programmes are followed in process and equipment, human resources, product design, supplier relationships and customer relationships [2]. The lean sigma concept (DMAIC) and kaizen is used to reduce wastage and increase the industries productivity. The various automobile tool industries are identified and surveys are made. The tool was validated and faced, content and reliability test and involvement in reliability is calculated. Only 31% of the industries are implementing lean concepts. Remaining industries are not aware the lean concept and make awareness of lean concept in workers, supervisors and all levels [3]. The rotary switch manufacturing organaisation is implemented lean six sigma methodology, cause and effect diagram is drawn to invent the faulty switches. The various process parameters with design of experiment were conducted to improve in defects are made. The overall equipment effectiveness (OEE) is calculated and overall defects are reduced [4]. The value stream mapping method is used to identify the current status of the industry. The welding and grinding operations are made separately and man machine chart is prepared for indicating the current position. The combined working of welding and grinding operations are made then future state man machine chart is drawn. Overall performance of industry is improved [5]. The manufacturing industry is identified and value stream mapping is drawn. The wasted area are identified and 5 why method is implemented to know the reason for wastage. The cause and effect diagram is drawn to calculate the root causes of the wastage. The various lean techniques are followed to reduce the lead time and wastage [6]. The process industry is identified and value stream mapping is drawn. The lean tools 5s, jit, kaizen, kanban are used to reduce the wastage[7].The impact of lean methods and tools are studied through various manufacturing industries. Structural modelling equation is used to validate the various lean tools. Jit and automation is highly responsive and kaizen, TPM, vsm are lesser effective [8]. The kaizen improvement technique is used to reduce the wastage and improve the overall efficiency of the industry. The new financial metric is used to reduce the wastage [9]. The lean manufacturing have seven levels: system, object, operation, activity, resource, characteristic, application. Poka yoke- fault proof device used in industry [10]. A case study is made in leading forging industry, value stream map is drawn. Various lean tools are used to reduce the wastage and cost. s/n ratios and anova methods are used to reduce the wastage . The lead time and non value added activities are reduced [11]. The 5s methodology is followed in an industry and to reduce the wastage. There are various actions are used, management teamwork training, test laboratory selection, guide designation, implementation team establishment, implementation planning, launch meeting, 5s establishment, implementation development, other laboratories development and continuous improvement to reduce the cost [12]. To get a better result in lean manufacturing, few activities are additionally used, special trolley or cart for product transportation, heat exchanger installation for cooling purpose in the industry [14]. Cellular manufacturing is a group technology, certain group of products produced in unique method. Takt time is calculated and lean techniques are applied to improve the productivity [15]. The lean manufacturing implementation in an industry is barriered for two reasons –the redundancy programme, lack of employees education about lean knowledge. These two problems are overcome in that paper [16]. The lean manufacturing method means not only reduce the defect, but also reduce the cost of production. The structural equation modeling (SEM) equation is used to build the measurement and structural models [17]. The IT industries and lean manufacturing are interdependent, using structural model various lean tools are used to reduce the effects and improve the industries performance [18]. The lean manufacturing material is handling manually in conventional method. By adoption of lean anchorage, the handling method and work material travelled are controlled by lean principles [19]. The lean tools are used in industries, jit, tqm and HRM are implemented, results show that Just In Time and Total Quality Management have a direct and good effect on operational performance while HRM has a normal effect on it [20] .The JIT is a main tool used in lean manufacturing. The relationship between lean manufacturing and just in time linkages are studied and analyzed [21]. Lean manufacturing have a number of operational performances such as efficiency and productivity [22], quick time [23] and quick delivery [24]. The lean manufacturing company is more productivity if the wastage is reduced. The kaizen is a advanced technique, design changes are made to improve the companys performance [25]. Lean manufacturing techniques promote improved flexibility, enhanced reliability and substantial cost reductions [26]. The kanban system works effectively in multinational organizations, the study suggest that top management, commitment, inventory management and quality improvement [27]. The kanban system is applied in small manufacturing company in malaysia, reduce the leadtime, minimize inventory on floor and optimize storage area [28]. The various 5s methodologies stage action is management team action, test laboratory selection, guide designation, implementation of team establishment, implement the planning, launch meeting, 5s board establishment, implementation development and continuous improvement are implemented. The 5s methodology applicable in university organizations and it becomes like industries. A clean workplace, well organized and visual indication of risks are a safe workplace [29]. The kanban based jit environment for single stage single product kanban controlled production line is developed. The queuing synchronizing mechanisms have simulated the interaction of the different system parameters [30]. The lean implementation in one third of the industry is failure due to lack of management and less awareness. The lean practice bundle is prepared and executed. the framework is developed for sustainable lean implementation using interpretive lean manufacturing[31]. The lean manufacturing with operational performance is explained, the survey made at 266 plants in 9 countries. The results say that JIT and TQM have direct and positive effect and HRM has mediating effect [32]. The various factors influencing the lean implementation, 4 case studies made in a manufacturing company and seven factors affect the implementation of lean practices. The seven factors are the reason for adopting LP, the experience of the company with LP, the need for involvement of supporting areas in LP practices, the interdependence of some practices, the variety of models produced by cell, the synergy between LP and MC, the size of equipment. The results says that presence and impact factors on it [33]. The MRP and JIT systems are combined to reduce the wastage and increase the profit of the industry. The material requirement planning is a push method and jit is a pull method, combination of these tools used to reduce the wastage [34]. The jit is an important tool which affect the financial status of the industry. If the inventory is more the storage cost is high and vice versa [35].

Research gap

From literature survey, more number of researchers follows the lean manufacturing method with value stream mapping (current and future state). But few of them used value stream mapping with simulation software method. The matlab simulation software is used to check the values within the range or not. The overall lean anchorage is used to overcome the defects of Indian automobile industries.

II. CASE STUDY OF THE COMPANY

A case study is made in leading automobile valve manufacturing company (XY) located in trichirappalli, tamilnadu, India. Currently, the plant has 8 manufacturing lines that produce valves for various original equipment manufacturers. The lean manufacturing concept is applied in manufacturing line 2 and the valves are produced by batch production method. Since the productivity is decreased, the arrival of new customers whose requirement is noted in table 1. The line2 is modified by adapting the techniques of lean production system. Average customer's demand has been calculated as 2,15,000 valves per month. Manufacturing of engine valve happens in two phases. The first phase is called as pre-machining, where the valves are forged, heat-treated. The second phase is called as machining for which each model of valves are produced in a dedicated line. In the pre machining process, the long bar is cut in to the required length. In the machining shop the valve undergoes series of process to become a complete valve as per the customer's demand. The process, right from start to end is mapped using current state value stream mapping. In table 1, the various automobile industry customers (A1, A2, B1, B2, C1, C2) for both inlet and exhaust valves with part numbers and requirement per month are noted.

A. Process sequence in forge shop

The raw material (cutbar) is deburred and it is inspected for upsetting and forging process. A heat treatment process is made on this material. Three separate processes such as hardening, washing and tempering are made. After that the material is allowed for straightening then admitted for stress relieving. It is processed in wet end grinding, shot blasting and it is converted in to forging approval process, then sent to kanban area. There are various machines used for this process rough centerless grinding, turning, groove grinding, undercut, stress relieving, finish centerless grinding, nitriding, seat grinding, induction hardening and auto cleaning.

Table 1

Customer	*Part Number*	*Requirement per Month (In Numbers)*
Automobile Industry-A1	A1 – Inlet valve- 50152	75000
Automobile Industry-A2	A2 – Exhaust valve - 50157	75000
Automobile Industry-B1	B1 – Inlet valve - 50491	7500
Automobile Industry-B2	B2 – Exhaust valve - 50496	7500
Automobile Industry-C1	C1 – Inlet valve - 50460	25000
Automobile Industry-C2	C2 – Exhaust valve- 50465	25000

B. Simulation used with VSM

In this manufacturing industry, it is very difficult to predict the exact values of raw material requirement, inventory management and number of employees, production planning and control. The current state of value stream mapping indicates the actual position of the industry. The matlab simulation software is used to calculate the simulated completion time, distance travelled, non value added time and lead time. Matlab is used to check the values within the range or not. In table 2, takt time is calculated. Automobile industry A,B,C and the customer's various part number are noted. The total demand per month and demand per day are noted. There are 3 shifts, total break time and total available time per day is calculated. Finally the takt time is calculated as 8.62 sec.

Customer	*Automobile industry A,B,C*
Part Number	46152/46157/46491/46496/40460/ 40465
Demand/month	215000 (Constant Demand)
Demand/day	8600 (Constant Demand)
No of Shifts	3
Shift Hours	8 hrs
Lunch Break	30 min
Autonomous Maintenance	10 min
Tea Break	10 min
Allowances	10 min
Part changeover time/month	10 hrs/month
Part changeover time/shift	8 min/shift
Available time / Shift	412 min/shift
Total Available Time / Day =	1236 min
	74160 sec
Takt Time =	Total Available Time / Demand
	8.62 sec

Table 2. Takt time calculation for line 2

III. RESULTS AND DISCUSSION

A. Matlab program output

In table 3, the various automobile valves part number and actual requirement per month are noted. The approximate completion period (30 days) and actual completion time are also noted in this table. Using matlab simulation software, simulated completion time is noted. The simulated values are within the range of actual completion of time. The difference of actual and simulated values are noted.

Part Number	*Requirement per month*	*Period (approximate days)*	*Actual Completion time (days)*	*Simulated Completion Time in Days*	*Time/ Job*	*Difference in Time*	*% of Difference*
46152	75000	30	49	47.12	54.28	1.88	**-3.84**
46157	75000	30	62	59.01	67.98	2.99	**-4.82**
46491	7500	30	8	6.57	75.68	1.43	**-17.87**
46496	7500	30	9	5.94	68.48	3.06	**-34**
40460	25000	30	27	22.56	77.98	4.44	**-16.44**
40465	25000	30	23	19.81	68.48	3.19	**-13.87**

Table. 3

Process Sequence	*Distance Travelled*	*Non Value Added time (sec)*
RC to Lathe	4.7 m to 1.91 m	79.17 m to 13m
Lathe to Groove Grinding	4m to 0.5 m	25 m to 13.5 m
Groove Grinding to undercut	10.1 m to 2.37 m	47.68m to 13 m
Undercut to stress relieving	15m to 0.2 m	120 m to 14 m
Stress relieving to finish centreless grinding	16.5 m to 2.91 m	0 m to 14.5 m
Finish centreless grinding to induction hardening	10 m to 3 m	105 m to 14m
Induction hardening to seat grinding	3m to 4.5 m	33 m to 13.5 m
Seat grinding to Finish end	1m to 0.5 m	48 m to 13 m
Finish end to auto cleaning	8m to 0.5 m	30 m to 14 m
TOTAL TIME WITHOUT CONSIDERING DISTANCE BY ORDER	DISTANCE REDUCED	72.3 m is reduced to 15.87m
TOTAL TIME CONSIDERING DISTANCE BY ORDER	NON V/A TIME REDUCED	8.130833 is reduced to 2

Table 4. Sequencing order 1

As per sequencing order given in table 4, matlab software is used to calculate the distance and non value added time. They are rough centreless grinding to lathe, lathe to groove grinding, groove grinding to undercut, undercut to stress relieving, stress relieving to finish centreless grinding, finish centreless grinding to induction hardening, induction hardening to seat grinding, seat grinding to finish end, finish end to autocleaning. The distance travelled for each process is noted in metre. The non value added time is noted in sec. Finally the distance is reduced from 72.3 m to 15.87 m. The non value added time is reduced from 8.13 sec to 2 sec.

Process Sequence	*Distance Travelled*	*Non Value Added time (sec)*
RC to Lathe	4.7 m to 13 m	15 m to 13m
Lathe to Groove Grinding	4m to 1.1 m	14 m to 13.5 m
Groove Grinding to undercut	10.1 m to 2 m	12m to 13 m
Undercut to stress relieving	15m to 2.4 m	15 m to 14 m
Stress relieving to finish centreless grinding	16.5 m to 2.2 m	18 m to 14.5 m
Finish centreless grinding to induction hardening	10 m to 1 m	17 m to 14m
Induction hardening to seat grinding	3m to 3 m	12 m to 13.5 m
Seat grinding to Finish end	1m to 0.2 m	1 m to 13 m
Finish end to auto cleaning	8m to 1.7 m	28 m to 14 m
TOTAL TIME WITHOUT CONSIDERING DISTANCE BY ORDER	DISTANCE REDUCED	14.9m
TOTAL TIME CONSIDERING DISTANCE BY ORDER	NON V/A TIME REDUCED	2.2

Table. 5

In table 5, the same process sequence is followed. Rough centreless grinding to lathe, etc. The distance travelled is noted in metre and non value added time is also noted in sec. The distance reduced to 14.9 m and non value added time reduced to 2.2 sec.

In table 6 and 7, the various machines coverage areas are noted. Rough centreless grinding, Turn head dia+ radius back of head, groove grinding +tappet end radius grinding, turn undercut, stress relieving ,finish centreless grinding, tappet end hardening, seat grinding, finish end, auto cleaning. The Lead time before LPS and after LPS are noted. Finally , without considering space, lead time is reduced from 31106.26 sec to 31029.26 sec. With considering space, lead time is reduced from 6729.26 sec to 6585.26 sec.

Machines	*Machine coverage area in metres*	*Lead time (sec) Before LPS*	*Lead time (sec) after LPS*
Rough Centreless Grinding	3.6*3.6m =12.96 m	6.26	6.26
Turn head dia +Radius back of head	2.3*1.1m = 2.53 m	4750	19
Groove Grinding +Tappet end radius grinding	3.4*2.3 m =7.82m	1500	21
Turn Undercut	2.3*1.1m=2.53m	2860	23
Stress relieving	2.5*1.7m=4.25m	7123	3456
Finish centreless grinding	3.6*3.6m=12.96m	1800	1800
Tappet End Hardening	3.7*3m =11.1 m	6300	16
Seat grinding	4.5*4m =18m	2010	21
Finish end	2.8*3.2m= 8.96m	2880	23
Auto Cleaning	1.1*2.8m=30.8m	1800	1200
TOTAL TIME WITHOUT CONSIDERING SPACE	31029.26 seconds	8.619238 hour	
TOTAL TIME CONSIDERING SPACE	6585.26 seconds	1.829238 hour	

Table. 6

Machines	*Machine coverage area in metres*	*Lead time (sec) Before LPS*	*Lead time (sec) after LPS*
Rough Centreless Grinding	3.6*3.6m =12.96 m	6.26	6.26
Turn head dia +Radius back of head	2.3*1.1m = 2.53 m	4750	19
Groove Grinding +Tappet end radius grinding	3.4*2.3 m =7.82m	1500	21
Turn Undercut	2.3*1.1m=2.53m	2860	23
Stress relieving	2.5*1.7m=4.25m	7200	3600
Finish centreless grinding	3.6*3.6m=12.96m	1800	1800
Tappet End Hardening	3.7*3m =11.1 m	6300	16
Seat grinding	4.5*4m =18m	2010	21
Finish end	2.8*3.2m= 8.96m	2880	23
Auto Cleaning	1.1*2.8m=30.8m	1800	1200
TOTAL TIME WITHOUT CONSIDERING SPACE	31106.26 seconds	8.6406 hour	
TOTAL TIME CONSIDERING SPACE	6729.26 seconds	1.86923 hour	

Table 7- Total time considering space

In table 8, lead time for each process before and after implementation of LPS is noted. The process machines are rough centreless grinding, turn head dia+ radius back of head, groove grinding +tappet end radius grinding, turn undercut, stress relieving ,finish centreless grinding, tappet end hardening, seat grinding, finish end and auto cleaning. The lead time is reduced from 8.64 hour to 1.86 hour.

Process	*Before LPS(sec)*	*After LPS(sec)*
Rough Centerless grinding	6.26	6.26
Turn head dia +Radius Back of head	4750	19
Groove Grinding + Tappet end radius grinding	1500	21
Turn under cut	2860	23
Stress relieving	7200	3600
Finish centreless grinding	1800	1800
Tappet end hardening	6300	16
Seat grinding	2010	21
Finish end	2880	23
Auto Cleaning	1800	1200
Total (sec)	31106	6729
Total (Hr)	8.64	1.86

Table 8. Lead time for each process before and after LPS

IV. CONCLUSION

By using various lean tools like 5s, JIT, set up time reduction and total quality management, the machines are aligned and used in compact space, the floor space is reduced from 351 metres to 174 meters (50.4 % improved). JIT tool is mainly used to reduce inventory and it is improved from 3309 to 568 (82% of improvement). Set up time reduction is the main tool used to reduce the Lead time from 8.64 hour to 1.86 hour (61% improvement). The man machine ratio is improved from 1. 2 to 2 (60% improvement) . The manpower utilization is improved from 48% to 80% (66% improvement). The distance travelled is reduced from 72.2 m to 15.87 m. Finally the number of machines are reduced from 12 to 10. The number of operators per shift is reduced from 9 to 5. The man machine ratio is increased from 1.3 to 2. The takt time is increased from 8.4 to 8.62 sec. Manpower utilization is increased from 48% to 85%. The floor space is reduced from 351 sq. m to 174 sq.m. Thus the implementation of lean principle, the non value added time is reduced from 61 min .The man power ratio is improved by 60%, inventory control by 93%, floor space by 49.5%, lead time by 8.5 times, distance travelled 4.56 times, man power utilization by 1.75 times. After implementing the line2, 259 m^2 free space is recieved as compared to the previous line before implementing.

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