Case Study on Lean Manufacturing System Implementation in Batch Type Manufacturing Industry

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ABSTRACT

To survive in today's competitive manufacturing era, every industry should take the decision to manufacture parts/components of good quality with minimum waste. The manufacturing industries always look for their better performance by minimizing the wastage of the parts manufactured and it depends upon technology /resources used for it. Lean management aims at finding out and eliminating /reduction all types of wastes. This can be achieved by a variety of lean management tools and techniques. Industries primarily choose to engage in lean manufacturing to increase customer responsiveness and product quality and also reduction in requirement of production resource and costs. This paper describes the reduction of total defectives of a component manufactured in batches. The data was collected by observing existing method of production and defects associated with each operation were noted for the component selected under case study. Root cause analysis was used to find out the causes for these defects and certain remedial measures were applied to correct those defects.

Keywords: *Lean manufacturing, Quality Improvement, 5S, Waste reduction .*

1.INTRODUCTION

The growing complexity of industrial manufacturing and the need for higher efficiency, greater flexibility, better product quality and lower cost have changed the face of manufacturing practice. To flourish and survive in today's competitive global marketplace, industries are increasingly focusing on their producing good quality of parts /components with minimum wastage by use of available resources for better performance. In today's competitive economic environment, customers do not just prefer but demand from manufacturers to provide quality products in a timely fashion at competitive prices. To satisfy this requirement, manufacturers need to plan necessary and optimum use of resources to meet market demands. However, waste reduction is a very challenging task for manufacturing industry for better performance.

Lean manufacturing is focused on getting the right things, to the right place, at the right time, in the right quantity to achieve perfect work flow while minimizing waste and being flexible and able to change. The main principles of lean manufacturing are zero waiting time, zero inventory, internal customer pull instead of push, reduced batch sizes, and reduced process times. Wastes have a direct impact on the cost of the product; they are non value adding operations which the customer will not pay for it. Typically in manufacturing industries only 5% of activities from total activities are value added and all the rest activities are non value added i.e. waste. Minimization of this waste can help in improving performance of industry in term of quality, profitability and customer satisfactions. Hence lean thinking has become extremely important in this era of global competition. The core idea behind lean manufacturing is to maximize customer value while minimizing wastage. This can help create more value for the customers with the usage of fewer resources. The goal of any industry is to earn profit by selling quality products at a price higher than the cost of the effort and materials used. This can be achieved by converting raw material into something of greater value using various manufacturing processes.

The rest of this paper is organized as follows. In Section 2, literature review for waste, lean principles and techniques. Introduction and Methodology used in Case study will be given in section 3. While Section 4 illustrates work carried out a case study in which proposed methodology is applied and finally, with concluding remarks paper would end.

2. LITERATURE REVIEW

2.1Seventypes of wastes:

The principle or philosophy of the lean concept is the ways to identify and eliminate waste to enhance the processes and products with the customer requirement and creating a system to pull in the process to ensure a continuous flow of processes, and improve continuously to enhance their processes and products regularly to eliminate waste in the production process. Different authors [Singh Sumit Kumar et. al (2014), Chanarungruengkij Veerasak. et. al (2017),Charles Okpala (2014), Khalil A,.et. al (2013)] were considered the types of wastes to explain lean concept in their research work. Following are the most commonly seven types of waste used in Lean concept.

a) Over Production: Overproduction deals with making more products than required one. Manufacturing of products in advance or in excess of demand consumes money, time, space etc.

b)Waiting : Waiting is idle time for workers or machines due to bottlenecks or inefficient production flow on the factory floor. Manufacturing processes start becoming ineffective when human workers have to wait or machines have to stay idle for any amount of time due to incompletion of previous operations. If workers have to wait, resources are consumed while no value is added. Similarly machine down time also doesnot add value.

c) Transportation: Unnecessary moving of products from one place to another does not add any value to the product and adds to the cost. Also there are chances of product deterioration during movement. Transportation cannot be completely eliminated, but it can be reduced. By use of proper handling system, good plant layout etc. can help in reducing transportation.

d) Over processing: This includes using more energy, time, resources than actual required for manufacturing a product. It may include unnecessary use of costly and large machinery in cases where even small machines could have been used, unnecessarily tight tolerances, finishing the product beyond the required limit etc. Usage of standard operating procedures (SOP's), proper design of products can help avoid this waste.

e) Excess Inventory: Inventory is the raw materials, work in progress (WIP) components and finished goods which are being held in the organization. Holding of inventory has various costs associated with it. Hence it is necessary to avoid holding excess inventory. JIT manufacturing principles can be used to reduce inventory losses.

f) Motion: It consists of any unnecessary movement of people which will not add any value to the component. Unnecessary movements can cause fatigue to the workers, thus reducing their efficiency and also increase the cycle time. Proper arrangement of work station and motion studies can help in resolving the problem.

g) Defects: In addition to physical defects which directly add to the costs of goods sold, this may include errors in paperwork, provision of incorrect information about the product, late delivery, production to incorrect specifications, use of too much raw materials or generation of unnecessary scrap, time and cost spent in the inspection and repairing / reworking of defects. They may be caused by incorrect design, improper process etc. Using Jidoka, standard processes can help in minimizing these defects.

2.2 Lean Manufacturing Principles:

The theory of lean manufacturing is based on following the principles to achieve the desired goals of the industry.

Table No.2.l Principles of lean manufacturing

Sr.No	Lean manufacturing principles	What it means?	Enablers	Authors/ Website
1	Standardization	Standardized work procedure to do routine and repetitive works to improve efficiency and quality.	Standard work procedure, standards for design, processes etc	Chaple A.P. et al (2014)
2	Simple and specified pathways	Flow of work to the right machine or person in the right form at the right time at the lowest cost with the highest quality possible which reduces production lead time.	Kanban system, JIT	
3	Teaching and learning	Through continuous effort of managers and supervisors acting as enablers or mentor in solving problems.	Scientific methods of problem solving	
4	Socialization	An atmosphere of trust, respect and common purpose in which work is performed to improve efficiency and productivity	Consistency, consensus and communication	
5	Continuous improvement	Experimentation by the people at every level toward improving their own work systems.	Kaizen, TQM, Six Sigma, JIT etc.	
6	Supplier - customer relationship	Supplier-customer relationship specifies the form and quantity of the goods and services to be provided, the way requests are made by each customer, and the expected time in which the request will met.	Long-term cooperative relationship	
7	Coordination through rich communications	Coordination through rich communication is required to develop the idea into an innovation.	go-see, involvement of suppliers early during PD	
8	Functional expertise and stability	Every company depends on highly skilled engineers , designers, and technicians to bring a product to the market; it is about developing standard set of skills	Job Evaluation and Merit rating	

9	Pursuit for perfection/ striving for ideal goal	A common sense of the ideal system and shared goal motivate to the subordinate to make improvement and meet the current needs of the customers.	Sharing a common goal	Chaple A.P. et al (2014)
10	Cultivating organizational knowledge	The faith of organization that the skills and knowledge generated will pay off later.	Knowledge sharing practices	
11	Specify Value as perceived by the Customer	By clearing defining value for a specific product or service from the end customer's, perspective, all the non value activities-or waste-can be targeted for removal.	Brainstorming, Quality Function Deployment(QFD)	Nasution Abdillah Arif . et al (2018), http://www.cardiff.ac.uk/lean/principles/
12	Identify and Map the Value Stream	The Value Stream is the entire set of activities across all parts of the organization involved in jointly delivering the product or service. This represents the end-to-end process that delivers the value to the customer.	Value stream mapping	http://leanmanufacturingtools.org/39/lean-thinking-lean-principles/
13	Create Flow by Eliminating Waste	Eliminating waste ensures that the product or service flows to the customer without interruption ,detour or waiting	Kanban, Cell design, to small machine	
14	Respond to Customer Pull	Understanding the customer demand on the service available and creating the process to respond to service required which help the industry to produce what and when customer wants.	Kanban	
15	Pursue Perfection	Creating flow and pull starts with radically reorganising individual process steps, but the gains become truly significant as the entire steps link together. As this happens more and more layers of waste become visible and the process continues towards the theoretical end Point of perfection, where every asset and every action adds value for the end customer.	Kaizen	

2.3 Lean Manufacturing Techniques:

Once the industry identify the major sources of waste, tools such as provided will guide the companies through corrective action so as to eliminate wastes. Implementation of lean manufacturing involves use of the following techniques:

Table No.2.2 Lean Manufacturing techniques

Sr. No	Technique Name	Description	Enablers
1	Work place Organisation 5S System	One of the most effective tools of continuous improvement is 5S, which is the basis for an effective lean company. 5S is a first, modular step toward serious waste reduction.5S consists of the Japanese words Seiri (Sort), Seiton (Straighten), Seiso (Shine and Sweep), Shitsuke (Standardize), and Seiketsu (Sustain). 5S is aimed at improving productivity of the organization and achieve cleanliness and standardization of the workplace.	Michalska J., Szewieczek D. (2007) Agrahari R. S. et. Al (2015) Singh Sumit Kumar et. al (2014) Kumar S. (2014) Saihong Tang.et. al (2016) . Patel Vipulkumar C and Thakkar Hemant (2014)
2	Jidoka	Jidoka highlights the causes of problems when they first occur. This helps in improving the processes by eliminating the root cause of defects	http://leanmanufacturingtools .org/489/jidoka/
3	Kaizen	Kaizen is the practice of continuous improvement This implies that small, incremental change routinely applied and sustained over a long perio result in significant improvements. It aims a continuous improvement to fall functions an employees ranging from the management to th line workers.	Ghushe Shubham et al. (2017), Kshitij Mohan Sharma and Surabhi Lata (2016), Gautam Rajesh, R.et. al (2012), Kaumar S. (2014) Gundeep Singh and Dr. Belokar R.M.,(2012)
4	PDCA cycle	PDCA cycle consists of four stages which are: Plan: Define the problem to be addressed, collect relevant data, and as certain the problem's root cause. Do: Develop and implement a solution; decide upon a measurement to gauge its effectiveness. Check: Confirm the results through before-and-after data comparison. Act: Document the results, inform others about process changes, and make recommendations for the problem to be addressed in the next PDCAcycle.	Sokovic, M.et. al (2010) Gill Preetinder Singh (2012)

5	Root Cause Analysis	Root cause analysis helps identify how and why something happened, thus aiding in the prevention of it's reoccurrence. It involves collection of data, analysis and giving recommendations.	Gosavi Vineet V., et.al (2014)
6	Total Productive Maintenance	Total Productive Maintenance (TPM) seeks t engage all levels and functions in an organizatio to maximize the overall effectiveness o production equipment. Machine breakdown is on of the most important issues that concern th people on the shop floor. The reliability of th equipment on the shop floor is very importan since if one machine breaks down the entir production line could go down. An important too that is necessary to account for sudden machin breakdown is total productive maintenance.	Singh S. K et. al (2014) Kaumar S. (2014) Saihong Tang .et. al (2016)
7	Just-in-time Production Systems/Kanba n	JIT enables a industry to produce the products it customer's want, when they want them, in th amount they want. JIT techniques work to leve production, spreading production evenly over tim to foster a smooth flow between processes. Many Industries asked the suppliers to delive components using JIT to have significan reduction in waste associated with unnecessary inventory, WIP, packaging, and overproduction.	Kaumar S. (2014)
8	Six-Sigma	Six Sigma's toolbox of statistical process contro and analytical techniques are being used by som industries to assess process quality and waste area to which other lean methods can be applied a solutions. Six-Sigma is also being used to furthe drive productivity and quality improvements i lean operations.	Kaumar S. (2014)
9	Value Stream Mapping	Value Stream Mapping is a lean-managemen method for analyzing the current state and designing a future state for the series of events tha take a product or service from its beginning through to the customer. A value stream map is a advanced form of process map that focuse particularly on the lean principles of value and flow within the process.	Gill Preetinder Singh , (2012), Kshitij Mohan Sharma and Surabhi Lata (2016), Ghushe Shubham .et al. (2017)

3.

3.CASE STUDY

3.1Introduction:

A case study was carried out at an industry XYZ situated near Pune, India which produces over 60 components and supplies to leading valve manufacturers in India. The component selected for study was valve body cap which having major volume and total defective relatively high. The volume of production of this component is in the range of thousands per month. The goal of this research is to find out the defects and causes which cause the defect and eliminating the root causes of making defective components at Industry XYZ. This goal is accomplished by establishing a direct communication and collaboration with every level of industry XYZ infrastructure, from the machine operators to management.

3.2 Methodology:

Following Table No. 3.1 shows the methodology used to carry out the actual work.

Sr. No	Name of Step	Description	Tool/Technique
1	Problem Definition	Selection of Component for study, scope, objective of study	Research Paper, Industry report, Visual physical observation
2	Data Collection	Collection of the available data. Finding the reasons for rejection of the components. Listing of data classification and all the reasons for the rejection.	Physical Measurement
3	Root Cause Analysis	Enlisting of the probable root causes for all the problems. Preparation of Fish Bone diagram for the listed causes	Brainstorming, Fish Bone diagram
4	Corrective Action	Deciding corrective actions for all causes and its step by step implementation	Work place Organisation 5S System
5	Post Implementation	After implementation the next step is to monitoring of all the measures for achieving the objective.	PDCA cycle
6	Regular Audit	This stage involves the monitoring of remedial measures to ensure that the corrective actions are implemented as per plan.	Kaizen or Continuous improvement

4. WORK CARRIED OUT

4.1 Problem Definition: The component selected for study is valve body cap, which is having major volume and total defective relatively high. The volume of production of this component is in the range of thousands per month. The scope of this research involves areas within the industry focusing production flow, identification of defects in each operation for part manufactured and corrective action for it. The objective is to improve the quality of the component.

4.2 Data Collection: The data was collected by observing existing method of production and defects associated with each operation were noted for the component selected under case study. This data was classified and all the reasons for rejection were subsequently listed. Following Table No.4.1 shows the defects associated with each operation performed on component selected for case study start from raw material stage to final operation.

Table No.4.1 shows the defects associated with each operation performed on component

Step no.	Operation Performed	Tool Used	Defects Associated With This Step	No.of Defects
1	Raw Materials Inspection	Non Destructive Testing (Magna Flux)	Hex oversize and undersize	02
			Crack	01
			Damaged raw material	01
2	Drilling and Semi-finish turning	Automat Machines	Total length undersize and oversize	02
			Step length undersize and oversize	02
			Die oversize and undersize	02
			Drill Dia. Oversize and undersize	02
			Chamfer missing	01
3	Machining (Facing, Chamfering, Drilling, Reaming, Threading)	CNC Machine	Flat Thread	01
			OD oversize	01
			OD under size	01
			ID oversize	01
			ID under size	01
			Total length oversize	01
			Total length undersize	01
			Thread No Gopass	01
			Thread Go undersize	01
			Thread damage	01
			ID unclean	01
			Rough Turning surface	01
			Step length oversize and undersize	02
			Dia .XX mm Go tight and No Go pass	02
			Dia .YY mm Go tight and NoGo pass	02
4	Machining (Turning, Facing, Threading, Face milling, ID Boring)	CNC Machine	Thread No Go pass and Go undersize	02
			Thread Damage	01
			ID unclean	01
			Step on surface	01
			Rough Surface	01
			Depth oversize and under size	02
			Dia .XX mm oversize and under size	02
5	Burnishing	Drilling Machine	Inner Dia over size	01
			Scratches on inner diameter	01
			Poor surface finish	01
6	Final Inspection	Various inspection tools	Thread undersize and oversize	02
			Flat thread	01
			Thread Face	01
			Dia .XX mm oversize and under size	02
			Rust	01
			Dent	01
			Face damage	01
			Chamfer oversize/ missing	01
			Hex damage	01
			Milling oversize and undersize	02
			ID unclean	01
			Hex draw mark	01

Each identified defect contributes a specific amount of defective pieces. It is necessary to find out those defects which contribute the maximum number of defective pieces. Following Table No.4.2 shows percentage defectives of each defect. Percentage defectives of each defect = (Defective pieces of that defect/Total defectives)*100

Table No.4.2 Percentage defectives of each defect

Operation Performed	Defects Associated With This Step	No. of Defectives	Percent Defectives
Raw Materials Inspection	Hex oversize and undersize	00	00000
	Crack	69	2.9870
	Damaged raw material	00	00000
Drilling and Semi-finish turning	Total length undersize and oversize	18	0.7792
	Step length undersize and oversize	00	00000
	Die oversize and undersize	00	00000
	Drill Dia. Oversize and undersize	00	00000
	Chamfer missing	02	0.0866
Machining (Facing, Chamfering, Drilling, Reaming, Threading)	Flat Thread	02	0.0866
	OD oversize	30	1.2987
	OD under size	12	0.5195
	ID oversize	117	5.0649
	ID under size	111	4.8052
	Total length oversize	38	1.6450
	Total length undersize	132	5.7143
	Thread No Go pass	165	7.1429
	Thread Go undersize	30	1.2987
	Thread damage	00	00000
	ID unclean	01	0.0433
	Rough Turning surface	04	0.1732
	Step length oversize and undersize	00	00000
	Dia .XX mm Go tight and No Go pass	00	00000
	Dia .YY mm Go tight and NoGo pass	06	0.2597
Machining (Turning, Facing, Threading, Face milling, ID Boring)	Thread No Go pass and Go undersize	02	0.0866
	Thread Damage	00	00000
	ID unclean	02	0.0866
	Step on surface	00	00000
	Rough Surface	00	00000
	Depth oversize and under size	00	00000
	Dia .XX mm oversize and under size	00	00000
Burnishing	Inner Dia over size	00	00000
	Scratches on inner diameter	187	8.0952
	Poor surface finish	00	00000
Final Inspection	Thread undersize and oversize	02	0.0866
	Flat thread	00	00000
	Thread Face	33	1.4286
	Dia .XX mm oversize and under size	00	00000
	Rust	215	9.3074
	Dent	07	0.3030
	Face damage	516	22.338
	Chamfer oversize/ missing	29	1.2554
	Hex damage	188	8.1385
	Milling oversize and undersize	92	3.9827
	ID unclean	293	12.684
	Hex draw mark	07	0.3030

Following observation were made after analysis of the data from Table No.4.2

Component were rejected due to total 59 number of defects

There were 12 number of top defects account for 92% of the total defectives and these were tackled carefully. From Table No.4:2 it is also seen that face damage having the highest percent defectives (24.31%) among all the defects which lead to defect in final component.

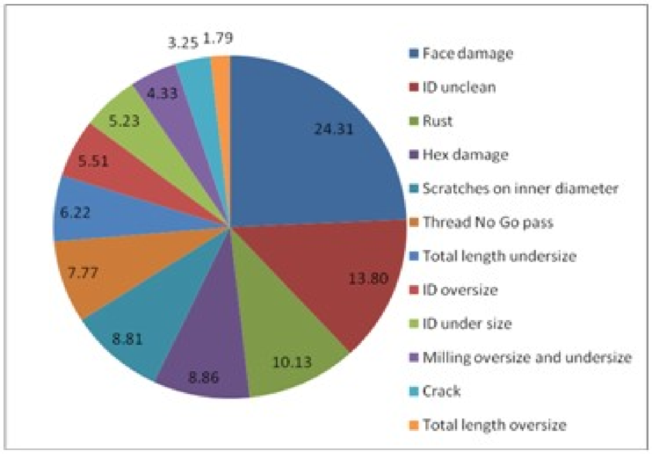

Figure No.4.1 Pie chart of top 12 percentage defectives

4.3 Root Cause Analysis: Next step is performing a root cause analysis for the defect considered in previous step for finding all cause which leads to defect. From Figure No. 4.1, it can be seen that face damage is the defect having highest percent defectives (24.31%) and hence this defect is taken for sample study. Analysis of the problem is carried out by brainstorming session which aimed at defining the scope of the problem and making a framework for further analysis. Following Table No.4.3 shows the analysis of the problem.

Table No.4.3 Analysis of the problem

Description	The problem is	The problem is not
What exactly is the problem?	Dents, Scratch mark on the front\ face of Valve body cap	Damages in other areas of valve body cap
Where exactly does the problem occur?	After blanking (handling / transit), after machining, during gauging and handling.	During blanking, during machining, during burnishing,
When exactly did the problem occur?	--	--
How often did the problem occur?	Daily	--
What is the problem history?	Damages were high when the machining was done on GPM. Currently machining is done in CNC	--

Next a validation was performed for all the probable root cause and a validation report was prepared highlighting the verification results and significance. Following Table No.4.4 shows the validation report.

Table No.4.4 Validation report

Sr.No.	Probable root Cause	Verification	Verification Results	Significant/Not significar
1	100% Thread Gauging	1000 Nos checked for face damage	One number found not ok after I00% Gauging	Significant
2	Mishandling	50Trays handling monitored	No concern found.	Not Significant
3	Uncleaned Trays	50Trays handling monitored	No concern found.	Not Significant
4	Over flow of material	25 Trays monitored for overflow	No concern found.	Not Significant
5	Improper Stacking	4 Trays monitored for improper stacking.	One number found not ok for improper stacking	Significant
6	Damaged parts with short length	10 Nos checked for face damage in short length Parts (Lower limit)	No concern found.	Not Significant
7	During air gauge checking in process	500 Nos, checked before and after air gauge Checking	No concern found.	Not Significant
8	Material Handling	5Trays monitored for material handling	No concern found.	Not Significant
9	Use of wrong trays	10 Different trays monitored.	No concern found.	Not Significant
10	'rays without partition	50Trays without partition monitored through process	No concern found.	Not Significant
11	During Total Length checking in-process	Before and after Total length checking	No concern found.	Not Significant
12	Improper flooring	Storage locations monitored throughout process	No concern found.	Not Significant

Enlisting the probable root causes for all problems. Fish Bone diagram for the listed causes faced by Industry for productivity is shown in Figure No.4.2.

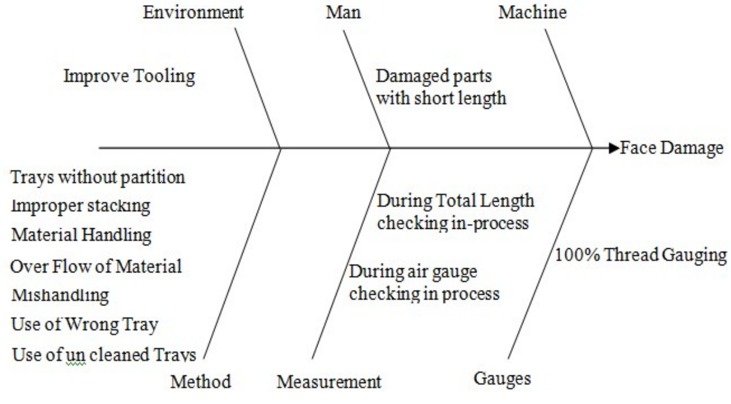

Figure No.4.2 Fish Bone diagram for the listed causes

4.4 Corrective Action

Following corrective action were suggested to minimize the defect in component for getting the better performance of the industry. a) Implementation of 5S in the production floor for effective flow, b) focusing on cleanliness and tidiness criteria, c) Up gradation of worker skill for component handling, machine operation, and processes, d)Periodic maintenance of machine, material handling devices and inspection tooling

4.5 Post Implementation

The next stage after implementation is the monitoring of all the measures. Daily meetings must be conducted to analyze and discuss the previous day's work. The PDCA cycle is used in this stage. Following Table No.4.5 shows the remedial measures taken for the defect.

Table No.4.5 Remedial measures taken for the defect.

Sr .N	ace damage and Hex damage	une19	uly19	Aug19	ept19	Oct19	Nov19	Dec19
1.1	nternal movement of blanks in trays instead o gunny bags			▲ ▼				
1.2	tacking of components should be eliminated- From1rows to Single row in trays in all stages				▲	Continuous Activit →		
1.3	omponent transfer between stations should b through only clean trays				▲	Continuous Activit →		
1.4	ake availability of in-house facility to clean the trays				▲			
1.5	ptimization of coolant flow while threading for self cleaning of chips				▲			
1.6	void multi handling of components at a time during inspection and machining				▲	Continuous Activit →		
1.7	wareness to operators about rejection and actions to be taken				▲	Continuous Activit →		
1.8	isual display and report for damages/defectives						△	▽
1.9	ork instruction for part checking				△	▲ ▼		

▲ :Process start, ▼ : Process finish, △ : Action planning start , ▽ : Action planning finished

⟶ Continuous activity

4.6 Regular Audit

This stage involves the monitoring of remedial measures to ensure that the corrective actions are implemented as per plan. The principle of Kaizen or continuous improvement is used ensure constant improvement on a month on month-basis. The small improvement points suggested which are carried out in the industry regardless of the situations present in the industry or anywhere else which might affect the performance of the industry . KAIZEN used in current situation in this industry for getting better quality of component were:

1. Advancement of automation in loading, unloading and changeover between the processes regularly.
2. Constant up gradation and Periodic maintenance of the machines.
3. Inspection of the safety standards.
4. Continuous improvement of skills of workers.
5. Periodic inspection and standards up gradation.
6. Formation of quality circles in each department.
7. Proper handling of materials with appropriate handling device.
8. Periodic maintenance of handing devices.

After the implementation of remedial measures, the bar chart for defect wise PPM is shown in Figure No.4.3 (a). The overall reduction in the total defectives of the part selected for case study is shown in Figure No.4.3(b).

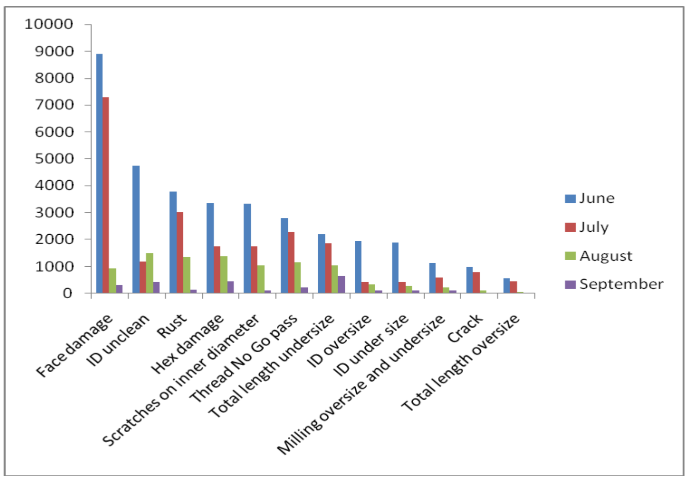

Figure No.4.3 (a) Defect wise PPM

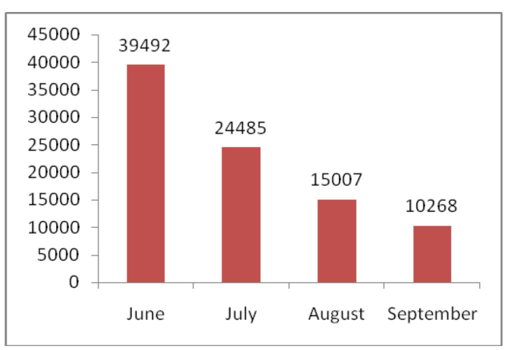

Figure No.4.3 (b) overall reduction in the total defectives

5. CONCLUSIONS

Following conclusions are drawn from this study

- Implementation of lean manufacturing has helped to reduce the overall defective components on a continuous basis.
- 74% reduction in total defectives was observed due to proper implementation of lean manufacturing, resulted in higher productivity of machines as well as humans.
- Inspection of these parts was carried out on sampling basis. However, if a lot is rejected then 100% inspection is required which resulted in reduction in defectives.
- Similar work can be carried out for the service industry.
- Similar type of work is required to be carried out for other functions in the manufacturing industry

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