Lean Manufacturing: The Need of the Hour for the Forging Industries

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Lean Manufacturing: The Need of the Hour for the Forging Industries

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Abstract: Today's scenario is the convert from its traditional batch methods to lean manufacturing. Maintaining standardized conditions and procedures is key to achieving a world-class work environment. Here, the primary objective is to eliminate waste on the shop floor. In this paper specially focused on lean manufacturing by finding defects in forging during process and reducing rejection rate. Ultimately increase the productivity of the plant. Productivity improvement is the key to improve the profit of company as well to generate better and better working conditions for the operations working at shop floor. Thus improvement in system leads to good results for company. Also focus on "zero defect" concept. It can boost profits and improve customer satisfaction by reducing defects.
Keyword: Lean Manufacturing,Forging defects, Pareto method.

I. Introduction

- **What Is Lean Manufacturing?**

Ohno defined waste as "any human activity which absorbs resources but creates no value." Is called a waste [1].We have toreduce the scrap during the forging process. The execution of a lean manufacturing strategy represents a strong involvement to the phase that leads to operational advantage and the continuous development through the elimination of non-value- added activities. Therefore, lean operations contribute extensively to the manufacturing operational performance[2]. Develop of the forge manufacturing processes utilizing lean manufacturing techniques to optimize process efficiency, productivity and capability[3]. Key to achieving this will be the need to constantly challenge the status quo and introduce best practice[4].
Lean techniques have been founded and developed from the Japanese Toyota Production Systems. The unique idea of lean techniques is to do away with waste (or muda) or non-value-added activities in manufacturing process and reduce manufacturing cost. Manufacturing time can be saved this way.

- **Lean Manufacturing in Forging[5]:**

In order for the forging industry to attain a large market share and contend with their global counterparts, the industry necessarily has to improve efficiency while maintaining lower cost and best quality. In the past, the forging sector was considered as predominantly labor-intensive, but with ever-increasing globalization, it has become capital-intensive. However, superfluous capital investment will not be able to solve the difficulty entirely; in fact this equates to squandering away the cash flow in the long run. Hence, strategic management of technology should be considered and then decisions regarding investments should be made. In this direction, the execution of lean philosophy is strongly suggested, so as to identify the areas generating waste; thus, it further assists in the optimization of the working conditions with a minimal outlay of funds.Lean know-how has been successfully applied to several industries such as automobile, electronics and garment industries. For the forging industry, due to its demand for manufacturing process, quantity of orders and cost's associated, lean tools can be estimated to gain greater benefits if suitably planned and implemented.

- **5S-Process in forging[6]:**

1. Short
2. Simplify
3. Sweep
4. Standardize
5. Self-discipline

- **"Jeffrey Liker [i] lists seven wastes identified through Lean thinking[7]:**

1. **Overproduction:** manufacture of items not yet demanded, creating the need of storage and transport more often than necessary.
2. **Wait:** workers merely watching an automated machine or waiting for the next step of a process, requests for parts in delay, production bottlenecks, etc.
3. **Unnecessary transportation**: need of long distance moving of a product in process between one step and the other or between unnecessary steps.
4. **Over or incorrect processing**: unnecessary manufacturing steps: inefficient process due to poor tools and production design requiring

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unnecessary movements which may cause low quality. Wastes when excess quality demanded.

5. **Excess inventory:** excess of raw material, product in process or finished product, causing long delivery times, obsolescence, damaged items, storage and transportation cost.
6. **Unnecessary movements:** whatever movements made by workers, be it to search or reach for parts.
7. **Defects:** production of bad parts. Any kind of rework, loss of products, inspection, does not add value."

- **Defects**
- **Definition[8]:**

"The properties of a product that do not conform to the design specifications, which make the product less suitable or unsuitable for the purpose for which it has been designed".

- **Defects in Forging[9]:**

During forging operation defects may occur at any stage i.e. raw material (composition) or those formed during forging or post forging operations. These imperfections can be categorized differently as per their origin[11]:

1. **Material defects:** Occurs due to material composition.
2. **Rolling defects**: Caused during rolling process before actual forging.
3. **Imperfections due to die design:** Caused due to undesirable die geometry.
4. **Defects due to fabrication:** Occurs during forging operations.
5. **Defects due to trimming:** Occurs during trimming and deburring operations.
6. **Defects due to operator error:** Inappropriate handling of part /inappropriate setting/ unskilled worker.
7. **Heat treatment defects**: Defects occurred during heat treatment.

Rate of waste[9]:

Present rejection rate from 2.43% to 0.21% and rework from 6.63% to 2.15%. Pareto analysis was used to analyze the intensity of defects and it shows that 83.33% of the total rejection were due to un-filling and lap. Results indicated that the rejection rate is more than 5% and major defects include lapping, mismatch, scales, quench cracks, under filling.

How waste can reduce[9]:

Accordingly proposed remedial actions to reduce the rejection rate. These remedial actions includes; the proper use of anti-scale coating, venting process to prevent the under filling, the simulation software for determining the material flow, proper lubricant (Espon-lss) instead of furnace oil etc.

How it identify[9]:

Authors used Pareto principle for identifying major defects like Fins/Flash, Mould shifting, Crushing, Lower Surface finish, Shrinkage, Porosity, Cold shut and Extra material. Cause and Effect diagrams describes that the defects occur due to negligence of human workers during the manual casting operation and suggested that defects like shrinkage, porosity and cold shunt are due to inappropriate pouring system and temperature of pouring metal.

Defect found in CASE STUDY[9]:

Present study was conducted at XYZ Forging unit situated in Ludhiana. The forging capacity of unit is up to 7000 kg daily if it runs on its full efficiency. Total work distribution is divided into three departments (Tool room, production department and quality assurance department).

Defect Analysis:

To understand and assess the current situation of the organization, final dispatch inspection reports are collected from Quality control department. Collected reports are sorted according to product wise production for January and February 2014. Table 2 shows the detail reports with product wise production, quantity inspected and number of defects detected. Defect rate in January and February is 9.8% and 6.3% respectively. These defects include scaling, crack, cut mark and Unfilled. This data is prepared from final inspection reports; during Final inspection forging defects are considered. Pareto analysis shows that the major defects which contribute to 75% of defect rate are cracks and scaling. In January 2014, 82 % defects detected are scaling and cracks, where as in month of February 75% of the defects occurred are due to cracks and scaling. Scaling and cracks are already prioritized at 1st and 2nd position in priority list. Other defects i.e unfilled and cut mark stand at 6th and 8th position respectively. Pareto charts for month of Jan. and Feb. are shown in Fig. 4 and Fig. 5.

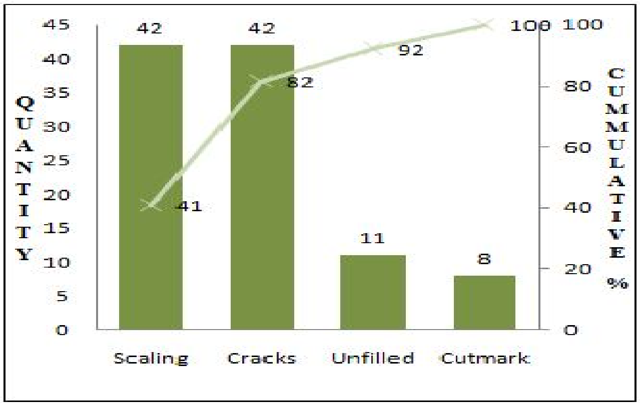

Fig [1]. **Pareto for Month of Jan.**

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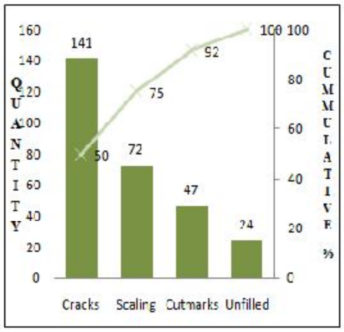

Fig [2].**Pareto for Month of Feb.**

II. OBSERVATIONS[9]

Under this phase, parameters recorded during the sampling phase are discussed. 400 samples are collected at each of the four different stages. The results obtained are shown in Table 4.

A total of 54 defects are detected during sampling. Major defects include cracks, scaling, burring and overlapping. Defect of burring is included in sampling because it affects the cracks during forging of product. Burring occurs during shearing of raw material.

At the second stage of inspection under which temperature of quenching medium is to be recorded. The observations were made at 30 minutes of interval during whole day of production and a Temperature Time graph is plotted which is shown in Fig. 6. It is observed during the inspection that the temperature lies in range of 36 0C to 45 0C (Refer Fig.6) But it is to be kept in between 400C to 500C. Quenching medium used is water. Lower temperature of quenching medium can result in cracks and does not produce required hardness. This temperature range is maintained manually by mixing cold water and hot water through flow control valves.

Pareto Analysis[9]:

Pareto chart for the collected samples is prepared, which shows that from the total 54 defects, major defects which contribute to 83% of the defects caused/observed are 29 cracks defects, 9 scaling defects and 7 low hardness defects. Majority of defects are due to cracks (53.7% defect rate) as shown in figure 7.

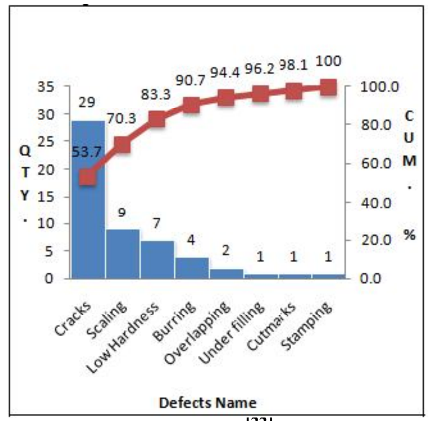

Fig [3].[22]

- **Cause and Effect Diagrams[9]:**

Bagchi suggested that statistical tools like cause and effect diagram can be used for problem solving and quality improvement [1]. Analysis of data through these tools focuses over identifying most promising factors causing defects and its strength lies in analyzing relationship in a structured way.

Various causes for major defects are identified using cause and effect diagram prepared using brainstorming and literature surveys. The reasons identified are then put into a cause and effect matrix so, as to identify common reasons for major defects. Cause and effect matrix is shown in Table 5

III. RESULTS AND DISCUSSION[9]

The study for detecting major defects occurred during the production of hand tools is done and the major defects contributing towards the defect rate are identified as cracks, scaling and low hardness. After collecting and analyzing the data, cause and effect diagram was drawn to identify causes of cracks, scaling and low hardness. The major causes of cracks are identified as improper quenching medium in use, insufficient quench delay, Temperature of quenching medium and temperature of forged product during quenching. After controlling the temperature range of forged product during quenching in a range of 900 0C to 950 0C and also the temperature range of quenching medium between 45 0C to 60 0C help in reducing the crack defects. It is also recommended to use mixture of polymers and water with 4% to 8% polymer in water as quenching medium instead of plain water to control this defect. Second major defect is identified as scaling and the major reasons behind this defect was identified as improper scale removal technique, insufficient lubrication, improper furnace oil or high temperature of heating furnace and chips or bubbles formed in forging die. Use of suitable lubricants of specified quality for the lubrication of dies and billet contact surface during forging operation or use of spray lubrication methods over the billet and forging die contact surface will allows the metal to flow more easily. Also, if the air blowers

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installed with the forging hammers are operated at proper speed and pressure will help in removing chips and bubbles formed in the forging die during forging operation.

Third major defect was identified as low hardness, Hardness range below 40HRC is not recommended. While controlling the defect of cracks and scaling when the temperature of product and quenching medium is maintained it affects the hardness of the product. More soaking time helps in eliminates the defect of cracks on the other hand contributed towards low hardness if this time is very high. If the temperature range of quenching medium is high it will give low hardness ranges but eliminates the chances of crack formation and vice versa. So, there is a serious need to achieve an optimum temperature range which could balance between all the parameters. This could be possible only with the help of Design of Experiments (DOE) or trough Finite Element Analysis (FEA).

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V. Conclusion

In this project, lean skills have been used to improve the manufacturing process of a forging line. Lean is said to be a journey rather than a destination. There will always be room for improvement. The workers need to ensure that there is no defect the first time they work on a part. Lean is a proven method of boosting the company’s profits. As above discussed as reduce the defects in forged parts by using Pareto method.

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