STUDY OF LEAN MANUFACTURING, FINDING ITS BARRIERS AND ITS RELATION TO QUALITY CONTROL: A CASE STUDY ON THE MANUFACTURING OF CRANKSHAFT FORGING

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Abstract: Lean manufacturing is one of the most accepted manufacturing technologies in industries. It is a management philosophy whose primary aim is to remove all kinds of wastes in a manufacturing process. This brings value to the process. Lean manufacturing means using raw material and available resources to its optimum level and thus obtaining greater and better output. Lean manufacturing was basically developed from the Toyota production system (TPS).It provides greater output and shorter production time. Not only in India but all over the world many industries have adopted lean manufacturing for making greater profits. Lean thinking has lot of tools which increases its efficiency and provides it with greater scope .Some of these tools are kaizen ,5S ,Kanban , JIT , Poka Yoke ,7QC ,SMED etc. Lean manufacturing aims at reducing rejection in production process which is one of the seven wastes. Thus by reducing wastes it brings quality to the process. Thus Lean manufacturing and quality control are somewhat related. In this research paper various barriers to the lean manufacturing during the production process and relation between Lean manufacturing and Quality control is found.

I. INTRODUCTION

Lean manufacturing is a method having a set of tools and techniques for removal of all types of wastes in production process. Lean thinking aims on making things which add value by removing other useless things. Lean manufacturing is basically a management philosophy derived mostly from Toyota Production system (TPS).The goals of lean manufacturing are increased output, lower production times and shorter lead times.[2]

II. WASTES IN INDUSTRY

Waste is anything that add price to the end product without adding any value. There are two categories of wastes

- One which can be calculated like machine breakdown and production setup time.
- Second which are not calculated like improper working environment, improper transportation of machine, papers in management work etc.

So, to detect and remove these wastes in any industry Lean manufacturing is used.

Mainly there are seven kinds of wastes. These are described below

- Over production- Production of a good more than demand and need.
- Rejection-Product as not per requirement is rejected
- Unnecessary movement- Unnecessary movement of parts during production.
- Inventory-Stocks of parts waiting to be transported.
- Unnecessary motion-Useless movement of the workers on the shop floor is considered as a waste.
- Work in process (WIP)-It is basically product in production line and are still to be finished.
- Waiting time-Useless waiting to begin the next step is termed waiting time.[8]

Fig.1.Categories of Waste

III. LEAN PRACTICES AND TOOLS

A. Total quality management (TQM)

It is a philosophy which says serving customer as if they are served first time.[2]

B. 7 quality control (QC)

They are used in most industries to solve the problems. They are divided into four stages:-

1. Identifying the problem.
2. Development of planning.
3. Making action plans.
4. Continuous improvements. [1]

C. Just in Time (JIT)

It emphasizes everything is done when they are actually needed. [1]

TABLE-1

Group category	Lean tools
Process and equipment	Kaizen Equipment layout 5S Product Design Setup time reduction Error proof equipment Continuous flow Preventive maintenance
Manufacturing planning & control	Leveled production Small lot size Kanban ,Daily schedule planning

Human resources	Group problem solving, Training, Team work management.
Supplier relationships	JIT delivery, Quality management for product supplied, supplier involvement in quality improvement.
Customer relationship	Customer involvement in quality program, customer involvement in product design, JIT link

D. Poka Yoke

It is a Japanese method whose main motive is Mistake proofing. [3]

E. Kaizen

Kaizen means small continuous improvements. It is dependent on PDCA cycle also known as Deming's cycle. This philosophy is given by Japan. [8]

Fig.2.PDCA or Deming's cycle [1]

F. 5S's

Following 5 elements are fundamental of 5S.

1. SERI- Finding and removing of unwanted items.
2. SEITION- To organize
3. SEISO-To clean
4. SEIKETSU-To standardize
5. SHITSHUKE-Maintain discipline [1]

G. Kanban

It is a system to control logistic chain. It is a inventory control system. It was given by Taiichi ohno .He is industrial engineer at Toyota. [5]

IV. RELATION BETWEEN LEAN MANUFACTURING AND QUALITY CONTROL

Lean manufacturing is set of principles which have specified tools and techniques aimed at removing wastes to production process thereby bringing quality to the product, thus Lean manufacturing and Quality control are correlated. Lean principles are aimed to add value to the process by removing useless wastes of production. The result of this is good quality product with fast production involving comparative less labour , raw material etc. In this research paper rejection of various forgings are analysed for 10 days period.

V. QUALITY INSPECTION IN MANUFACTURING INDUSTRY

Quality inspection is basically one of the trait of Quality Control .It is concerned with checking measurements of product, alignment, defects which can occur in the product etc

Basically quality inspection process can be divided into two parts

Process Inspection

Quality Inspection involved when manufacturing is in process

After Process Inspection

Quality inspection involved when product is being manufactured and then needed to go for other processes like Heat treatment etc. The defected jobs found during this process are sent for reworking and after it they are again quality inspected and sent to heat treatment.

Final Inspection

Quality inspection involved after all the jobs made and heat treated. After this process they will be dispatched.

VI. INTRODUCTION TO FORGING TECHNOLOGY

Forging is a metal working process involving metal shaping through compressive forces with the help of hammer or dies. Earlier Forging operation was performed with the help of hammer and Anvil. Forging process is most ancient metal working process from 4000 BC. Typical forging products are bolts, rivets, connecting rods, Gears etc.

THE FORGING PROCESS

- Heated metal is placed on a mold and pressure is applied to metal with the help of a press or hammer and due to this impact metal
- conforms the shape of die shape cavity. This is possible due to malleability in the metal.
- Extreme pressure is produced when dies are closed. The seam of dies and punch act as relief valve. Once the metal object is shaped metal , flash is removed.
- Use of oil or a proper lubricant during the forging process helps to prevent sticking of job to the dies. It acts as a thermal insulator and help in avoiding wear and tear on the dies.
- The forgings have uniform shape and do not have any voids, inclusions, or defects etc. This helps in later operations like finishing and coating, and surface preparation is minimized.
- Parts that are produced by this method have high strength to weight ratio. This makes them appropriate for use in automobiles and aircraft.
- It offers low cost from moderate to long runs.

DIFFERENT TYPE OF FORGING PROCESS

Open die forging or Hand forging

It is similar to traditional forging process used by Blacksmith. In this forgings are made with the help of repeated blows in an open die. Here the skill of operator is very important as he manipulates the forging in an open die.

Impression Die Forging or Closed die forging

The workpiece takes the shape of the die cavities after being forged.

Upset Forging

Upset forging increases the diameter of work piece by reducing its length through compressive forces. This process is used to make head on valves , bolts and fasteners. [14]

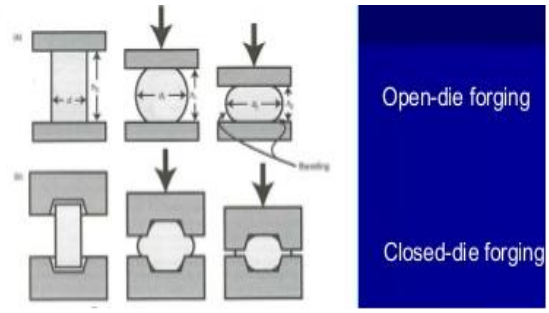


Figure 1. Open die forging and Closed die forging

CHARACTERISTICS OF FORGING

Usually involves discrete parts, they can be performed on cold as well as hot materials, Often requires additional finishing operations example heat treatment, cleaning, grinding , machining etc. They can be done on fast as well as slow deformation rates, may be used for small as well as very large parts and improves the flow properties of a part by controlling and refining flow or grain of a material.

GRAIN STRUCTURE

- Parts have good strength.
- High toughness

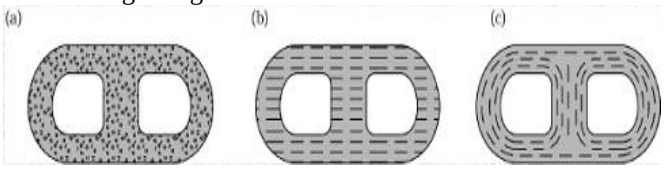


Fig: A Job made by three different methods, showing grain flow (a) casting (b) machining (c) forging

FORGING DEFECTS

When a forge shop starts facing problems in quality of product formed it should find out the problem , reason for its occurrence and take remedial action .After this, it should be ensured that the problem will not reoccur during production.

Surface Cracking

Reason: Excessive working on the surface and too low temperature

Solution: To increase the work temperature

Folds or Cold Shut:

Two surfaces of metal fold against each other without combining completely.

Reason: Sharp corner (less fillet) , excessive chilling, and high friction.

Solution : Increase fillet radius on the die.

Residual stresses in forging:

Reason: Inhomogeneous deformation of forging and improper cooling of forging.

Solution: Slow cooling of forging and under ash cover over a period of time.

Unfilling in job

Some portion of the die is not completely filled by the flowing material which resulted in unfilling in job.

Reason: Improper design of forging die , less raw material ,poor heating, scale pit got stuck in the die during forging.

Solution: Proper designing of die , proper raw material ,proper heating and asking worker on machine to clean the die by removing scale pit and properly blowing the air.

Cracks in the flash

The crack penetrates into interior after the flash is trimmed off.

Reason: Very thin flash

Solution: Increasing flash thickness , relocating the flash to less critical portion of the forging , hot trimming and stress relieving.

Mismatch:

Misalignment of upper portion and lower portion of job.

Reason : Misalignment of the die halves.

Solution: Aligning the two dies by providing proper notches on each halves so that during production alignment occurs and they match with each other.

Incomplete Forging Penetration

In this defect dendritic ingot structure in the interior of forging is not affected, actually it should be broken to give uniform grain structure. In this case actually forging takes place only at the surface.

Reason: Use of Light Hammer blows.

Solution: Using forging press for full penetration.

Improper grain flow:

Reason: Improper die design which causes improper flow of material.

Solution: Properly designing the die.

Scale pits:

Pits of irregular shape on the surface of forging.

Reason: Improper blowing of air during forging, improper cleaning of material used for forging.

Solution: Blowing air properly during forging and proper cleaning of material before forging.

Flakes:

These are internal fractures in the forging.

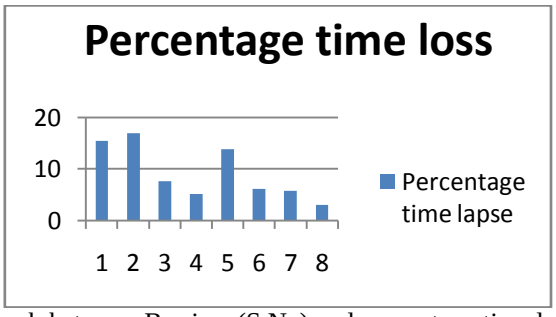
Reason : Rapid cooling of forging which causes temperature difference in its surface. Outer surface is cool and inner surface is hot causing cracks in it.

Solution : Follow proper cooling practice.[11]

VII. RESEARCH METHODOLOGY

A research has been done in which timings of various operations during production have been recorded. From these timings the reasons are found for a late operation .These reasons are basically barriers in lean production. The whole research was done in a Small Manufacturing Industry which makes forgings used in automobiles. The jobs for which the readings were taken are two crankshafts and a fishplate which were forged on 1.5 ton, 3ton and 1.25 ton hammers. The whole research is conducted during the timings in which raw material came for production and First job which is qualitatively correct is made. From the data Barriers to the process of production was found then percentage time loss and probability of occurrence of each barrier was calculated.

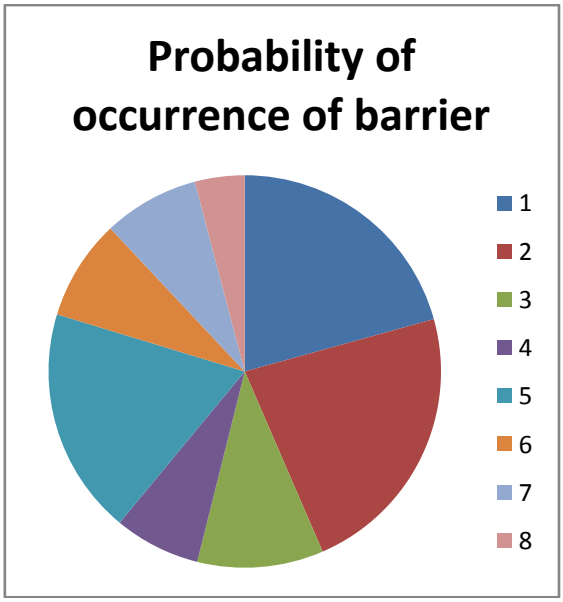
After this rank is allotted to each barrier. Graphs are plotted for probability and percentage loss. Then, Rejection data for 10 days Crankshaft Sk is analyzed and total rejection percentage is found for 10 days when Lean manufacturing is implemented.



Graph between Barriers (S.No) and percentage time loss

TABLE-2

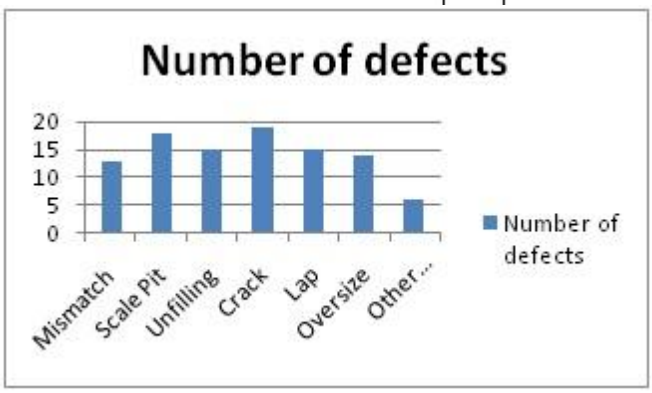
S.No	Barrier to process of production	Time in hours	Percentage time loss	Probability of occurrence of barrier	Rank
1	Lack of planning	0.5	15.38	0.207	2
2	Lack of Human Resource Development	0.55	16.92	0.228	1
3	Lack of methodology	0.25	7.69	0.104	4
4	Lack of quality inspection techniqueand staff	0.17	5.23	0.071	7
5	High cost of advance technology	0.45	13.84	0.187	3
6	Lack of organizational structure	0.20	6.15	0.083	5
7	Lack of activeness	0.19	5.84	0.079	6
8	Social factor	0.10	3.07	0.014	8



Graph between Probability of occurrence and Barriers (S.No)

TABLE 3: Rejection data of Crankshaft Sk

Days	Mismatch	Scale pit	Unfilling	Crack	Lap	Oversize	Other reasons
1	3	2	4	2	1	2	1
2	1	1	1	1	2	3	0
3	1	1	0	2	2	3	0
4	0	3	0	2	1	1	0
5	4	0	0	1	1	0	1
6	1	2	2	0	1	2	2
7	0	4	1	5	2	1	0
8	1	1	6	1	2	0	0
9	2	3	1	2	1	0	2
10	0	1	0	3	2	2	0
Total	13	18	15	19	15	14	6



Graph of various defects and their occurrence in number.

Observation of Rejection for 10 days

% Rejection in 10 Days = (100/2000)*100= 5%

% Successfully Quality controlled

Production in 10 days = 95%

VIII. CONCLUSION

Mainly 8 barriers are found during production process is implemented. These are stated in table 2.

Rejection percentage is found 5% when lean manufacturing is implemented.

IX. LITERATURE REVIEW

1. Hines p. & Taylor D. (2000) Lean production method was pioneered by Toyota in Japan. Lean thinking gives its approach in five principles and how the concept can be extended to any industry, in any sector or in any country. [3]

2. Hines P., Holweg M. & Rich N. (2004) For successful lean thinking implementation we have to remove many barriers in its path which will help in improving the performance of the organization.[4]

3. Bhasin S. & Bucher P (2006) Lean manufacturing is a technique to increase the productivity of a firm by eliminating wastes. It was stated that tools for any organization to apply lean manufacturing for any organization is Kanban, TPM, value and seven wastes [5].

4. Chandnaand Chandra (2009) This research work focuses on forging analysis of a six cylinder crankshaft manufactured by TATA motors, Jamshedpur INDIA. The f analysis found

how the defects occur and how to remove them. Analysis was done by various Quality tools such as Pareto analysis, Cause and Effect diagram and Brainstorming session of workers .[14]

5. Esfondyari Alireza & Osman M.R (2011) .They identified some of the barriers in any industry for lean implementation. They suggested that role of management is very important in implementing lean thinking. [6]

6. Nordin N. & Deros B. (2013) Lean thinking implementation requires efforts so the barriers in its path should be removed. These efforts are systematic and continuous in nature. [7]

7. Christry Mathew et. al (2013) The research is focused on analyzing the forging process of an integral axle ,In this analysis it is found defects occur and how to prevent.[13]

8. M.G. Rathi, N.A. Jakhade , et al (2014) The research work describes the forging defects along with cause and remedies.The fish bone diagram describes the possible cause of defect.[11]

9. M.Sekhon , Dr. G.Brar , et.al (2014) The author studied various forging defects occurring in industry using six sigma and 7 quality control tools. The major defects found are cracks , scaling and low hardness and appropriate remedy is found.[9]

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