Enhancement in Quality in Manufacturing by DMAIC Method in Small Scale Industry: A Case Study.

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Abstract- The purpose of this paper is to develop a Lean Six Sigma framework according to the Six Sigma systemic process improvement methodology; Define, Measure, Analyze, Improve and Control (DMAIC).The quality of castings in green sand mould is influenced by its properties such as green compression strength, green shear strength, permeability etc. The relations of these properties with the input parameters like sand grains size, shape, binder, clay are complex in nature. Binders play a vital role on green sand mould to enhance specific mould properties. The mould properties such as compression strength, permeability, hardness & shear strength have been studied & comparison have made with different binders. Foundry sand control can only by testing of all the raw materials; sands, binders, and additives prior to the preparation of the sand mix. Sands found in different locations can have wide variations in surface, physical, and chemical characteristics due to environmental, ecological, climatic and geological factors. Different sands have different foundry properties.

Index Terms- six sigma techniques, six sigma goals, Motorola Bill Smith, reduction of manufacturing defects.

I. INTRODUCTION

Six Sigma is a collection of methods, techniques and tools for process improvement and solve them effectively. Today, the principles are widely adopted across industry sectors, and in recent years the Six Sigma ideas have merged with the Lean manufacturing methodology, naming it Lean Six Sigma. The Lean Six Sigma methodology aim to support the business and operational excellence by focusing on variation, design, waste issues and process flows. Companies such as Motorola, General Electric, Verizon, and IBM uses Lean Six Sigma as a growth strategy to rethink and transform themselves through efficiency - from organizational setup to manufacturing, software development to sales and distribution, and finally for service delivery functions. The Six Sigma process includes measurement, improvement and validation activities.

II. DEFINATION OF SIX SIGMA

Six Sigma can be defined as "A business process that allows by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction"

III. SIX SIGMA PROCESS MODEL

We had implemented and verified a six sigma process at one engineering company in Kolhapur, Maharashtra, India. The originality of this methodology was evident in integrating and using tools related to lean-production, six-sigma, simulation and cost benefit analysis. The process of six sigma consists of five steps namely Define (D), Measure (M), Analyse (A), Improve (I) and Control (C).

1. Define:

The primary aim is to identify, within each sub-process, the possibilities for defects or quality problems which can be arrived at through the use of different statistical tools, such as regression analysis, design of experiments and chi-square testing. The quality problem which requires break-through solution has to be defined clearly in measurable terms. During the define phase a component by name "Cover sealed" was identified to have potential for overcoming many defects. Subsequently necessary data were gathered and supplier input process output and customer (SIPOC) chart as shown in fig. was developed.

Supplier	Chougule Industries
Input	Cover sealed
Process steps	Receive order Turning outer diameter Boring Inner diameter Plan delivery
Output	Machined component dispatch for assembly
Customer	Mahindra and Mahindra

2. Measure:
The second most important step is the establishment of the metrics that will be improved using Six Sigma. It is also necessary to identify and rank the improvement opportunities. First the CTQ (Critical To Quality) characteristics of the process have to be identified in order to focus six sigma on areas that will have the greatest impact on customer satisfaction.

3. Analysis:
This is the stage at which new goals are set, and the route maps created for closing the gap between current and target performance levels. It begins with bench marking key product performance against the best-in-class so that the sigma levels attained be comparable processes can be ascertained as the basis for new targets.

4. Improvement:

Improve the process performance by eliminate root cause of variation. Develop creative plans and implement the plan.
If the existing quality level is < 3 sigma, efforts must be directed to improve the processes so as to achieve at least 3 sigma.

5. Control:
The final stage of Six Sigma implementation is to hold the gains that have been obtained from the improve stage. Unless there is a good control we are likely to go back to the original state. Hence, in this stage the new process conditions are documented, and frozen into systems so that the gains are permanent. In order to ensure aspects a separate inspection room is to be created in which NDT facilities are installed and castings are continuously inspected.

Methodology:

The framework allows the user identify the process problem and solve them effectively. Methodology of six sigma implementation is as follows:

1. Check Sheet:
The check sheet is a simple document that is used for collecting data in real-time and at the location where the data is generated .The document is typically a blank form that is designed for the quick, easy, and efficient recording of the desired information, which can be either quantitative or qualitative. Rejection check sheets are generally large data sheets showing the total information about rejected items. Following is the six month data of production per month. Rejection of cover sealed is given in table

Month	Rejection	Batch of Production per Month
Jan.	**94**	**812**
Feb.	**268**	**2079**
March	**297**	**2269**

Overall percentage of rejection has been found as below:

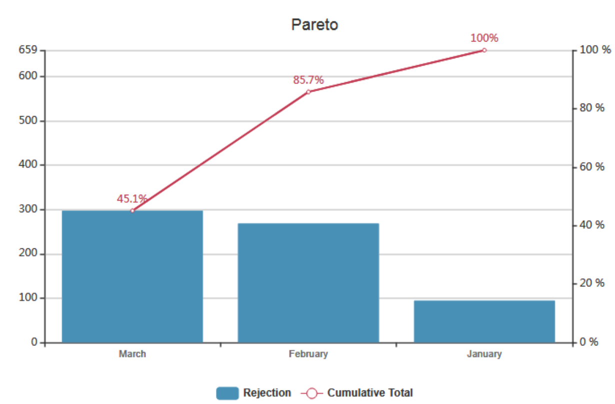
Total production of parts in three months= 5160

Total rejected pieces due to blow holes= 659

Overall rejection percentage= 659/5160*100=12.77%.

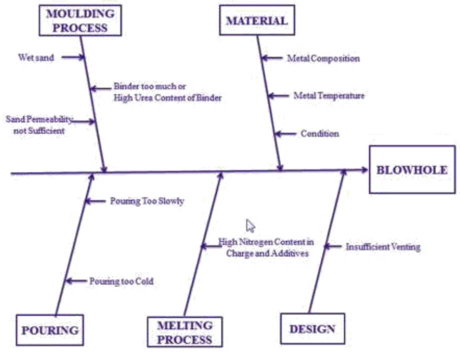
It is clear that overall rejection is very high. So it is very necessary to reduce the rejection.

2. Pareto Chart:



Using Pareto chart we can conclude that 80% of rejection occurs in month of March and February due to blowhole

3. Cause and Effect diagram:
Cause and Effect diagram for blowhole has been drawn and causes have been studied as below:



4.Cause and Effect Matrix:

The five categories like moulding process, material, pouring, melting process and design are used in diagram. The brainstorming was held for finding different causes behind the blowhole defect and identifying the main causes those are responsible for the damage. It consists of group of members working in foundry. There are members in brainstorming session from different foundry departments which include Lab In charge, Quality manager, Furnace supervisor, Worker. We started with cause and effect analysis to find generalized reasons for blowhole defect.


Blow Hole Defect

Process Indicator	Output
Wet sand	9
Sand permeability not sufficient	8
Too much binder	5
Metal composition	5
Metal temperature	5
Workpiece condition	5
Pouring too slow	5
Pouring too cold	5
High nitrogen contain in charge and additives	5
Insufficient venting	8

After that Brain storming Sessions were conducted with Key members of industries from where root causes for the problem was taken out for further analysis. So some factors responsible for blowholes are:

- Wet sand
- Sand permeability is not sufficient
- Insufficient venting
- Too much binder

5. Sand Control Test:

A] Moisture Testing: The development of bond strength between the grains depends upon on the hydration of clay. The green strength and permeability of a moulding mixture increases with water content up to an optimum value determined by the proportion of clay. Water content in the mixture of 1.5% to 8%, activates the clay in the sand, causes the aggregate to develop plasticity and mold strength. Without water addition, no strength would be achieved, as the sand and clay would be just two different dry materials Too little water fails to develop adequate strength and plasticity where sands and clays grains are combined together apart thus the permeability is very poor.

SOP for MOISTURE TESTING:

- Take 140 gm mould sand in weight pan.
- Take mixture of mould sand in rapid moisture tester and clamp properly.
- After clamping ram the sand for 3 times.
- After ramming the sand take reading of moisture % on tester dial.
- Required % of moisture is 3.0-4.0 %.

B] Permeability Testing: Permeability is the physical property of molded sand, which allows the gases to pass through it. It is determined by measuring the rate of flow of air (2000 cm3) through the metric standard rammed specimen (Ø50 mm×50 mm in height) under a standard pressure (10 g/cm2). The amount of clay and moisture content has a significant role in improving the strength and permeability of green sand mould and it should be controlled to get defect free castings.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

SOP for CHECKING PERMEABILITY:

- Take 140 gm moulding sand.
- Fill the specimen tube with sand.
- Compact the sand with three blows of sand rammer.
- Place the rammed sand sample and tube in test position permeability.\
- Take reading on pressure manometer and compare with conversion table.
- Required permeability is 102-140.

6. Description:

Various factors responsible for occurring Blow hole such as Pouring, Molding process, Solidification, Melting process,

1.Design: This is one of major cause for occurring blow hole.If the design of pattern is incorrect then it leads to blow hole and also if the design of getting, runner, riser system is wrong then it leads to blow hole.

2. Molding Process: Various sand parameters such as permeability, compatibility, grain size and shape, percentage of binder is high or low then it leads to blow hole.

3. Melting Process: During melting of metal if the content of nitrogen & CO gas is excess then it leads to blow hole.

4. Pouring: During poring of molten metal there is chances of trapping of air due to pressure. Due to this air gets trapped and there is no chance to escape the trapped air. So pouring should be done in proper manner.

5. Solidification: If there is insufficient height for runner and riser then it leads to blow hole. The molten metal get chance to solidify early which cannot fill the cavity which leads to blow hole.

7. Solutions:

Increase gas permeability of sand: Coarser sand have higher permeability.

Incorporate good fluxing and melting practices: Melt metal in vacuum.

Increase rate of solidification by reducing metal temperature during casting.

Dry out moulds and cores before use and store dry.

8. Result Analysis:

The root factors for blow holes defects are high moisture percentage and low permeability. The industry was using 100% of reuse sand. Therefore to reduce the blow holes defects it is necessary to increase the percentage of new silica sand to reduce the moisture percentage and adding the permeability. So according to this results are obtain which are repreesented in below chart:

Before increasing the percentage of silica sand moisture percentage and permeability are as:

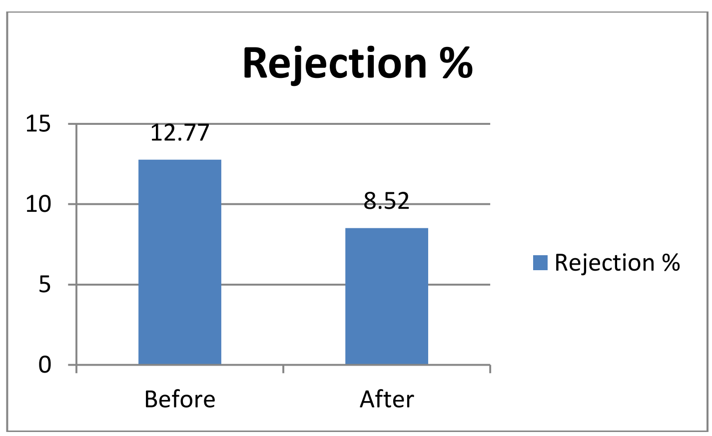
Pattern Name	Moisture %	Permeability
Cover Sealed	**4.20%**	**102**

After increasing the percentage of silica sand moisture percentage and permeability are as:

Pattern Name	Moisture %	Permeability
Cover Sealed	**3.30%**	**115**

After implementation of this improvement, the data of company was collected again. The table given below shows the data collection after improvement.

Month	Rejection	Batch of Production per Month
April	**23**	**409**
May	**126**	**1034**
June	**61**	**1021**



IV.CONCLUSION

A six sigma is very powerful quality improvement tool but they will only work if they are implemented appropriately. The key strategy for successful implementation of Six Sigma is that the industry applying it should follow a correct methodology and use the correct tools and techniques.

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