DETERMINATION AND CORRECTION OF SAND CASTING DEFECT: BY IMPLEMENTATION OF DMAIC TOOL OF SIX SIGMA

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ABSTRACT

The present paper deals with the reduction of rejection due to casting defects in a foundry industry. The industry is making cast iron castings of submersible pumps components such as Upper housing, Motor Pulley, Mini Chaff cutter wheel in large scale and having rejection in the form of slag inclusions .The three important part of industry were chosen for complete analysis.The improvement in these defects can be done by the application of DMAIC approach. The study was done at HARYANA(India) on application of Six Sigma methodology and Selection of tools and techniques for problem solving, because of its high rejection rate.

Keywords: Reduction, Defects,Casting,Housing,Mini Chaff, Blow hole,Misruns,Analysis

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INTRODUCTION

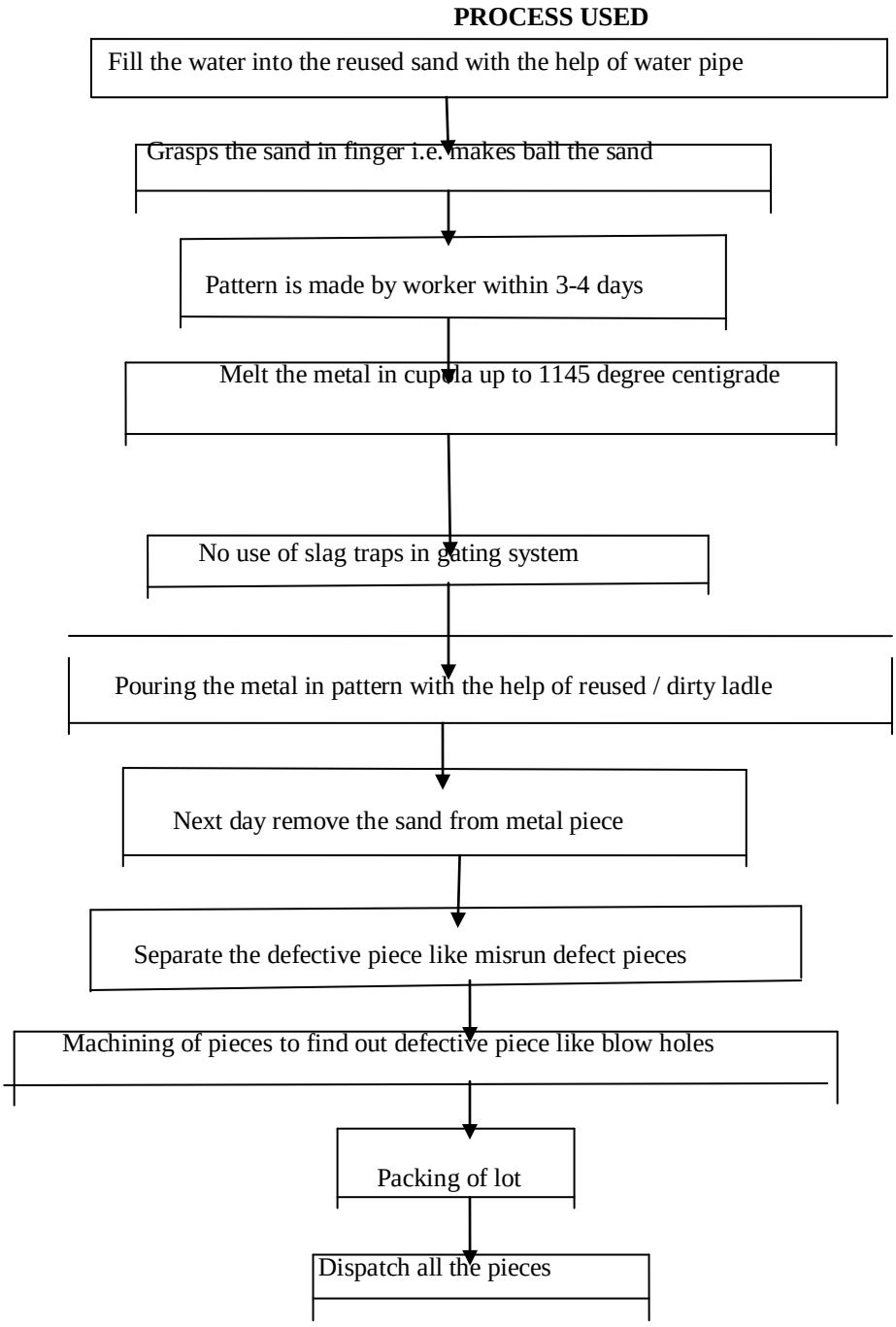
DMAIC refers to a data-driven improvement cycle used for improving; optimizing and stabilizing business processes.The DMAIC technique is an overall strategy to accelerate improvements in its processes, products and services. This approach is a project driven management approach to improve the organization products, services and processes by continually reducing defects in the organization. It is a powerful improvement business strategy that enables companies to use simple and statistical methods for achieving and sustaining operational excellence. DMAIC approach differs from other quality programs in its top down drive in its rigorous methodology that demands detailed analysis fact based decisions. It is a rigorous data driven method for dealing with defects, waste and quality problems, in manufacturing, services and other business activities. This approach is an upcoming quality improvement process and is proving to be a powerful tool for solving complex problems. It would not work well without full commitment from upper management .It is a scientific method to improve any aspect of a business, organization process. Six sigma is an overall strategy to accelerate improvements in its processes, products and services. It is also a measurement of total quality to let the company know how effective it is in eliminating defects and variations from its processes. It encompasses tools from all improvement initiatives, including those in operational, technical and customer excellence. It just applies to every function in the company, not just the factory floor. Six sigma is a quality improvement programme with a goal to reduce the number of defects. The goal of a six sigma quality programme is to improve customer satisfaction through reducing and eliminating defects and to continuously improve processes thereby improving quality and productivity.Six sigma is more than a quantitative statistical measure of processes; it embraces every aspect of work, using a disciplined, fact based approach to problem-solving. It is a new way of thinking about work and customer value. It is also a powerful force to create one corporate culture, some of it is bureaucracy busting-pushing down decision-making to lowest practical levels, empowering employees.

METHODLOGY

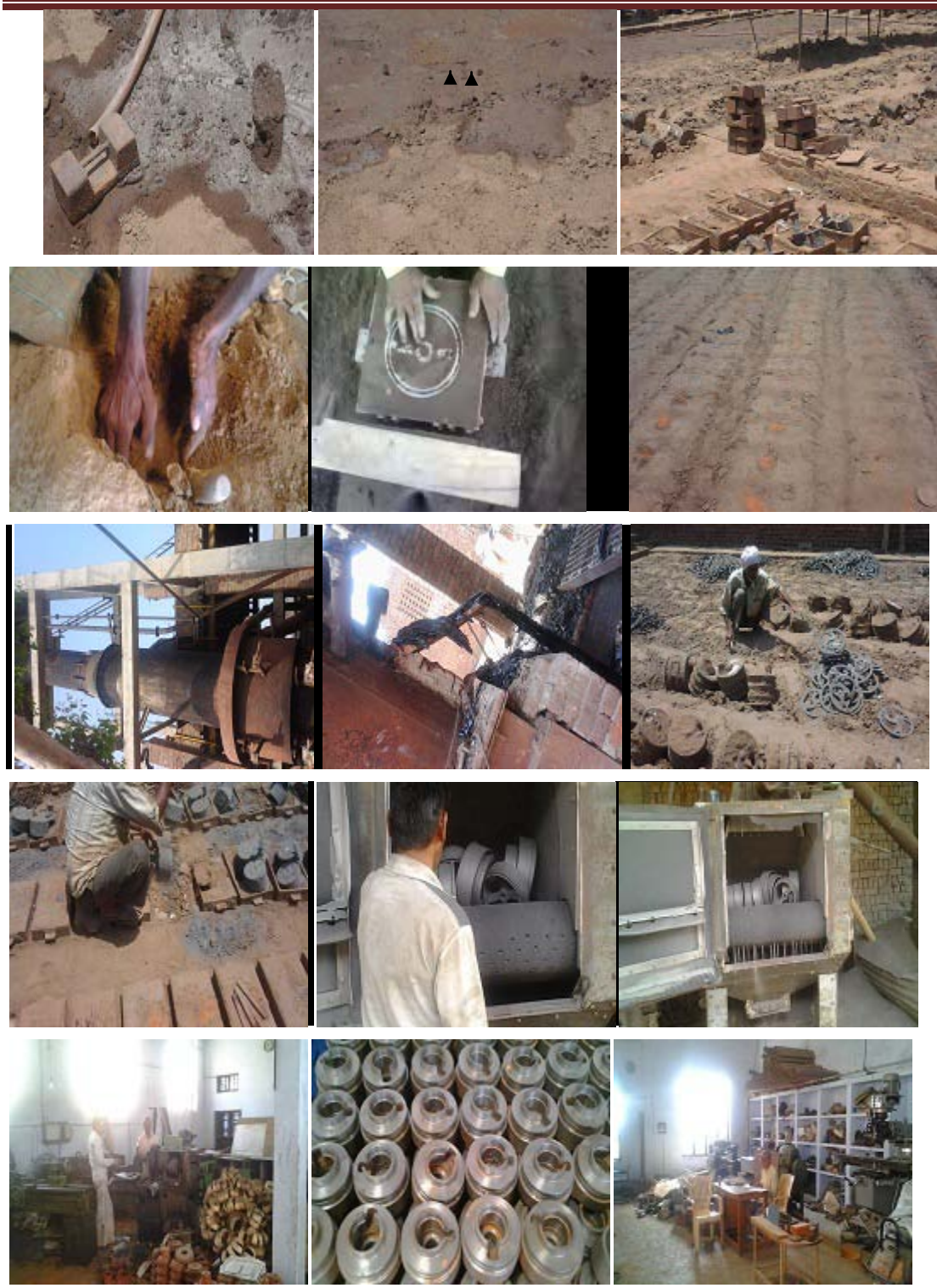
In this process, a pattern is made in the shape of the desired part. The pattern can be made of wood, plastic, or metal. Simple sand castings can be made in a single or solid pattern. More complex designs are made in two parts, called split patterns. The pattern is then packed into sand, mixed with a binder and removed, leaving a hollow space in the sand in the shape of the desired part called mould.The pouring temperature of the material should be a few hundred degrees higher than the melting point of the material to assure good fluidity, thereby avoiding premature cooling, which can create voids and porosity. The mixture of sand and clay is moistened with water to develop strength and plasticity of the clay to make the aggregate suitable for molding. The term Sand Casting can also refer to a casting produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 75% of all metal castings are produced via a sand casting process. In modern foundries, green sand molding method is widely used for small size automotive castings. It is the least expensive method and gives optimum quality due to low cost of sand and its ingredients and its reusability for further production.Sand casting process is shown in A solid shape of the required object is made (known as the pattern). Sand is then rammed around the pattern in a ‘Moulding box’. When the pattern is removed it leaves a shaped cavity behind. The runners (where the fluid is

poured in) and risers (where excess fluid can escape) also act as reservoirs of liquid to top up the casting as the metal contracts on cooling. The process can be used to make hollow castings. To do this, 'cores' are inserted into moulds to produce shapes that would be difficult or impossible to make by just using a pattern.The mould is destroyed when the solid casting is removed. The surfaces of the castings produced by this method tend to be rather rough, even though quite fine-grained sand is used for the moulds. So some machining of the surface is generally required before a finished product is made. The runners and risers need to be removed.

Picture of the Sand-Casting Process



Flow chart before improvement of ABC industries



Picture of process mapping before improvement

MEASUREMENT PHASE FOR SLAG INCLUSION:

Collect the data for slag inclusion of four month, which are given below.

Data collection (before improvement) – UPPER HOUSING

Month	Production pieces	Rejection Pieces	Slag inclusion defects
Sep. 2011	510	98	39
Oct.2011	505	96	37
Nov.2011	514	101	40
Dec. 2011	508	99	41
Total	2037	394	157

Total production of four month = 2037,

Total rejection of slag inclusion = 157,

pieces % of rejection = 157/ 2037 = 0.0771 x 100 = 7.71%

Data collection (before improvement) – MOTOR PULLEY

Month	Production pieces	Rejection Pieces	Slag inclusion defects
Sep.2011	5004	828	344
Oct. 2011	5007	831	335
Nov.2011	5003	825	331
Dec.2011	5009	829	340
Total	20023	3313	1350

Total production of four month = 4017,

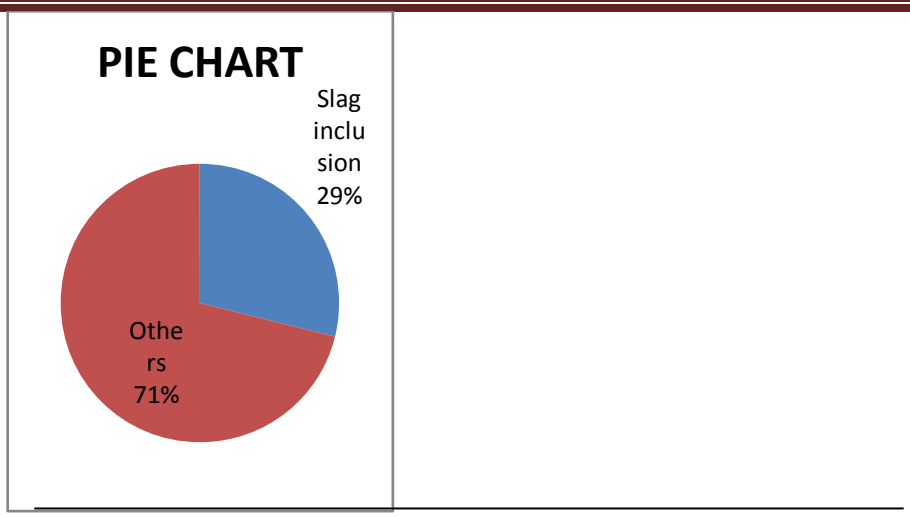
Total rejection of slag inclusion = 250 pieces % of rejection = 250/ 4017 = 0.0622 x 100 = 6.22

Data collection (before improvement) – Mini Chaff Cutter Wheel

Total production of four month = 20023, Total rejection of slag inclusion = 1350 pieces % of rejection = 1350/ 20023 = 0.0674 x 100 = 6.74%

Total rejection data

Defects	No. of defective pieces	Percentage of rejection
Slag inclusion	1506	1506/26077= 0.0577 x 100=5.77%



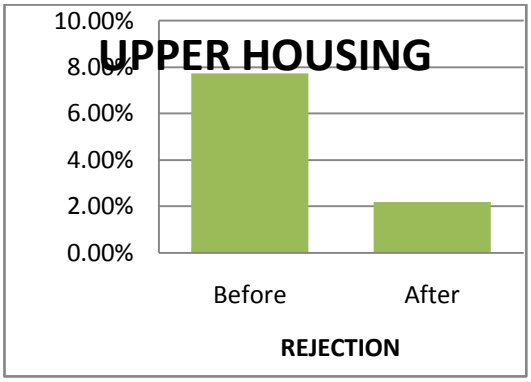
Pie chart for Slag inclusion defects

Data collection (after improvement) – Upper Housing

Month	Production pieces	Rejection Pieces	Slag inclusion defects
Feb.2012	503	30	11
March 2012	507	33	10
April 2012	504	31	11
May 2012	512	35	12
Total	2026	129	44

IMPROVE PHASE FOR SLAG INCLUSION:

Improvement in slag defects: The root factors for slag defects were rough ladle lining and skimming metal. Therefore to reduce the slag inclusion defect some new material has been added which was not used by the company before applying technique. Slag traps is used in gating system. By using clean ladle. After implementation of these improvements, the data of the company was collected again.

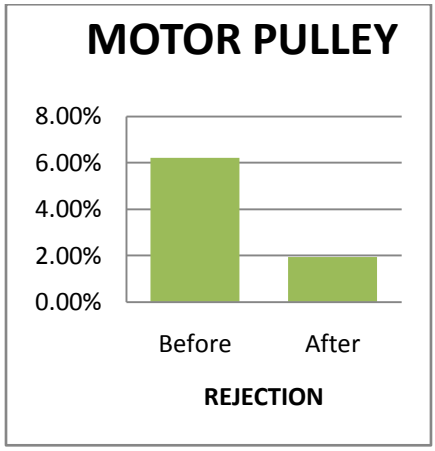


Bar chart for upper housing

Total production of six month = 2026, Total rejection of slag inclusion =44, pieces % of rejection =44 / 2026 = 0.0217 x 100 = 2.17%

Data collection (after improvement) – Motor Pulley

Total production of four month 4031, Total rejection of slag inclusion =78, pieces % of rejection =78 / 4031 = 0.0194 x 100 = 1.94%

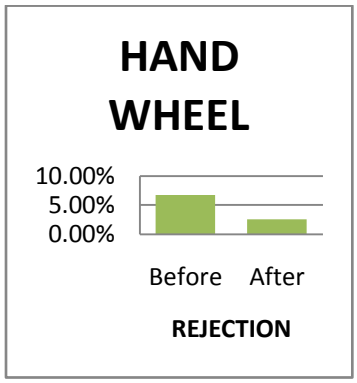


Bar chart for Motor pulley

Month	Production pieces	Rejection Pieces	Slag inclusion defects
Feb.2012	1010	56	19
March 2012	1013	59	21
April 2012	1006	58	20
May 2012	1002	55	18
Total	4031	228	78

Data collection (after improvement) – Mini Chaff cutter wheel / Hand wheel

Total production of four month = 20034, Total rejection of slag inclusion =509, pieces % of rejection = 509/ 20034= 0.0254 x 100 =2.54%



Bar chart for Hand wheel /Mini Chaff cutter wheel

Month	Production pieces	Rejection Pieces	Slag inclusion defects
Feb.2012	5012	303	136
March 2012	5005	299	124
April 2012	5009	302	126
May 2012	5008	303	123
Total	20034	1207	509

Total rejection data (After improvement)

Defects	Before improvement	After improvement
Slag inclusion	5.77%	2.41%

Improvements in rejection

Bar chart for Slag inclusion defects

Defects	No. of defective pieces	Percentage of rejection
Slag inclusion	631	1122/26091= 0.0241 x 100=2.41%

So after the complete analysis it was found that rejection due to slag inclusion defects has been reduced.

CONTROL PHASE FOR SLAG INCLUSION:

After the study of slag inclusion in foundry unit the following recommendations are made to control the reduction of slag inclusion defects of submersible pumps parts. Control the inclusion slag traps is used in gating system. The ladle may be cleaned after every casting

Overall analysis of Misrun after applying DMAIC process

Month	Type of defects	Number of defect	Percentage of defect	Factor	Result	Suggestions
Feb-May(2012)	Slag inclusion	631	2.41 %	1.Clean ladle 2.Slag traps	Moderate satisfaction	1.Use clean ladle after casting 2.Always use slag traps in gating system

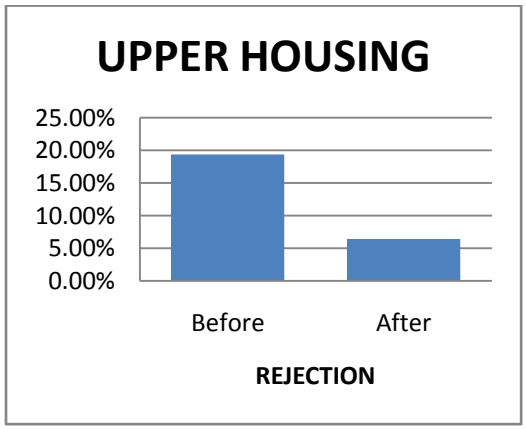
If the above recommendation are implemented the major slag inclusion defects are likely to be reduced.

Picture of clean ladle after casting

COMPLETE DATA OF ALL PRODUCTS:

Improvement of all component & defects are given below. To clear understand point of view.

Data collection (after improvement) – Upper Housing



Bar chart for Upper housing

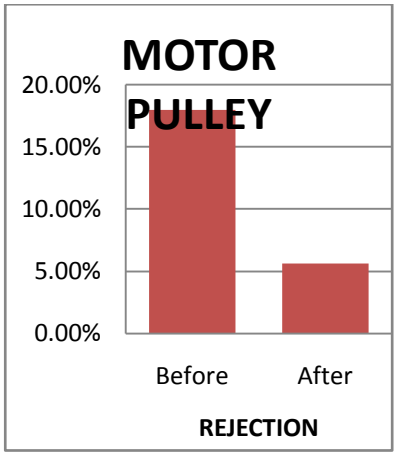
Month	Production pieces	Rejection Pieces	Blow holes defects	Misrun defects	Slag inclusion defects
Feb.2012	503	30	13	06	11
March 2012	507	33	14	09	10
April 2012	504	31	13	07	11
May 2012	512	35	15	08	12
Total	2026	129	55	30	44

Total production of six month = 2026, Total rejection =129 pieces % of rejection =129 / 2026 = 0.0636 x 100 = 6.36%

Data collection (after improvement) – Motor Pulley

Month	Production pieces	Rejection Pieces	Blow holes defects	Misrun defects	Slag inclusion defects
Feb.2012	1010	56	24	13	19
March 2012	1013	59	26	12	21
April 2012	1006	58	25	13	20
May 2012	1002	55	23	14	18
Total	4031	228	98	52	78

Total production of four month 4031, Total rejection =228 pieces % of rejection =228 / 4031 = 0.0565 x 100 = 5.65%



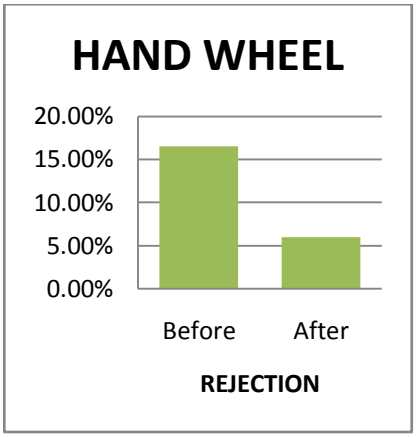
Bar chart for Motor pulley

Data collection (after improvement) – Mini Chaff cutter wheel / Hand wheel

Month	Production pieces	Rejection Pieces	Blow holes defects	Misrun defects	Slag inclusion defects
Feb.2012	5012	303	91	76	136
March 2012	5005	299	93	82	124
April 2012	5009	302	90	86	126

May 2012	5008	303	97	83	123
Total	20034	1207	371	327	509

Total production of four month = 20034, Total rejection =1207, pieces % of rejection = 1207/ 20034= 0.0602 x 100 =6.02%



Bar chart for Hand Wheel

But the overall percentage of rejections has been found as below.

Total production of 3 parts in four month = 26091

Total rejection = 1564

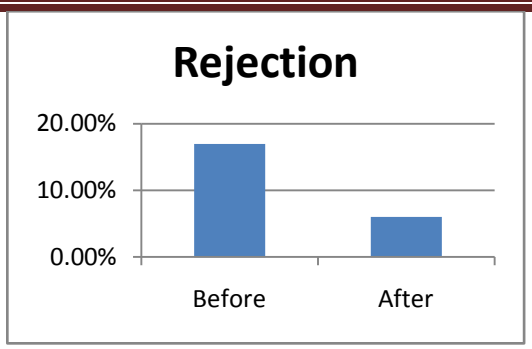
Overall %age of rejection = 1564 / 26091 = 0.0599 x 100= 5.99%

So after the complete analysis it was found that rejection due to casting defects has been reduced.

Improvements in rejection

Defects	Before improvement	After improvement
Slag inclusion	5.77%	2.41%

So after the complete analysis it was found that rejection due to casting defects has been reduced



RESULTS AND DISCUSSION

From the result of the application of DMAIC approach in the foundry shop the following results were obtained.The rejection due to slag defects were reduced from 5.77 % to 2.41% by using slag traps in gating system.. The overall result of present work is clearly shows that by applying DMAIC approach the rejection has reduced from 16.96% to 5.99 % and saving of cost .

CONCLUSIONS

The DMAIC approach is a viable solution to their shop floor problems. This case study has substantiated the fact that many defects of sand casting can be overcome by adopting this approach. A number of experiments are carried out to validate the results which indicate that the cost of experimentation will be less, in comparison to the gain or profit of the company.

On the basis of the results, the following conclusions have been drawn:

1. DMAIC has been considered as an approach to improve quality of product and process.
2. Reduced rejection of industry.
3. The DMAIC approach provides a suitable visible road map for entire work force to achieve new knowledge.
4. Accuracy of this approach is very high.

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