REDUCING THE DEFECTS OF MANGANESE STEEL CASTING BY IMPLEMENTATION OF DMAIC TOOL OF SIX SIGMA

[1]V SAI SATHWIK, [2]DR K. VENKAT SUBHAIH, [3] K. CHAITANYA PRANAVI

[1]M.Tech Scholar, Department of Mechanical Engineering,

[2] Professor Department of Mechanical Engineering

[3] Research Scholar, Department of Mechanical Engineering

Andhra University College of Engineering (A), Visakhapatnam, Andhra Pradesh, India.

Abstract: DMAIC approach is a business strategy used to business profitability and efficiency of all operation to meet customer needs and expectations. The applications of six sigma methodology to the manganese steel casting process in foundry to minimize the defects in this process. The primary tool used in the process map and cause and effect diagram.an attempt has been made to apply DMAIC (define, measure, analysis, improve, control) approach. the emphasis was laid down towards reduction in defects (blow holes, shrinkage & draw, cracks, slag inclusion, surface roughness) occurred in manganese steel casting by controlling the parameters with DMAIC technique. six sigma is statistical and scientific methods to reduce the defect rates and achieve improved quality. Finally, we have changed the bedding sand from silica sand to olivine sand of the manganese steel casting.so that we have reduced the defects of manganese steel casting mainly the surface roughness. Surface roughness defect occurs due to the reaction between the silica sand and manganese and comes to MnO. Due to the surface roughness is high and its difficult for machining. So that we have introduced olivine sand instead of silica sand. After introducing olivine sand, the defect rate is decreased and the production rate is increased

Index Terms: Manganese Steel Casting, DMAIC Tool, Six Sigma.

1. INTRODUCTION

Visakhapatnam Steel Plant has the distinction to be the first integrated steel plant in India to be certified to all the three international standards for quality ISO-9001,for environment management ISO-14001 & for occupational health and safety OHSAS-18001.The certificate covers the quality systems of all operational maintenance and service units, besides purchase systems, training and marketing functions spreading over 4 regional marketing offices,20 branch offices and 22 stockyards located over the country. Visakhapatnam steel plant is the first costal based steel plant in India is located, 16KM south west to the city of destiny i.e., Visakhapatnam. Having advanced technologies, VSP has an installed capacity of 3million tones of liquid steel per annum. At VSP there is emphasis on total up-gradation, which results in wide range of long and structural products to meet the stringent demands of discerning customers within India and abroad. VSP products meet exalting international standards such as JIS, DIN, BIS, BS etc.

Visakhapatnam steel plant by successfully installing and operating efficiently Rs.480crores worth pollution control and environment protective equipment and converting barren landscape by planting more than 3,50,000 plants has made the steel plant township and surroundings into a heaven of greenery. This had made the temperature to be 3-4o centigrade lesser even in peak summer compared to the Visakhapatnam city

Visakhapatnam steel plant exports quality pig iron and steel products to Srilanka, Mayanmar, Nepal, Middle East USA and south East Asian countries. Having establishing a fairly dependable export market, VSP plans to make a continuous presence in the export market. Having a total manpower of 17250 VSP has envisaged a labour productivity of 230tons of liquid steel per man per year, which is the best in our country and is comparable in the international levels

1.1 DEFINITION OF SIX SIGMA

Six Sigma has been defined by many experts by numerous ways. In couple of initial definitions Tomkins (1997) defined Six Sigma as a program aimed at the near elimination of defects from every products, process, and transactions. Technically, sigma(s) is a statistical measure of the quality consistency for a particular process/product. The technical concept of Six Sigma is to measure current performance and to determine how many sigma exist that can be measured from the current average until customer dissatisfaction occur. When customer dissatisfaction occurs, a defect results.

It is a disciplined, systematic and data-driven approach to process improvement that targets the near-elimination of defects from every product, process and transaction defined Six Sigma as a strategic initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools that can lead to breakthrough quantum gains in quality. “A comprehensive and flexible system for achieving, sustaining and maximizing business success. Six Sigma is uniquely driven by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes. The application of Six Sigma is growing and moving from the manufacturing field to encompass all business operations, such as services, transactions, administration, Research& Development (R&D), sales and marketing and especially to those areas that directly affect the customer.

As per Park (2002) Six Sigma implies three things: statistical measurement, management strategy, and quality culture. It tells us how good products, services, and processes really are, through statistical measuring of quality level. Six Sigma is new, emerging, approach to quality assurance and quality management with emphasis on continuous quality improvements. The main goal of this approach is reaching level of quality and reliability that will satisfy and even exceed demands and expectations of today's demanding customer. As a project-driven management approach, the range of Six Sigma applications is also growing from reduction of defects in an organization's processes, products and services to become a business strategy that focuses on improving understanding of customer requirements, business productivity and financial performance. Six-sigma is a formal methodology for measuring, analyzing, improving, and then controlling or "locking-in" processes. This statistical approach reduces the occurrence of defects from a three-sigma level or 66,800 defects per million opportunities (DPMO) to a six-sigma level of less than 3.4 DPMO.

Linderman, Schroeder, Zaheer and Choo (2003) in defining Six Sigma stress up on process improvement and new product development by stating that Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates. Six Sigma has been adopted by many leading companies. The benefits are well documented for manufacturing industries and increasingly, in service industries (Wright &Basu, 2008). Six Sigma is a synergistic mixture of many statistical and non-statistical tools and techniques which employs quality and performance improvement of the processes and products Six Sigma is a proactive and quantitative continuous improvement approach which improves bottom line of the organizations through reduction of costs, waste and non-conformance. Six Sigma is a highly structured program developed by Motorola and used to improve quality world widely Indian foundry industries an overview.

1.2 HISTORY OF SIX SIGMA

The roots of Six Sigma as a measurement standard can be traced back to Carl Friedrich Gauss (1777-1855) who introduced the concept of the normal curve. Six Sigma as a measurement standard in product variation can be traced back to the 1920's when Walter Shewhart showed that three sigma from the mean is the point where a process requires correction. Many measurement standards (Cpk, Zero Defects, etc.) later came on the scene but credit for coining the term "Six Sigma" goes to a Motorola engineer named Bill Smith. (Incidentally, "Six Sigma" is a federally registered trademark of Motorola). Bill Smith, a Motorola engineer, developed the Six Sigma programme in 1986 as a response to the necessity for improving quality and reducing defects in their products. The CEO, Bob Galvin, was impressed by the early successes, and under his leadership, Motorola began to apply Six Sigma across the organization, focusing on manufacturing processes and systems. Motorola established Six Sigma as both an objective for the corporation and as a focal point for process and product quality improvement efforts. The Six Sigma concept was tremendously successful at Motorola. It has been estimated that they reduced defects on semiconductor devices by 94% between 1987 and 1993(Douglas C. Montgomery and William H.Woodall 2008). In 1991 also, Allied Signal, (which merged with Honeywell in 1999), adopted the Six Sigma methods, and claimed significant improvements and cost savings within six months. It seems that Allied Signal's new CEO Lawrence Bossidy learned of Motorola's work with Six Sigma and so approached Motorola's CEO Bob Galvin to learn how it could be used in Allied Signal. In 1995, General Electric's CEO Jack Welch (Welch knew Bossidy since Bossidy once worked for Welch at GE, and Welch was impressed by Bossidy's achievements using Six Sigma) decided to implement Six Sigma in GE, and by 1998 GE claimed that Six Sigma had generated over three-quarters of a billion dollars of cost savings. (Source: George Eckes' book, The Six Sigma Revolution.)

1.3 FOUNDARY SAND CASTING PROCESS

1.3.1 Foundry:

The Indian foundry industry is the fourth largest in the world. There are more than 7,000 foundries in India These units produce a wide range of castings that include automobile parts, agricultural implements, machine tools, diesel engine components, manhole covers, sewing machine stands, pump-sets, decorative gates and valves. 32.4% of total production of Indian foundries supplies goes to serve only automobile sector, which is quite substantial as compare to other sectors these units are mostly located in clusters with numbers varying from less than 100 to around 400 per cluster. Some of the notable clusters in this regard are Agra, Howrah, Batala, Coimbatore, Kolhapur, Rajkot and Belgaum. In India, manufacturing industries like foundries do not enjoy monopoly but they have to face competition.

Sand Casting is the most widely used process to produce castings among the all casting processes. Especially, intricate shapes in large numbers can be easily produced through sand casting process. Several types of defects could occur during casting and considerably reduce the total output of castings, besides increasing the cost of their production. Whenever a defect occurs in castings, the various departments in the foundry normally blame each other for its occurrence. Defects may occur due to single cause or a combination of causes. Correct identification and finding the root causes for the defect is difficult due to the Involvement of various technical factors like Process Design, Process Flow, Pattern Shop, Sand Preparation, Core Making and Melting.

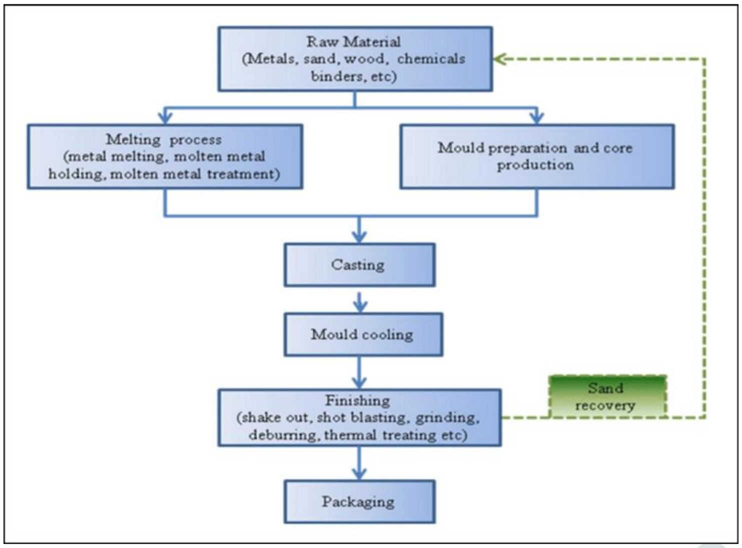

Figure 1.1: Process Chart of Foundry

Sand Casting is the most widely used process to produce castings among the all casting processes. Especially, intricate shapes in large numbers can be easily produced through sand casting process. Several types of defects could occur during casting and considerably reduce the total output of castings, besides increasing the cost of their production. Whenever a defect occurs in castings, the various departments in the foundry normally blame each other for its occurrence. Defects may occur due to single cause or a combination of causes. Correct identification and finding the root causes for the defect is difficult due to the Involvement of various technical factors like Process Design, Process Flow, Pattern Shop, Sand Preparation, Core Making and Melting.

Metal casting process is a complex process with several sub-processes, such as patternmaking, mould and core making, melting and pouring, heat treatment and cleaning and finishing. Six Sigma methodologies have been attempted in steel foundries to minimize the casting defects and improve profitability. Six Sigma uses DMAIC methodology to improve the processes. Six-sigma heavily focuses on statistical analysis as it is data driven and is a methodical approach that drives the process improvements through statistical measurements and analyses. In view of the large number of factors that are responsible for the casting defects, the general statistical approach is not always the best. Foundries, and indirectly, their customers, continue to pay a heavy price for poor quality. The immediate fallouts include loss of productivity (saleable castings per poured metal), and the cost of cutting and re-melting of rejected castings.

1.4 MANGANESE STEEL CASTING

Manganese Steel Casting is a unique alloy with high toughness, ductility, high work hardening capacity, non-magnetic in nature and usually good resistance to wear. Manganese Steel's ability of work hardening is unique and probably has no equal in this respect. manganese steel is used extensively in field of Mining, cement, earthmoving, mineral processing, oil well drilling, railroading and power sector. Single metallographic structure of high manganese steel decide it has ability to create work hardening. Within high impact environment, the surface hardness is always more than 500HB, but the inside also keeps high toughness. As a casting, high manganese part also needs basic work to ensure it inside quality. The high manganese steel follows sequential solidification, the riser and the pouring system should be designed rightly to ensure high density inside. The shrinkage rate of high manganese steel is more than carbon steel, the high manganese steel need low pouring temperature, the solidification time is shorter than carbon steel, so the riser should be given more safety margin than carbon steel. Manganese increases the ductility of the metal and adds greatly to its toughness and resistance to abrasive action. Sir Robert Abbott Hadfield was an English metallurgist noted for his 1882 discovery of manganese steel, one of the first alloys steel. His invention was based on adding large percentage of manganese to molten iron whereby producing a steel that have good toughness and hardness while possess distinguished characteristics. After a number of experiments performed by sir Hadfield, a conclusion was made that a steel having good toughness and hardness while possess distinguished characteristics can be found when the Mn content is between 11-13% Mn and 1-1.3% carbon with a Mn\C ratio of 10:1. The table below shows the effect of different manganese content on the mechanical properties of Hadfield steel.

Steel making is important. Beside the chemical should be meet the specification, the quality of liquid steel is also very important. The harmful gas such like H_2, N_2 and Non-metallic inclusion such like Al_2O_3, MnO, SiO_2 which cannot be inspected by spectrometer but should be removed as much as possible. Our ARC-electric furnace gives much help to complete this job. We use traditional Oxidation reduction method to refine the steel. During the Oxidation period, blowing in oxygen, through the reaction between oxygen and carbon to remove the most harmful gas and non-metallic inclusion, during the process the Amount of decarburization should be ensured between 0.3%-0,4% C, the decarburization speed should be ensuring between 0.08%-0.15%C/10min. After Oxidation period, entering the reduction period, first using Mn alloy, Si alloy and Cao to reduce the oxygen content in steel, when the reduction slag keep white color for 10 minutes, it shows the O_2 in liquid steel has been nearly removed, next step is adjusted chemical content and pouring out. Heat treatment is key process of high manganese steel, during high temperature more than 950℃, the carbide start melting in the Austenite structure, and then though fast cooling in water fix the carbide in the Austenite structure to get the single structure. Because the bad thermal conductivity of high manganese steel, before 650℃, the heating rate cannot be more than 50℃/h. When the temperature more than 950℃, the holding time should be calculated according to the maximum wall thickness of casting, generally the holding time is 1h/25mm. The maximum temperature cannot be more than 1100℃ to avoid the grain separating.

1.5 THE CONCEPT OF LEAN SIX SIGMA

1.5.1 Lean:

Taiichi Ohno, working for Toyota as an engineer is a person behind the Lean production theory. Lean gives a significant idea about the causes of waste and the methods to reduce or eliminate the amount of waste during production. With Lean culture and execution methodology helps in minimizing waste and also efforts in order to generate maximum value. The concept of Lean philosophy was first introduced in manufacturing industries which include the increased output flexibility and transparency of production system. However, it has been ideal for construction industries too.

1.5.2 Six Sigma: In the 80s concept of Six Sigma was first coined by Bill Smith. The fundamental purpose of

Six Sigma is to eliminate the variability and defects thereby improving customer satisfaction and profitability. The principle of Six Sigma is governed by the disciplined, quantitative and multi-faceted approach to the process improvements, therefore, achieving 'closet-to-zero defect' product. Six Sigma methodology provides a structured framework DMAIC for continuous process improvement. The steps involved are:

1. **Define**. Define the customer requirements, key variables affecting the quality and causing waste, project goal and scope.

2. **Measure**. Data collection plan and measure the process performance.

3. **Analyse** the data collected and determine the root cause of key variables.

4. **Improve**. Generate the potential solution in order to improve the processes by eliminating the root causes.

5. **Control**. Establish a control plan to ensure sustainability of improvements

Six-sigma is a disciplined, data-driven methodology for eliminating defects in any process. To achieve six sigma quality, a process must produce no more than 3.4 defects per million opportunities. According to Devane, six sigma's basic value proposition is that principles for process improvement, statistical methods, a customer focus, attention to processes, and a management system focusing on high-return improvement projects result in continuous improvement and significant financial gains. According to George, Motorola recognized that there was a pattern to improvement (and use of data and process tools) that could naturally be divided into the five phases of problem solving, usually referred by the acronym DMAIC (da-may-ick), which stands for Define-Measure-Analyse-Improve-Control. DMAIC forms the five major phases of any six-sigma project. DMAIC phases and a brief description are given below:

Phase I: Define
The purpose of this phase is to clarify the goals and value of a project.
Phase II: Measure
The purpose of this phase is to gather data on the problem.
Phase III: Analyze
The purpose of this phase is to examine the data and process maps to characterize the nature and extent of the defect.
Phase IV: Improve
The purpose of this phase is to eliminate defects in both quality and process velocity.
Phase V: Control
The purpose of this phase is to lock in the benefits achieved by doing the previous phases. Manganese steel is used in harsh applications that require high levels of toughness. Its total production is small, however, at least when compared to carbon and alloy steels. John Tasker describes manganese steel by saying "it is the only material that will survive in most of the large crushing equipment used today." When one of my colleagues said that "manganese steel was a metallurgist's dream," he was extolling all of its good properties while completely ignoring its weaknesses. A more accurate statement might be: "manganese steel is the best alloy for any application where all other alloys fail". The uses and properties of manganese steels and the production methods that produce high quality castings. In addition, some of the modifications to the alloy system will be presented.

Manganese steel was discovered by Sir Robert Hadfield in 1882. In above Figure shows an image of Hadfield cast in manganese steel. Earlier experiments with manganese additions to produce steels that were sound and free of cavities had been conducted by the Terre Noire Company. At the time of this work manganese alloys containing 5% carbon and 20% manganese were all that was available. This composition, due to its low manganese and high carbon content, prevented its use in the production of low carbon steels, and therefore sound low carbon steels could not be produced at this time. Due to this problem, work was begun on the concept of producing a manganese alloy with higher manganese content. Alexander Pourcel is credited with producing the first ferro-manganese alloy with 80% manganese and 6% to 7% carbon. This achievement opened the way for producing low carbon steels with manganese contents that improved soundness and ultimately Hadfield's work.

2. PROCESS AND METHODOLOGY

3.1 INTRODUCTION

The main purpose of the study is to explore the benefits which lean six sigma provides to the steel plant foundry for improvement of their manganese steel casting quality and compete with today's globally competitive environment in 21st century; this is an attempt to show directions to steel plant foundry for implementation of lean six sigma project.

2.2 DMAIC

2.2.1 Define

In the define phase, the goals of the improvement activity are clearly defined. The parameters which greatly influence the goals of the enterprise in respect to quality are called critical to quality (CTQ) parameters. In the process of defining, the goals CTQ are identified through Voice of Customer (VOC). VOC is collected by conducting brain storming sessions among the customers. Project Charter, CTQ flow down and Process mapping are the important tools used in this phase. Project charter is a document stating the purposes of the project. It contains the elements such as business case, problem statement and goal statement. Business case indicates the purpose of the project in which the goals and objectives are established. The next element is the problem statement which clearly expresses the problem to execute. After establishing the problem statement the six-sigma team has to decide the target values by thoroughly observing the past data. These values are mentioned in a statement called Goal statement. Process mapping is the key step in understanding the processes involved in an enterprise. The process map (SIPOC chart) starts with supplying raw materials and ends with the benefits received by the customer.The Six-Sigma program achieves reduction of wastage through rejects and improves the quality of the output in the process by working on the technical factor as well as the human factor involved in the production process. This study was conducted in a foundry located at an industrial estate in Southern India. The company manufactures lower bowl mantle, upper bowl mantel, bowl liner, cone crushers ,crushing ring, crusher rollers ,blow bars by using manganese steel casting techniques. To know the importance of the various processes, their dependence on one another, and their influence on quality of castings, we need to understand the entire process in the foundry. It was performed a SIPOC analysis and then flow chart was drawn for the process. A pareto analysis was performed on 55 castings from which 23 were rejected, revealing that surface roughness (18 rejected) as the major defect. Problems being addressed by identifying the factors critical to the quality and the factors Causing defects within manganese steel casting is rough surface.

2.2.2 Measure

Data related to defects which were required for the CTQ measure were collected from the factory under span January 2016 to august 2018. In this phase past data pertaining to CTQ s is collected to find out sigma level by evaluate and understand the current state of the process is purpose of the measure step. In this phase includes collecting data on measures of quality and quantity has been tabulated in table1.
In order to measure the defects in manganese steel casting for different perspectives of quality and waste

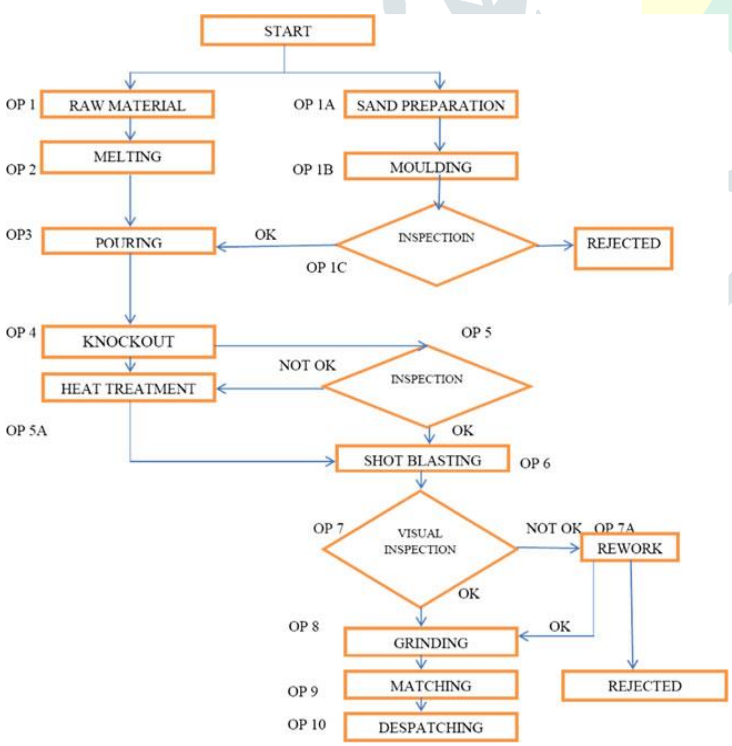

Figure 2.1: Flow Chart for Manganese Steel Casting

Figure 2.2: Rough Surface

Figure 2.3: Blow Hole

Figure 2.4: Shrinkage and Draw

Figure 2.5: Cracks

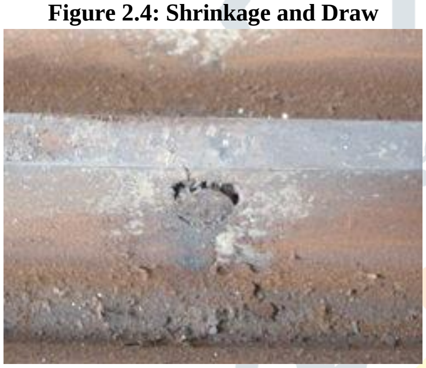

Figure 2.6: Slag Inclusion

Table 2.3: Data Collection of Total Defects

S. No	Lower Mantle	Cone Crusher	Mantle	Total	%
1	3	3	5	18	78.26
2	0	0	1	2	8.70
3	1	0	0	1	4.35
4	0	1	0	1	4.35
5	1	0	0	1	4.35
Total	5	4	6	23	100

It was found that the most significant defects in this work to be considered are surface roughness, blow hole, shrinkage & draw, cracks, slag inclusion, were responsible for 78.26, 8.70, 4.35, 4.35 and 4.35 defect percentage in total percentage. One major defect surface roughness which creates major changes were taken into account. The surface roughness defect contribution is 78.26% in total defect percentage for this reason we select this one defect for next analysis.

Data related to defects which were required for the CTQ measure were collected from the factory under study. The collected data span January 2016 to August 2018. This record contained information on (i) the tonnage of products produced, (ii) non-conforming products, (iii) defect types. The analysis in this project shall be done in kilograms and as a percentage of defects to the total production run since aluminium products are measured by mass, The Sigma level of the process was calculated based on the data collected and this showed that the casting section. This indicated an abundant room for improvement in this section.

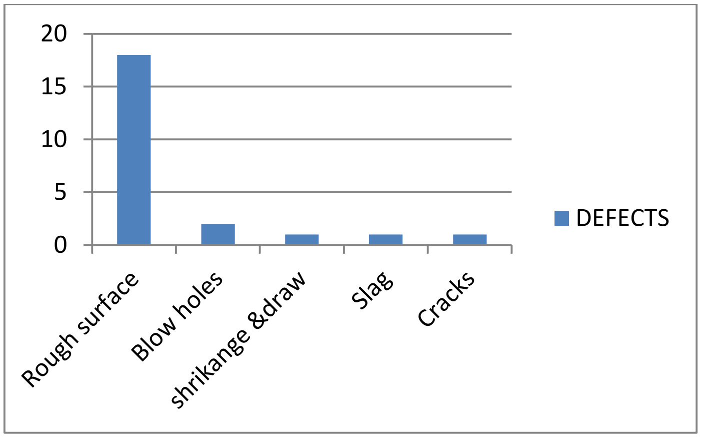

Figure 2.7: Pareto Diagram

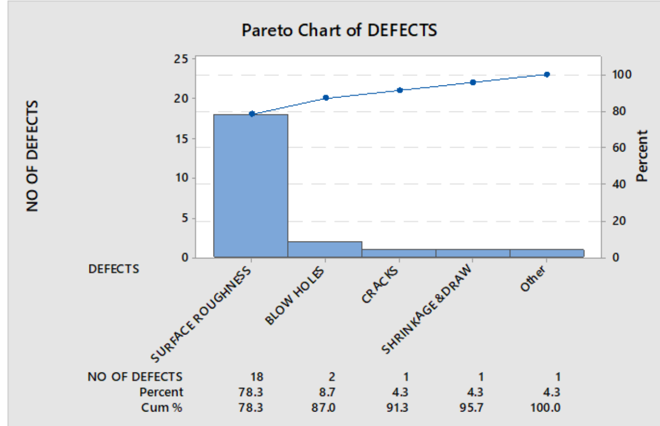

Figure 2.8: Pareto Chart of Defects

2.2.3 Analyze

In this phase critical analysis is carried out with the help of certain tools such as Fishbone diagram (Cause and Effect diagram) and Pareto diagram. Fishbone diagrams are used to identify and systematically list the different root causes that can be attributed to a problem. Thus, these diagrams help to determine which of several causes has the greatest effect. The main application of these diagrams is the dispersion analysis. In dispersion analysis, each major cause is thoroughly analyzed by investigating the sub causes and their impact on quality characteristics. The Fishbone diagram helps to analyze the reasons for any variability or dispersion. Pareto diagram is useful to reduce the many causes to vital few.

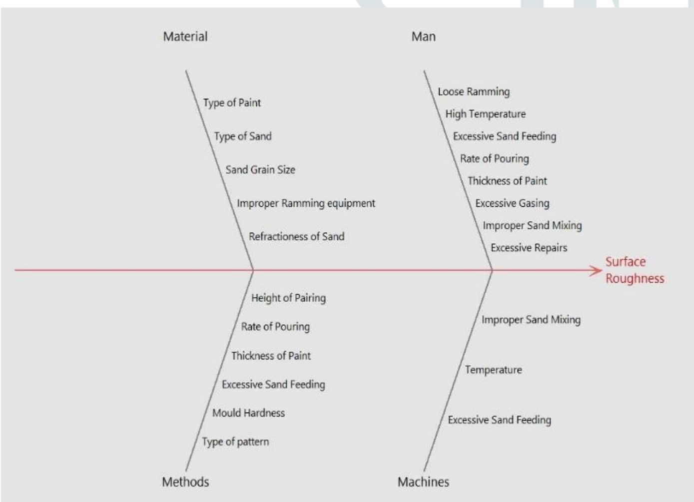

Figure 2.9: Cause and Effect Diagram

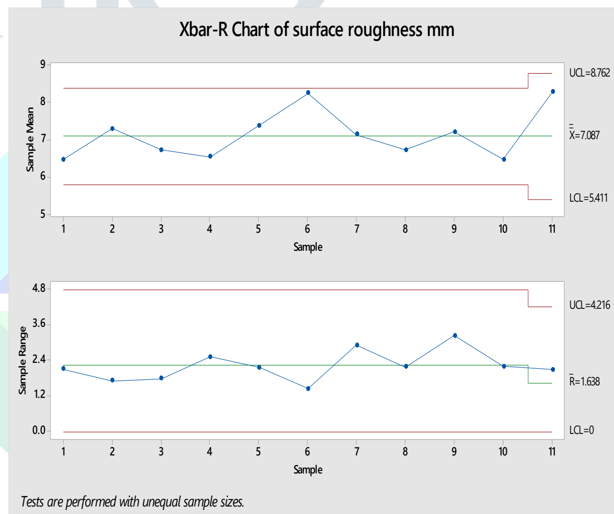

Figure 2.10: X-Bar chart of Surface Roughness

The Pareto diagram helps the management to quickly identify the critical areas (those causing most of the problems) that deserve immediate attention. After measuring the data and gaining the information about the significant causes having a high impact on the quality and contributes most to material waste. Further, the root cause analysis was done. The cause and effect (fishbone) diagram are used for the key factors affecting the quality and contribute to material wastes is depicted in figure.

2.2.4 Improvement

This phase statistically reviews he variations in the process and determines what factors significantly contribute to the output. Failure Mode and Effect Analysis (FMEA) is carried out in this phase to identify the possible types of failures. The objective of conducting FMEA is to anticipate all possible types of failures that could occur. The FMEA tabular form includes parameters such as mode of failure, effects of failure and its severity rating (S), possible causes of failure and their intensity of occurrence (O), current prevention methods, detection column (D), Risk Priority Number (R), recommended actions and Responsible persons. The severity column has an entry designating the severity of the effect for the failure mode, that is, the seriousness of the impact of the particular failure. The occurrence column has an entry designating the likelihood that is the failure will occur. The detection column has an entry designating the likelihood that the detection method is accurately detect the failure. Based on the data observations the team has to decide the entries in the above mentioned columns in the FMEA tabular form by adopting a suitable scale. The Risk Priority Number aids in prioritizing the failure mode with the higher number designating highest priority. The Risk Priority Number is calculated by multiplying the values in the columns of severity rating, intensity of occurrence and detection. Based on the recommendations from analyze phase silica % is the most affected parameter. So, we are implementing olivine sand instead of silica sand.

2.2.5 Control

In this phase the control stage is the last and final stage and is sole purpose is to preserve the optimized response obtained from the experiments. the main part of this phase includes standardization and documentation of the improved process and creating a plan for monitoring the process. The process stays in control after the solution has been arrived and the out of control state is checked. In project phase the project team are to make a fully documentation of the process and what improvement changes is done. The major defects of surface roughness were analysed and corrective action was taken. The rejection percentage declined to 0.020 from 78.6 %. The process stays in control after the solution.

3 RESULTS AND DISCUSSION

3.1 INTRODUCTION

In this study, DMAIC based six sigma approach is implemented to improve the quality and quantity of manganese steel casting in foundry. For the conformation of experiment, we have taken 55 manganese steel castings from four different casting from which we have 23 defectives in which 18 are surface roughness, 2 are blow holes, 1 is cracks, and 1 is sand inclusion and last one is shrinkage and draw.

Table 3.1: Data collection of total defects

S.No	Defects	Bowl liner	Lower mantle	Cone crusher	Mantle	Total	%
1	Surface roughness	7	3	3	5	18	78.26
2	Blow hole	1	0	0	1	2	8.70
3	Shrinkage &draw	0	1	0	0	1	4.35
4	Cracks	0	0	1	0	1	4.35
5	Slag inclusion	0	1	0	0	1	4.35
	Total	8	5	4	6	23	100

After so many discussions we have taken the parameters of manganese steel casting from that we have observed one thing that is when the % of silica is increasing in sand then the surface roughness of casting is also increasing so we observed that % of silica of sand is the main effecting parameter. So, we have introduced olivine sand in place of silica sand due to it has very less amount of silica will be there in olivine sand. It can seen from the verification of test results that the rejection percentage of defects of casting process was greatly reduced. from the above results it is proved that the casting parameters were optimized and minimum percentage of casting defect values were obtained, the stability of the casting process is increased. We have used ANOVA for MINITAB purpose only. Resulting in superior product quality and quantity. After our case study the After using olivine sand the improvement of manganese steel casting is as

Table 3.2: After using olivine sand the improvement of manganese steel casting

Date	Bowl liner				Lower mantle			
	Inspect	accept	reject	reason	Inspect	accept	reject	Reason
04sep 2018	2	2	0		2	2	0	
12sep 2018	1	1	0		1	1	0	
18sep 2018	1	1	0		1	1	0	
29sep 2018	3	3	0		1	1	0	
05oct 2018	2	2	0		2	2	0	
15oct 2018	1	1	0		1	1	0	
22oct 2018	1	1	0		1	1	0	
30oct2018	3	2	1	CR	1	1	0	

Table 3.3: After using olivine sand the improvement of manganese steel casting

Date	Cone crusher				Mantle			
	Inspect	accept	reject	reason	Inspect	accept	reject	Reason
04sep 2018	1	1	0		3	3	0	
12sep 2018	1	1	0		1	1	0	
18sep 2018	1	1	0		1	1	0	
29sep 2018	2	2	0		2	2	0	
05oct 2018	1	1	0		3	3	0	
15oct 2018	1	1	0		1	1	0	
22oct 2018	1	1	0		1	1	0	
30oc t2018	2	2	0		2	2	0	

After using olivine sand in place of silica sand the defect rate is reduced to 0.02%.so olivine sand has improved the quality and quantity of the product.

4.1 CONCLUSION:

This study in steel plant foundry we have observed defects in manganese steel castings and started work on it by presenting application of a six sigma a six sigma DMAIC methodology to identify the problems in a casting process and solve the problem by determining the optimal parameters for reducing surface roughness defect. The problem was refined in the define phase to create a feasible project. The current condition of the company was inspected in the measure phase, and significant parameters were identified in the analyze phase. In the improve phase we have changed the sand to set the parameters. In control phase, we determined an optimal parameter setting for reducing the surface roughness defects.

1. The effect of casting parameters on the casting defect was evaluated, with the help of ANOVA and optimal casting parameters conditions were determined to minimize the percentage of defects. The specific application of ANOVA, find out the silica % is the most effecting parameter on percentage of defect compared with another parameter.

2. By applying six sigma methodology to the process the effect of casting parameters on the casting defect was evaluated, with the help of fish bone diagram and ANOVA to minimize the percentage of defects.

3. After drawing fish bone diagram, we have observed that there is no problem from man, method, machine so finally we have concluded that the defect is from material only.

4. After comparing we have finalized that the silica % is identified as the dominant parameter for the casting defect and the % of surface roughness defect is 78%.

5. So that we have implemented olivine sand in place of silica sand and done the casting process so the defects reduced to 0.02% because the silica% is low in olivine sand.

4.2 FUTURE SCOPE:

1. we can also analyse the data in minitab and for future work.

2. By taking this as the reference paper they can use for reducing the defects of other castings.

REFERENCES

1.Valter R. Morais, Sérgio D. Sousa, Member, IAENG and Isabel Lopes, Implementation of a Lean Six Sigma Project in a Production Line, Proceedings of the World Congress on Engineering 2015 Vol II, ISBN: 978-988-14047-0-1 ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online).

2.Dr. Shanmugaraja M, Tharoon T, Lean-Six Sigma Case Study to Improve Productivity in a Manufacturing Industry, Int Journal of Engineering Research and Application www.ijera.com ISSN: 2248-9622, Vol. 7, Issue 9, (Part -6) September 2017, pp.38-46.

3.A. Kumaravadivel & U. Natarajan, Application of Six-Sigma DMAIC methodology to sand-casting process with response surface methodology, The International Journal of Advanced Manufacturing Technology, November 2013, Volume 69, Issue 5–8, pp 1403–1420.

4.Sumit Sehgala, Deepak Kaushisha, Vijayesh Rathia, Qualitative Analysis of Foundry Industry: A DMAIC Approach, Journal of Business Management & Social Sciences Research (JBM&SSR) ISSN No: 2319-5614 Volume 4, No.9, September 2015.

5.vinitkumar k. modi & darshak a. desai, six sigma implementation practices in indian foundries and benefits derived: critical examination. International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN(P): 2249-6890; ISSN(E): 2249-8001 Vol. 5, Issue 5, Oct 2015, 81-102.

6.Abidakun OA, Leramo RO, Ohunakin OS, Babarinde TO and Ekundayo-Osunkoya, quality improvement of foundry operation in nigeria using six sigma technique SENRA Academic Publishers, British Columbia Vol. 8, No. 1, pp. 2751-2760, February 2014 Online ISSN: 1920-3853; Print ISSN: 1715-9997.

7.Mr. S. Chandra, Dr. B. Doloi, and Dr. B.K. Bhattacharya, implementation of six- sigma methodology for improvement of process yield by reduction of rejection (for %) in a manufacturing process, 5 th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) December 12th–14th, 2014, IIT Guwahati, Assam, India.

8.Suraj Dhondiram Patil, M M Ganganallimath, Roopa B Math, Yamanappa Karigar, Application of Six Sigma Method to Reduce Defects in Green Sand-Casting Process: A Case Study, International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE) ISSN: 2349-7947 Volume: 2 Issue: 6.

9.koji TANI ,yoshisada UEDA and shohei MORI interfacial reaction between cast steel And olivine sand or silica sand, Originally published in Imono (The Journal of The Japan Foundrymen's Society), 53 (1981), 319 and 565.

10.Sachin s and Dileeplal J(2017) Six Sigma Methodology for Improving Manufacturing Process in a Foundry Industry, International Journal of Advanced Engineering Research and Science (IJAERS) Vol-4, Issue-5 ISSN: 2349-6495(P) | 2456-1908(O)

11. Virender verma, Amit Sharma, Deepak juneja, Utilization of six sigma (DMAIC) Approach for Reducing Casting Defects International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014 ISSN 2091-2730.

12.Chintan C. Rao, Darshak A. Desai A Review of Six Sigma Implementation in Small Scale Foundry, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 12, December 2015, ISSN(Online): 2319-8753 ISSN (Print): 2347-6710.

13.Wasim Ahmad, Anil Verma and Priyanka Jhavar A review on casting defects reduction in a foundry shop using DMAIC technique, International Journal of Advance Research, Ideas and Innovations in Technology, (Volume 5, Issue 2) ISSN: 2454-132X.

14.Hemadri Chadalavada, D. Samuel Raj, M.Balasubramanian, Six Sigma implementation in a manufacturing unit – a case study International Journal of Productivity and Quality Management Vol. 19, No. 4, 2016.

15.Mr. Mohit Chhikara, Dr. M. S. Narwal and Mr. Pradeep Dahiya, Implementation of Six Sigma in Indian Manufacturing Industries, International Journal of Advance Research, Ideas and Innovations in Technology, (Volume3, Issue1) ISSN: 2454-132X.

16.N. Venkatesh and C. Sumangala, Success of manufacturing industries – Role of Six Sigma, MATEC Web of Conferences 144, 05002 (2018) RiMES 2017.

17.Hsiang-Chin Hung and Ming-Hsien Sung, applying six sigma to manufacturing processes in the food industry to reduce quality cost, Scientific Research and Essays Vol. 6(3), pp. 580-591, 4 February, 2011.

18.Riddhish Thakore, Rajat Dave, Tejas Parsana and Amit Solanki, A Review: Six Sigma Implementation Practice in Manufacturing Industries, Riddhish Thakore et al.Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 4, Issue 11(Version - 4), November 2014, pp.63-69.

19.Ploytip Jirasukprasert, Jose Arturo Garza-Reyes, Horacio Soriano-Meier and Luis Rocha-Lona, A Case Study of Defects Reduction in a Rubber Gloves Manufacturing Process by Applying Six Sigma Principles and DMAIC Problem Solving Methodology, International Conference on Industrial Engineering and Operations Management Istanbul, Turkey, July 3 – 6, 2012.

20.J. Hilla , A. J. Thomasa , R. K. Mason-Jonesa and S. El-Katebb, The implementation of a Lean Six Sigma framework to enhance operational performance in an MRO facility Production & Manufacturing Research, 2017 VOL. 6, NO. 1, 26–48.

21.Abhishek Pandey and Dr. K. K. Jain, Six Sigma in Manufacturing of Ingot Moulds in Foundry and Pattern Shop by Improving Sand Quality, American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-5, Issue-4, pp-209-217.

22.Vinitkumar K. Modi, Darshak A. Desai, Analysis of Six Sigma- DMAIC Methodology and Tools Used at Various Phases of DMAIC and Critical Success Factors in Foundries, International Journal for Research in Applied Science & Engineering Technology ISSN: 2321-9653, Volume 5 Issue X October 2017.

.