Satyendra Kumar Tiwari, 2021, 9:4
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

A Review on Casting Defect Reduction in Manufacturing Industry

M. Tech. Scholar Satyendra Kumar Tiwari, Prof. Shyam Kumar Barode
Department of Mechanical Engineering,
BIST, Bhopal,MP,India

Abstract- This work presents a systematic procedure to identify as well as to analyze major casting defects. Defects are responsible for time waste, money and eventually they affect productivity adversely. The defects need to be diagnosed correctly for appropriate remedial measures; otherwise, a new defect may get introduced. The proper classification and identification of a particular defect is the basic need to correct and control the quality of the casting. Present study was done at on application of DMAIC methodology and Selection of tools and techniques for problem solving, because of its high rejection rate.

Keywords: Casting, DMAIC, Quality analysis, Cause and Effect (Ishikawa) diagram.

I. INTRODUCTION

Six Sigma began in 1986 as a statistically based method to reduce variation in electronic manufacturing processes in Motorola Inc. in the USA. It is developed by Bill Smith at Motorola, later it was adopted by General Electric's and Allied Signals, where it was initiated by Jack Welch. There are two important contributions from GE's way of implementation to the evolution of Six Sigma. First, Jack Welch demonstrated the great paradigm of leadership. Second, he backed the Six Sigma program up with a strong rewards system.

GE changed its incentive compensation plan for the entire company so that 60 percent of the bonus was based on financials and 40 percent on Six Sigma results. The new system successfully attracted GE employees' attentions to Six Sigma. Moreover, Six Sigma training had become a prerequisite for advancement up GE's corporate ladder.

Welch insisted that no one would be considered for a management job without at least Green Belt training by the end of 1998. Further, Six Sigma has undergone many changes and improvement with the passage of time, also its implementation from manufacturing industries to service industries as well. Six Sigma can be applicable to any product, process or transactions.

It can also be applied business operations such as Research & Development (R&D), sales and marketing, on time delivery process, administration and other areas that directly affects the customers. It is a project-by-project improvement approach, which consists of analysis of quantitative data by using statistical tools and techniques. It is a highly data driven approach. Because breakthrough improvements and profits are associated with it, it has taken an attention from academics and practitioners worldwide.

1. Six -Sigma: Definition:

Being highly disciplined, systematic, customer-centric and profit-driven or organization-wide strategic business improvement initiative, which helps to focus on developing and delivering very close to perfect solutions, products or services. In a different way Six Sigma seek to reduce variation in the processes that lead to the defects.

Six-Sigma is considered a strategic corporate initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools and techniques that can lead to breakthrough quantum gains in quality. Six Sigma blends management, financial and methodological elements to make improvement to process and products concurrently. To become globally compatible and to gain business as well operational excellence industries are implementing various quality improvement initiatives like Lean manufacturing, ISO

certification, Total Quality Management, Quality Circle, etc. But results explored by these initiatives are timely constrained and not that much profitable.

So methodology, which can provide breakthrough improvement in a short time, is required to be introduced and implemented. Six Sigma is the same methodology which can provide breakthrough improvements in short time period, so it is very essential to explore it application for gaining quantum gains and profit in terms of quality, market share and customer satisfaction.

II. THE SIX SIGMA STRATEGY

To achieve Six Sigma quality, a process doesn't produce more than 3.4 defects per million opportunities. An opportunity is defined as a chance for non-conformance, or not meeting the required specifications.

This means we need to be nearly flawless in executing our key processes.

- Strategy
- Know what's Important to the Customer
- Reduce Defects
- Reduce Variation
- Centre around Target

1. Key Concepts of Six Sigma:

At its core, Six Sigma revolves around a few key concepts.

1.1 Critical to Quality: Attributes most important to the customer

1.2 Defect: Failing to deliver what the customer wants

1.3 Process Capability: What your process can deliver

1.4 Variation: What the customer sees and feels

2. Methodology of Six Sigma:

Six Sigma has been defined as the statistical unit of measurement, a sigma that measures the capability of the process to achieve a defect free performance.

Six is the number of sigma measured in a process, when the variation around the target is such that only 3.4 outputs out of one million are defects under the assumption that the process average may drift over the long term by as much as 1.5 standard deviations. The term sigma is used to designate the distribution or the spread about the mean of any process. Sigma measures the capability of the process to perform defect-free work.

A defect is anything that results in customer dissatisfaction. For a business process, the sigma value is a metric that indicates how well that process is performing. Higher sigma level indicates less likelihood of producing defects and hence better performance.

3. Six Sigma has two key methodologies:

DMAIC Methodology and DMADV Methodology, both inspired by Deming's Plan-Do- Check-Act Cycle.

- DMAIC
- DMADV

3.1 DMAIC: The DMAIC means Define, Measure, Analyses, Improve and Control. These all works together to create the DMAIC process. This process is incredibly important in six sigma process because it is what helps bring a diverse team together. This is what helps them complete a process or model so that they can share their work and get the job done. It is used to improve an existing business process.

DMAIC consists of following steps:

- Define process improvement goals that are consistent with customer demands and the enterprise strategy.
- Measure key aspects of the current process and collect relevant data.
- Analyze the data to verify cause-and-effect relationships. Determine what the relationships are, and attempt to ensure that all factors have been considered.
- Improve or optimize the process based upon data analysis using techniques like Design of Experiments.
- Control to ensure that any deviations from target are corrected before they result in defects. Set up pilot runs to establish process capability, move on to production, set up control mechanisms and continuously monitor the process.

Fig 1. Five Steps to DMAIC approach.

3.2 DMADV: The DMADV means Define, Measure, Analyze, Design and Verify where DMAIC is used to improve the existing business process. DMADV is used to create new product or process design.

DMADV consists of following steps:

- Define design goals that are consistent with customer demands and the enterprise strategy.
- Measure and identify CTQs (characteristics that are Critical to Quality), product capabilities, production process capability, and risks.
- Analyze to develop and design alternatives, create a high-level design and evaluate design capability to select the best design.
- Design details, optimize the design, and plan for design verification. This phase may require simulations.
- Verify the design, set up pilot runs, and implement the production process

III. CASTING PROCESS

Production of casting involves various processes such as pattern making, molding and assembly, sand preparation, core making and melting, pouring, shakeout etc. The overall casting process becomes very critical for complex parts. Based on various researches find best foundry process in which included all the activity.

Casting process is the most widely used process in manufacturing industries. The activities involved in casting process are, Pattern making for creation of mould box, Core making for insertion in mould assembly, fitting of pattern, gating system and sand for mould preparation, remove prepared mould and placed for pouring, fill the mould cavity with molten metal, allow it to solidify and at last, remove the cooled desired casting. These activities are commonly used because of its simplicity in process, economic to operate and easy to produce small size castings. Casting is a process which carries risk of failure occurrence during all the process of accomplishment of the finished product.

Casting process involves complex interactions among various parameters and operations related to metal composition, methods design, moulding, melting, pouring, shake-out, fettling, machining like grinding and inspection etc various operation carried out.

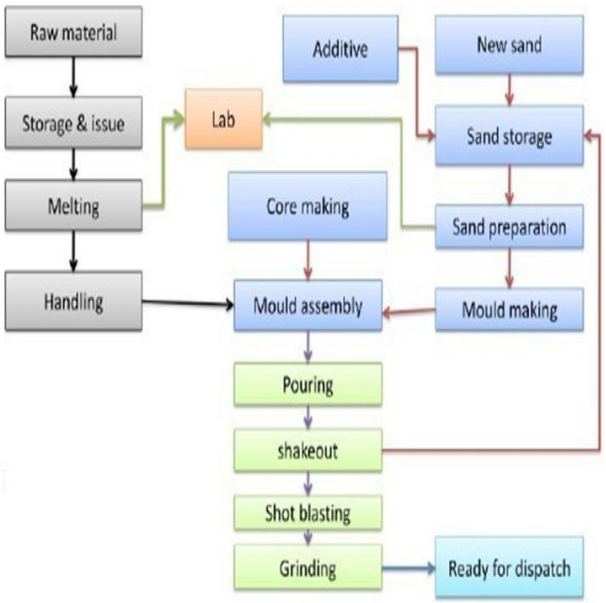

Fig 2. Various casting process from raw material to finish product.

IV. REVIEW OF PAST STUDIES

According to **Ahmadet al (2019)** to become globally compatible and to gain business as well operational excellence industries are implementing various quality improvement initiatives like Lean manufacturing, ISO certification, Total Quality Management, Quality Circle, etc.. But results explored by these initiatives are timely constrained and not that much profitable.

So methodology, which can provide breakthrough improvement in a short time, is required to be introduced and implemented. Six Sigma is the same methodology which can provide breakthrough improvements in the short time period, so it is very essential to explore its application for gaining quantum gains and profit in terms of quality, market share and customer satisfaction.

Ahmed et al. (2018) Six Sigma is a well-structured methodology that helps organizations to achieve their goals due to its role as a problem-solving technique. This research discusses the application of the Six Sigma methodology in home appliance industrial Company in Egypt.

The paper follows the Six Sigma DMAIC methodology (Define, Measure, Analysis, Improve, and Control) to systematically identify and define the

root cause(s) of defects and to provide a reliable solution to reduce/eliminate them.

Moreover, the use of the design of experiment (DOE) and the regression analysis have permitted to determine any existing correlation between the measurable causes and the increase in defects quantity and to identify the optimum temperature of the aluminum molten metal.

The analysis of Six Sigma (DMAIC) methodology and the statistical analysis (DOE and regression analysis) determined that the aluminum molten metal temperature has a significant impact on the defects quantity of aluminum parts.

After using the optimized temperature of the aluminum molten metal, the defects in aluminum products decreased from 10.49% to 6.1% and the Six Sigma level improved from 2.8 to 3.06. Therefore, Six Sigma can be considered a successful methodology in reducing defects and consequently increasing the cost savings and customer satisfaction.

Anuj kumar et al (2017) studied on local foundry shop in Haryana and objective of my study are: 1. to identify the root factors causing casting defects in Brake drum. 2. To improve the quality by reducing the casting defects in Brake drum. 3. Compare the defects in Brake drum with and without DMAIC.

Jaykar Tailor and Kinjal Suthar (2017) presented a review on reducing defects in various areas by Six sigma DMAIC Methodology. In modern era, the Six Sigma tools and techniques have been implemented in various sectors, which strive to ameliorate continuous improvement in achieving less variation, cost and high quality of end products. Six Sigma emerged as a natural evolution in business to increase profit by eliminating defects. Six Sigma is a powerful world class improvement business strategy that enables companies to use simple but powerful statistical methods to define, measure, analyze, improve and control (DMAIC) processes for achieving operational excellence. In this paper, how DMAIC approach is carried out that has been reviewed from different research papers.

Patil Sachin S and Naik Girish R. (2017) prescribed comprehensive review of work pertaining to process improvement techniques used for defect minimization in casting. In India many foundries have followed conventional and manual operations. Foundry industries suffer from poor quality and productivity due to large number of process parameters combined with lower penetration of automation and shortage of skilled worker.

Mould shifting, sand inclusions, poor surface finish, shrinkage, porosity, cold shut and flash are common casting defects in casting. Since casting process involves complex interaction among various parameters and operations related to metal composition, method designs, melting, pouring, shake-out, fettling and machining and hence need to improve.

Darshana Kishorbhai Dave (2017) applied DMAIC (Define, Measure, analysis, improve, control) approach. The emphasis was laid down towards reduction in the defects (Blow holes, metal spread out, Surface cracks, uneven metal layer thickness) occurred in the castings by controlling the parameters with DMAIC technique. The results achieved show that the rejection due to defects has been reduced from 31.703% to 12.82%.

Borikar et al. (2017) worked on Optimization of casting components by Minimizing cold shut defect. They observed that 80% of rejections are mainly due to cold shut. The authors carried out different techniques to minimize Cold Shut. This defect also in the moulds which are not properly vented because of the back pressure of the gases. By various control tools, the ranges of temperature, Phosphorous, and Silicon are find out.

Vivek V. Yadav and Shailesh J. Shaha (2016) presented research work carried out in foundry to minimize casting rejection due to major defect. A problem is facing with the single cylinder head. Study focuses on analysis of Blow hole defect which contributes more in total rejection percentage.

Quality analysis is carried out which includes the Root cause analysis to find out actual reasons behind occurring the blow holes. Quality control tools such as Pareto analysis, Cause and Effect (Ishikawa) diagram, and why-why analysis are used for analysis. Accordingly corrective actions and preventive measures are suggested and implemented. Central gas vent cleaning practice is added as a check point in process control check sheet and Pasting of wet

green sand on central gas vent during mould box assembly is added as process compliance.

Evaluation of effectiveness after implementation of these changes shows significant reduction in rejection due to blow hole as well as in total rejection. Rejection due to blow hole is minimizes from 7.74% to 1.81%. It turns into considerable reduction in total revenue loss as well as productivity improvement by 8.60%.

Suraj Dhondiram Patil et al (2016) study carried out for a green sand casting manufacturing industry. Here Six Sigma methodology is used for the part: Transmission Case. DMAIC (Define–Measure–Analyze–Improve–Control) methodology along with Taguchi method is used to minimize the defects in the Transmission Case. The major tools used in this work are the project charter, process map and cause-and-effect diagram.

Use of design of experiments (DOE) and analysis of variance (ANOVA) techniques are combined to determine statistically the correlation of defects with the mould hardness, green strength, and pouring rate also to find their optimum values needed to reduce/eliminate the defects.

The experimental results were statistically analyzed and modeled through Taguchi analysis. Based on the findings, the optimized process parameters are taken for experiment and better performance obtained in the production process was confirmed.

The comparison between the existing and the proposed process has been attempted in this paper and the results have been discussed in detail.

Harvir Singh and Aman Kumar (2016) investigated the casting defects like pinholes, scabs, sand holes, slag, mould shifting, parting line defects, runner & riser defects which mainly occurs in valve casting in foundry. The research on controlling the casting defects in foundry shop which comes in various check valves -PN 10 and these causes may results the reduction of quality of casting.

Here we have studied minimize the casting defects using Taguchi's method through change in various parameters like as pouring temperature, green strength, mould hardness and permeability. These experiments were conducted based on standard acceptable and foundry men experience in this casting organization for casting check valves - PN 10 of various sizes & type's significant changes are taken during controlling the parameters.

First we collected the data as casting defects from AV VALVE Pvt Ltd, Agra. Identify the major defects which are scab, cold shut and shrinkage. Complete this task we analyze the cause of this casting defects with the help of fish bone diagram.

So we conclude that there are four parameters responsible for these casting defects. 1. Pouring Temperature (oC) 2. Sand Particle Size (AFS) 3.Mould Hardness Number 4. Permeability Number First we define the range of these parameters and then we perform the casting process at different trial and find that average percentage rejection is 6.25 of the casting product.

Then we apply the Taguchi's method and use of MINITAB 17 software to find out the optimum solution. These optimum solutions were applied on casting process and the calculated the percentage rejection 4.416 of the products. Thus we could improve 1.25% in casting defects.

V. CONCLUSION

Understand current scenario of foundry industry. in now a day's foundry industry produce product different types like ferrous and non- ferrous, this case study mainly focuses on steel foundry, present china provide casting product good quality with less time various types of casting process like melting, moulding, core making, melting, pouring, shake out. Study about various casting defects occur in foundry industry like shrinkage, blow hole, porosity, pinhole, sand inclusion, cold shut, miss run, surface discontinuity, mould break, flash etc. Give idea about how to occur defects and which types of precaution taken in future. process mapping means flow process chart – material types in which shows all activity from raw material to finish goods with time, find non value added activity and remove it.

Tools & technique used in foundry industry based on quality and productivity aspect like 7 QC–tools, DOE, Taguchi method, method study, TQM, TQC, just in time, casting simulation techniques, six sigma–DMAIC method etc. Understand implementation of this technique in foundry industry at last which types of benefits occur after implement methodology.

Many researchers have conducted experiments to find the sand process parameters to get better quality castings. They have successfully reduced the casting defects considerably up to 6% by proper selecting sand parameters. DoE is the technique which can be implemented in any processing industry. In India there are number of small scale industries which can implement such techniques to improve the yield, give standard process parameter and increase the effective capacity of the unit.

From the study of all the research paper we conclude that six sigma is a breakthrough improvement methodology with the use of six sigma it is confirm that we get a min.50% improvement, if we work hard and top management involvement is good.

It can also be concluded that DMAIC methodology is mostly used by the industries for their performance improvement. This study will help small scale foundry to initiate Six Sigma projects in their organizations and improve their performance in terms of customer satisfaction as well as financial benefits with increase in competitiveness in worldwide market of foundry.

REFERENCES

[1] Neamat Gamal Saleh Ahmed, Hanaa Soliman, Mohamed Fahmy (2018), Defect Reduction Using Six Sigma Methodology in Home Appliance Company: A Case Study, Proceedings of the International Conference on Industrial Engineering and Operations Management Washington DC, USA, September 27-29.

[2] Wasim Ahmad, Anil Verma, Priyanka Jhavar (2019), A review on casting defects reduction in a foundry shop using DMAIC technique, International Journal of Advance Research, Ideas and Innovations in Technology, 5(2), pp. 1449-1454.

[3] Anuj kumar, Naveen kumar, Dinesh kumar (2017), —Defects Reduction In Brake Drum In Foundry Shop Using DMAIC Technology, International Journal of Scientific Research Engineering & Technology, Volume 6, Issue 7, PP: 114-119.

[4] Jaykar Tailor, Kinjal Suthar (2017), —Review on Defects Reduction in Multiple Sector by Using Six Sigma DMAIC Methodology, International Conference on Ideas, Impact and Innovation in Mechanical Engineering, Volume5, Issue 6, PP: 111-116.

[5] Suraj Dhondiram Patil, M Ganganallimath, Roopa B Math, Yamanappa Karigar (2017),—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, Volume 2, Issue 6, PP: 37-42.

[6] Darshana Kishorbhai Dave (2017),— Implementation Of DMAIC Methodology To Casting Industry, International Journal of Advance Engineering and Research Development, Volume 4, Issue 8, PP: 369- 374.

[7] Vinod Borikar, Kapgate N., Prashant G. Wairagade, Rani A. Kshirsagar, Aniket D. (2017), —Optimization of casting components by minimizing cold shut defect, International Journal Of Advance Research And Innovative Ideas In Education, Vol- 3, Issue-2, PP 124-128.

[8] Vivek V. Yadav,Shailesh J. Shaha , (2016) "Quality Analysis of Automotive Casting For Productivity Improvement By Minimizing Rejection", International Journal of Mechanical and Production Engineering, 4(6), pp. 1-8.

[9] Suraj Dhondiram Patil, M Ganganallimath, Roopa B Math, Yamanappa Karigar (2016),—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, Volume 2, Issue 6, PP: 37-42.