JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

"A REVIEW OF DMAIC (DEFINE, MEASURE, ANALYZE, IMPROVE, AND CONTROL) PROCESS USING SIX SIGMA"

Name - Luvvesh Kumar Kaushik

Professor Qasim Murtaza, Dr.Mohd. Shuaib

Department of Mechanical Engineering

College -Delhi Technological University

ABSTRACT

Casting is a method of forming a product into the desired shape by pouring liquid metal into a mold that already contains the product's shape. The finished product is commonly called to as a casting. Casting companies must deal with issues such as blowholes, shrinkage, and cracks, which cause customers to reject the product because it does not meet their standards. This means that the company is losing money. In this paper, a "zero defects" approach known as "six sigma" was used to reduce casting flaws and speed up production to meet customer demands. A six sigma-based approach called as DMAIC (Define, Measure, Analyze, Improve, and Control) has been used as a problem-solving method to reduce casting defects by controlling various parameters and processes. Using the six sigma (DMAIC) technique to reduce casting defects yielded excellent results in terms of reducing production wastes and, consequently, costs. This paper's application is to demonstrate how six sigma can be used in the small-scale foundry industry. This paper's application is to demonstrate how DMAIC can be used in the real world to reduce casting failures and reduce the rate of rejected products.

INTRODUCTION

Six sigma define a business process that significantly improves a company's bottom line. This is accomplished by designing and monitoring daily business operations in ways that reduce waste and resource use while increasing customer satisfaction. Six Sigma is a business-driven, multifaceted approach to reducing errors and improving the efficiency of a process. Six Sigma is a well-structured process that focuses on reducing variation, measuring nonconformance, and creating problem-free products, processes, and services. Motorola was the first company to implement the six sigma method in the mid-1980s. In 1988, Bill Smith, an engineer and statistician at Motorola who worked on electronic products, introduced the six sigma concept to the company with the goal of correcting existing quality issues. The Six Sigma management method focuses on better understanding customer needs, improving business systems throughout the organization, and improving the organization's financial performance. It is used to improve the organization's products, services, and processes in a variety of areas including manufacturing, product development, marketing, sales, finance, and administration. It is accomplished by understanding how processes work and reducing or eliminating errors and waste. The Six Sigma management method integrates a wide range of expertise in statistics, engineering, process, and project management.

LITERATURE REVIEW

Motorola Bill Smith started Six Sigma approximately 25 years ago, expanding on Deming's whole quality management concept, principles, and procedures. Since then, numerous of firmshave adopted particular training and project management procedures to become six sigma corporations. It became necessary to evaluate the academic contributions to six sigma as the linked area of study matured because of its industry-based roots.

According to Ahmadet al (2019) Lean Production, ISO Certification, Total Quality Management, Quality Circle, and many more product innovations are used to achieve worldwide compatibility and company and organizational excellence. In spite of this, the outcomes of their efforts were both timely and unprofitable. Developing and implementing an approach that might result in considerable change in a short amount of time is the goal here. Anapproach like Six Sigma may provide big results in a short time period, but it must also be thoroughly investigated to determine its use in terms of efficiency, market share or benefit for quantum advancements in consumer pleasure.

Ahmed et al. (2018) Companies benefit greatly from Six Sigma's problem-solving capabilities,which make it a wonderful tool to have at their disposal. This study examines the use of the SixSigma methodology in the Egyptian home appliance industry. Both flaws are identified and described in detail using Six Sigma DMAIC approaches, and the essay provides a trustworthy plan for minimising their severity (definition, measurement, analysis, improvements, and control). An experimental design (DOE) and regression analysis helped determine the optimaltemperature for both the molten aluminium metal and the rise in defects. Moreover Aluminummolten metal temperature has a substantial effect on the quantity of defects in aluminium components, according to research and statistical analysis using Six Sigma (DMAIC) approach(DOE and regression analysis).

Anuj Kumar et al (2017) The purpose of my investigation is to: 1. Determine the root causesof brake drum casting issues. 2. Identify a nearby Haryana foundry. By reducing faults in the casting of the brake drum, you may increase efficiency. With and without DMAIC, examine brake drum issues.

Jaykar Tailor and Kinjal Suthar (2017) A quality control system based on the six sigma methodology. Defect reduction in numerous domains was studied using the DMAIC Methodology. In recent years, Six Sigma methods and strategies have been utilised in a wide range of sectors to enhance the efficiency, cost, and diversity of final goods. In order to boost profits by eliminating errors, Six Sigma originated as an organic market development.6. Companies may use Six Sigma to design, measure, analyse, improve, and manage (DMAIC) processes via the use of basic but effective mathematic tools. Throughout the paper, they examine several research publications to see how the DMAIC method is used.

Patil Sachin S and Naik Girish (2017). There is a lot of interest in R's process managementstrategies for casting fault reduction. Conventional and non-conventional funerals were common throughout India. Because of the high degree of process parameters, the low level of automation, and the lack of properly educated employees, the foundation industries have poor quality and productivity. Sand inclusions, poor surface quality, disinvestment, porosity, cold shut, and flash are among the main casting flaws that migrate. Techniques like melting, pouring,shaking, fettling, or machining must be improved since casting involves a dynamic relationship between numerous composition-related criteria and operations.

Darshana Kishorbhai Dave (2017) DMAIC was employed (Defining, Measuring, analysing, improving, controlling). The DMAIC settings were tweaked to eliminate both casting faults (blow holes, metal spreads, surface splits, and irregular layer thickness) and defects (blow holes,metal spreads, surface splits, and irregular layer thickness) (Blow holes, metal spreads, surfacesplits, irregular layer thickness). Defect-related rejection has decreased from 31.703 percent to 12.82 percent, according to the findings.

Borikar et al. (2017) I worked on a project called Casting Part Optimization by Reducing ColdShut Flaw. Cold shut was shown to be the major cause of 80% of refusals. The authors used a number of strategies to minimise Cold Shut. This weakness may also be seen in moulds that arenot adequately ventilated due to gas back pressure. Temperature, phosphorus, and silicon levels were all controlled using various control tools. The lowest defect temperature is 1362–1382°C,which reduces the Cold Shut to 0.06 percent for minimal defects between 9% and 5% and the Silicon range between 2.4 and 2.6 percent.

Vivek V. Yadav and Shailesh J. Shaha (2016) For the sake of reducing casting rejects, a newresearch has been presented at the foundry. Single-cylinder head issues are major problems. Blowing holes are a major contributor to the overall rejection rate in this investigation. The rootcause analysis is necessary to establish the true cause of the blow holes. What is the purpose ofquality management tools like the Pareto diagram and the Cause and Effect diagram (Ishikawa) and why are they used? Therefore, remedial and preventive measures are recommended and performed. " Wet green sand on the central gas vent during moulding is put to the process control check board as a control point and as a process enforcement. Blow hole rejection and overall rejection have dropped significantly after these adjustments were implemented. The blow hole rejection ranges from 7.74

percent to 1.81 percent. There is an 8.60 percent rise in production and a decrease in gross sales loss of almost half as much.

Suraj Dhondiram Patil et al (2016) A study was done to discover how to make green sand casting. The Six Sigma approach is being used to apply it to the component transmission situation. Defects in the transmission case may be eliminated entirely using the Taguchi approach and the DMAIC technique. "Define-Measure-Analysis-Improve-Control" is the acronym for DMAIC. It is essential to have a project contract, phase map, and cause-and-effectdiagram on hand at all times throughout a project. Faults and mould hardness, green power and pouring rate will be analysed using design of experiments (DOE) and analysis of variance (ANOVA) to identify optimum values for reducing/eliminating defects in the cast iron castingprocess. Taguchi analysis was used to analyse or forecast the findings of the study. Based on the findings, new process parameters were implemented and the outcomes were much better than the baseline. For this essay, the primary goal is to distinguish between present and suggested methods, which will be discussed extensively in the next part.

Harvir Singh and Aman Kumar (2016) Cast faults, including pinholes, shafts, sand holes andslags as well as mould modifications, dividing lines defects, rider and rider flaws and other castdefects, were examined. PN 10: Foundry shop management of casting faults across many valves, which might reduce casting efficiency. By altering variables including pouring temperature, green pressure, mould hardness, and penetrability, they investigated Taguchi

strategies for minimising casting faults. At this casting company, the tests were carried out using standard-suited and foundry men's experience of casting valves PN 10 with varied sizes and significant parameter variations.

Singh and Kumar (2016) Valve control difficulties such as cold shut, shrinkage, and scab wereinvestigated. In research, the Taguchi approach is utilised to reduce faults caused by flow temperature, permeability, mould toughness, and sand particles. For testing reasons, the L9 orthogonal range is employed. The S/N Rate response, contribution to other process variables, and interactions between S/N ratio both levels and other process parameters are all investigatedin order to get optimum process parameters. After a variety of experiments and procedures, theoptimal validation temperature was determined to be 13400°C, with a permeability of 150(No),a sand particle size of 42 AFS, and a mould hardness number of 91.132.

Nimbulkar and Dalu (2016) In order to better comprehend the final solidifying region, the casting and removal of these defections were worked on as part of the gating device design. They used the Auto-CAST X1 simulation tool to duplicate a prior gating system for efficiencyand malfunction testing, following which they made changes to the present gating system. Because the molten metal flux was not uniform and gases were fast escaping into the atmosphere, they realised that the vertical raising technique was no longer acceptable for thickcasting components; as a consequence, they devised a horizontal raising system for such components. The number of food-related malformations has dropped by roughly 30%.

Chintan C. Rao and Darshak A. Desai (2015) The major topic of this research study is a broad examination of the publishing and case industries, as well as the methodology used by the business. It also goes through the different techniques and processes utilised by businesses, as well as the advantages of using the DMAIC approach. The efforts of the industry are detailedin this report, which also includes a specific publication and case study.

Javedhusen Malek, Darshak Desai (2015) Dedicated to paving the way for Indian SMEs to adopt Six Sigma in their respective industries. The essay looks at Six Sigma's reliance on a small Indian operation to reduce reject/rework rates while employing the pressure die casting process to produce materials. The preceding article discusses the integration of all DMAIC phases in process, as well as the influence of Six Sigma on quality assurance.

Shantanu Joshi and B.R. Jadhav (2015) There has been a documented improvement in the reduction of casting flaws and the increase in production in the vehicle component. The authorused a combination of experimental and technical design to investigate the issues associated with sand in shell mould casting. Through the use of a cause-and-effect diagram, it was possibleto determine the fundamental cause of troubles and parameters. Once again, the most crucial circumstances for experimentation have been identified. On the basis of Taguchi, nine observations and responses are carried out. The ANOVA test is used to determine the percentages of casting rejection that have a statistically significant impact on the casting processparameters. The failure rate has dropped from 3.2 percent to 1.5 percent in the last year.

METHODOLOGY

Six Sigma is an evolutionary, not revolutionary, quality management methodology that incorporates a variety of valuable quality management methods. As a result, it's not unexpected that the six sigma, TQM, lean, and ISO methodologies overlap. Six sigma's basic approach is driven by a deep knowledge of consumers, and it necessitates the disciplined use of factual data and statistical analysis, which is divided into five phases: define, measure, analyse, improve, and control (DMAIC).(Tailor, J., & Suthar, K.,2017).

The define phase identifies the issue and establishes the project's objectives and deliverables. The essential to quality (CTQ) features are selected and the measurement system is examined in the measure phase. To guarantee data quality, the nature and qualities of the data gathering must be properly understood. In the analyze phase, both quantitative and qualitative techniques are employed to separate the critical information needed to explain problems. The main components and processes are continually managed and monitored throughout the enhance phase to ensure that the improvement is durable and that the issue does not return.

The DMAIC process

We're using the DMAIC technique in particular phases to move our emphasis away from the output performance (i.e., y) and toward the fundamental cause (i.e., x). We convert a practical issue into a statistical problem (mapping x and y), find a statistical solution for it [e.g., solving y = f(x)], and then convert the statistical answer into a practical one using these procedures. Figure 1 depicts each stage, which is discussed in the next part, with the relevant critical tools mentioned in a subsequent section. (Trimarjoko et al,2019).

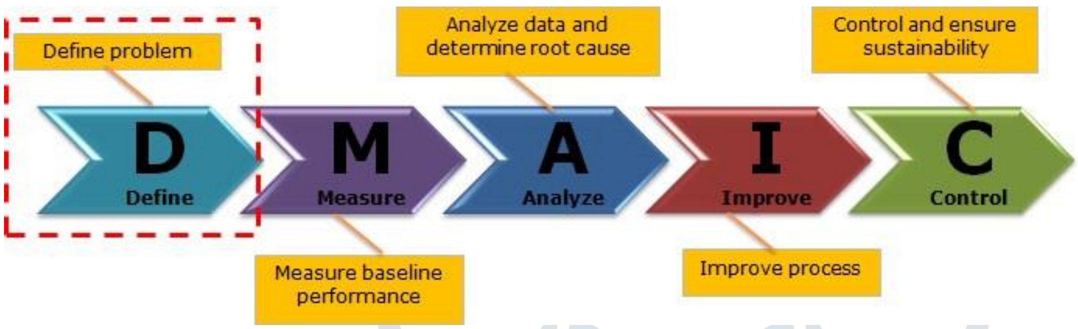

Figure- 1: Phases of Six Sigma.(Kumar, D. et al,2015)

- Phase 1: Define (D)

Here, the project's goals, scope, team structure, and timetable are all laid out for you, so you can get started on your Six Sigma journey. It is expected that we will have a detailed operational definition of the project matrix at the end of this phase. Determine who the customer is, choose the project area, identify the project purpose, scope, and resources, and outline the duties of the team members to ensure the project's value. Estimate profit and cost for this project. SIPOC (suppliers, input, process outputs, and consumers) are all significant instruments in this phase, as is the project charter.

- Phase 2: Measures (M)

We can only know where we're going if we know where we are now, and we can only prepare for the future if we know where we are now. This information is obtained by taking actions during the measurement phase. This phase includes the selection of quality-critical (CTQ) measures, the formation of deliverables, and the quantification of measurability.

- Phase 3: Analyse (A)

After identifying the y in process, we utilize a variety of management and statistical methodologies to unearth the x that will be used to develop future improvement plans and to identify the reasons of variation that will be used to develop those plans.

Establish the baseline

Determine the present process's process capacity to get a sense of where we're at. Heuristics like as histograms and process capability indices (PCI) are important tools to employ in collecting and analysing current process data. We also must compute the defects per million opportunities (DPMO) and the z-score (Z).

Determine improvement plan

To make the project's purpose obvious, we quantify the improvement goals. Hypothesis testing may help us evaluate if the improvement goals vary substantially from current performance (i.e. the baseline). Benchmarking, hypothesis testing, and analysis of variance (ANOVA) are a few of the most important methods.

Identify variation sources

We create a list of all the probable variables (x) that might have an impact on the performance of y. A regression analysis may be carried out, if necessary, in order to determine the potential value of x. Among the most important tools are brainstorming, cause and effect diagrams, regression analysis, and so forth.

- Phase 4: Improve (I)

As we learn more about the root causes of variance, we will be able to address them. The design of experiment (DOE) is a vital strategy to help us quantify the relationship between the y and x, and to enhance the process by determining the ideal setting of x for each y in the improve phase. Three implementation steps are followed in this phase: Identify probable sources of variation, establish a variable connection, and create a strategy for execution.

Screen Potential Sources of Variation

In the next phase, we separate the few essential x from the numerous inconsequential x that exist. DOE is a critical tool in the screening of risk factors. It is possible to conduct both full factorial and fractional factorial experiments. If historical data is required, it should be handled with caution, and a comparable model or simulation may also be employed if necessary.

Discover Variable Relationships

We create the transfer function [y = f (x)], which connects the crucial x to the y. We next establish and check the ideal settings for the crucial x based on this. DOE is also an important technique for characterization and optimization. In this stage, many DOE approaches such as response surface methods (RSM), resilient design, and the Taguchi method may be used. In addition, modelling and surveys may be utilized to discover the association.

- Phase 5: Control (C)

When we find out how to fix it, we want the process improvement we create to be long-lasting. A control phase, which includes the deployment of measurement devices, is performed to ensure long-term success. Consider the financial benefits and develop a transfer plan now. Verifying the implementation strategy, guaranteeing input and output control, and monitoring and maintaining the change are the first three steps. Validate the Implementation Plan

Measurement systems will be validated on the x in order to evaluate how effectively they regulate x. If necessary, improvements will be made to the measurement system prior to moving ahead. DPMO and new sigma values will also be reported at this stage.
Control Inputs and Monitor Outputs
In this stage, we establish a monitoring strategy for the y and x and identify how each essential x may be regulated (e.g., variable control chart, error proofing, etc.). Statistical process control (SPC), attribute control charts, variable control charts, Pokka-Yoke, and other techniques are important. Sustain the Change

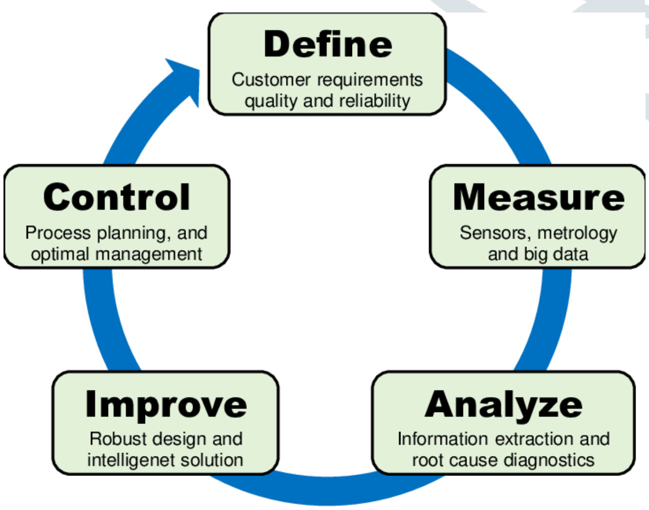

Figure 2 DMAIC Approach (Kumar, S,2020)

This step's goal is to make sure that changes stick once the improvement method is applied. Each x requires the development and implementation of process control. We'll also look at the financial benefits that may be realized and whether or not this project can be applied to other areas, lines, sites, or processes. Out of control planning, error proofing, audit strategies, and other tools are important in this last level.

CONCLUSION

So, in conclusion, we can say that this paper shows the Six Sigma strategy in the Indian foundry industry by reducing defects, scrap, and waste in foundry operations. With an increase in the Six Sigma quality level, this effectively improves production efficiency and productivity. Six Sigma is easier to apply when it is based on the DMAIC method, which is more inspiring and aids in the removal of various barriers. We can bridge the gap between theory and practice with the help of effective theoretical knowledge on various statistical tools and software, as well as the application of different tools in different DMAIC phases. Management must be developed in order to bridge the gap between the theory and practice of six sigma in order to increase profit margins and bring business excellence. Several Indian foundries can increase from the Six Sigma method by improving results, increasing rejections, and increasing annual yield. Six Sigma can also be used in foundries to improve processes and create "zero defect units," which can result in significant cost savings.

REFERENCES

1. Ahmad, W., Verma, A., & Jhavar, P. (2019). A review on casting defects reduction in a foundry shop using DMAIC technique. *Int. J. Adv. Res. Ideas Innov. Technol.*, *5*(2), 1449-1454.
2. Ahmed, N. G., Abohashima, H. S., & Aly, M. F. (2018). Defect reduction using six sigmamethodology in home appliances company: A case study. In *Proceedings of the International Conference on Industrial Engineering and Operations Management* (pp. 1349-1358).
3. Albliwi, S. A., Antony, J., & halim Lim, S. A. (2015). A systematic review of Lean Six Sigma for the manufacturing industry. *Business Process Management Journal*.
4. Antony, J., Gijo, E. V., Kumar, V., & Ghadge, A. (2016). A multiple case study analysisof Six Sigma practices in Indian manufacturing companies. *International Journal of Quality & Reliability Management*.
5. Bhat, S., Gijo, E. V., & Jnanesh, N. A. (2014). Application of Lean Six Sigma methodology in the registration process of a hospital. *International Journal of Productivity and Performance Management*.
6. Bilgen, B., & Şen, M. (2012). Project selection through fuzzy analytic hierarchy processand a case study on Six Sigma implementation in an automotive industry. *Production Planning & Control*, *23*(1), 2-25.

7. Borikar, V., Kapgate, N., Wairagade, P. G., Kshirsagar, R. A., & Aniket, D. (2017). Optimization of casting components by minimizing cold shut defect. *International Journal Of Advance Research And Innovative Ideas In Education*, *3*, 124-128.
8. Chandel, R., & Kumar, S. (2016). Productivity enhancement using DMAIC approach: a case study. *International Journal of Enhanced Research in Science, Technology &Engineering*, *5*(1), 112-116.
9. Chatrad, B., Kammar, N., Kulkarni, P. P., & Patil, S. (2016). A study on minimization ofcritical defects in casting process considering various parameters. *International Journal of Innovative Research in Science, Engineering, and Technology*, *5*(5), 8894-8902.
10. Chaudhari, S., & Thakkar, H. (2014). Review on analysis of foundry defects for quality improvement of sand casting. *International Journal of Engineering Research and Applications*, *4*(3), 615-618.
11. Dabade, U. A., & Bhedasgaonkar, R. C. (2013). Casting defect analysis using design of experiments (DoE) and computer aided casting simulation technique. *Procedia Cirp*, *7*, 616-621.
12. Dambhare, S., Aphale, S., Kakade, K., Thote, T., & Borade, A. (2013). Productivity improvement of a special purpose machine using DMAIC principles: A case study. Journal of Quality and Reliability Engineering, 2013.
13. Dave, D. K. (2017). Implementation Of DMAIC Methodology To Casting Industry. *International Journal of Advance Engineering and Research Development*, *4*(8), 369-374.
14. de Albuquerque Marques, P. A., & Matthé, R. (2017). Six Sigma DMAIC project to improve the performance of an aluminum die casting operation in Portugal. *InternationalJournal of Quality & Reliability Management*.
15. Desai, T. N., & Shrivastava, R. L. (2008, October). Six Sigma–a new direction to qualityand productivity management. In *Proceedings of the World Congress on Engineering andComputer Science* (Vol. 6). San Francisco, CA: Elsevier.
16. Gandhi, S., Sachdeva, A., & Gupta, A. (2019). Reduction of rejection of cylinder blocksin a casting unit: A six sigma DMAIC perspective. Journal of Project Management, 4(2),81-96.
17. Gupta, V., Jain, R., Meena, M. L., & Dangayach, G. S. (2018). Six-sigma application in tire-manufacturing company: a case study. *Journal of Industrial Engineering International*, *14*(3), 511-520.
18. Hakimi, S., Zahraee, S. M., & Rohani, J. M. (2018). Application of Six Sigma DMAIC methodology in plain yogurt production process. *International Journal of Lean SixSigma*.
19. Heddure, R. B., & Telsang, M. T. (2014). Casting Defect Reduction Using Shainin ToolIn Ci Foundry–A Case Study. *International Journal of Mechanical And Production Engineering*, *2*, 70-73.