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A Review of Six Sigma Implementation in Small Scale Foundry

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Abstract- Industrial products were manufactured using the casting technique. A few years later, it was used to manufacture weapons and tools using metals such as copper as raw materials. After then, casting was used to create goods with a variety of forms and sizes, as well as various materials such as cast iron and ductile iron. Casting production is important around manufacturing because of its many advantages and requirements. The incidence of casting flaws has a financial impact on the casting business. As a result, fault incidences should be minimized and casting quality should be increased, which may be accomplished via the employment of methods such as six-sigma and quality tools. In this paper, the author reviews previous published papers and identifies areas where the industry needs to work. This paper focuses on the general overview of publication and the case industry. It also discusses the various tools and techniques used by the company, as well as the benefits gained by using DMAIC methodology.

Keywords: Casting defects; Six-sigma; DMAIC process; Taguchi; ductile iron.

I. INTRODUCTION

Casting industries play an important part in the manufacturing industry. Complex form and size goods are created in a single procedure that cannot be produced in other manufacturing methods.

Because the other method requires more than one step to transform a raw material into a finished product. The casting's quality should be maintained without flaws throughout production. This is not feasible since we cannot achieve a 100% accuracy rate. However, some quality control instruments and methods may assist to decrease the proportion of faults. [1]

Industrial products were manufactured using the casting technique. A few years later, it was used to manufacture weapons and tools using metals such as copper as raw materials. After then, casting was used to create goods with a variety of forms and sizes, as well as various materials such as cast iron and ductile iron.

Casting production is important in the area of manufacturing because of its many advantages and requirements. [1]

The incidence of casting flaws has a financial impact on the casting business. As a result, fault incidences should be minimized and casting quality should be increased, which may be accomplished via the employment of methods such as six-sigma and quality tools.

As a result, defect incidences should be minimized and casting quality should be increased, which may be accomplished via the employment of methods such as six-sigma and quality tools. The problem in a specific location is discovered, and modifications are made to minimize the defect. [2]

The External Bearing Ring, which is constructed of ductile cast iron and is one of the major components of the windmill, is examined in this article. The premier casting company in Coimbatore is dealing with a large amount of shrinkage defects on this specific product.

With the assistance of Minitab software, shrinkage flaws are minimized using the six-sigma method and quality control tools. [3]

II. SIX SIGMA

Being extremely disciplined, methodical, customer-centric, and profit-driven, or a company-wide strategic business improvement effort that aids in the development and implementation of solutions, products, or services that are really perfect.

In a different manner, Six Sigma is attempting to decrease the irregularity of processes that leads to mistakes. Six Sigma has been seen as a competitive business effort aimed at increasing profitability, market share, and customer satisfaction by using statistical instruments and methods that may result in substantial efficiency gains. Six Sigma is a technique of process and product optimization that combines financial and methodological accounting components.

Many quality assurance efforts, including as bend manufacturing, ISO certification, comprehensive quality management, quality circle, and so on, are undertaken in order to become internationally compatible with and acquire market and organizational excellence sectors. The results of these initiatives, on the other hand, are timely and not so lucrative.

As a result, it is critical to adopt and implement a technique that will develop effectively in such a short time frame. Six Sigma is an acronym that stands for "six is the same method that can provide rapid collapse changes, and it is critical to investigate its use in order to gain efficiency, market share, and customer retention Benefits and profits from qualitative analysis.

To achieve Six Sigma accuracy, a process must produce more than 3.4 faults per million chances. A potential of failure is defined as "an opportunity," or failing to comply with the criteria.

This implies that our major operations must operate nearly perfectly.

1. Strategy:

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

2. Key Concepts of Six Sigma:

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

- **Critical to Quality:** Attributes most important to the customer
- **Defect: Failing** to deliver what the customer wants
- **Process Capability:** What your process can deliver
- **Variation:** What the customer sees and feels.

3. Methodology of Six Sigma:

Six Sigma is a stand for "six A sigma, which evaluates a method's ability to achieve flawless efficiency, is also known as a statistical measuring unit. Six sigma is the number of sigma's computed in either a process where the change around the goal is so high that only 3.4 out of one million outputs become faults or in a process where the entire process now goes up to 1.5 standard deviations over time.

The word "sigma" refers to the spread or dissemination of a process's meaning. Sigma This test determines if the process is capable of producing work that is free of faults. Any mistake causes the customer to be dissatisfied. The sigma value is, in fact, a measure of how well a company process performs. A higher sigma level indicates a lower risk of faults and, as a result, greater performance.

4. Six Sigma and Indian SMES:

In today's market of globalization and competitiveness, Indian companies use sophisticated methods to enhance productivity, such as Six Sigma and other continuous quality improvement initiatives. Since Indian SMEs are expected to compete on the global market, they must be familiar with global quality standards and customer demands.

To meet these international standards, Indian businesses have to adopt continuous process improvement techniques such as Six Sigma (Sambhe, 2012). It's worth remembering that although Six Sigma's success in big sectors may be demonstrated in a variety of ways, few SMEs have implemented Six Sigma in their business, indicating a lack of understanding of the impact of Six Sigma on SMEs.

According to research on Six Sigma's penetration in Indian sectors, including its benefits, 69 percent of Six Sigma is used in the manufacturing industry. IT is ranked second, with a 15% share of the market.

Manufacturing and service, as well as other things, were included in Six Sigma with a percent contribution. For large-scale industries, "cost reduction" is the most important advantage, while for SMEs, "profitability growth" is the most important benefit.

Attempts to show the impact of Six Sigma in Indian SMEs include the effective application of the Six Sigma method in a small-scale foundry business to reduce refusals and redesign the leaf springs manufacturing process.

All critical input variables were improved using the Six-Sigma project, resulting in a reduction in total rejection from 48.33% to 0.79 percent. Six Sigma's implementation resulted in an annualised savings increase of USD 8,000 per year. (Gijo et al., 2014).

In order to reduce manufacturing costs for reprocessed track shoes, Indian SMEs used a promising Six Sigma technique. With the optimization of key input factors, the sigma level was raised from 1.51 to 4.15, resulting in a reduction in poor quality costs (COPQ) from Rs. 22,72,480 to Rs. 20,187 per year. Six Sigma increased the savings of Rs 2,252,293 per year and the ROI significantly (Gholap and Desai, 2012).

Some of the finest practices are carried out by many authors in Indian SMEs. Six Sigma was effectively utilized to improve efficiency and productivity in the aluminum plating process, lowering defect rates from 17.22% to 4.82%. (Shanmugaraja et al., 2011). Six Sigma was utilized to lower the sleeve rejection rate, resulting in increased production and profitability.

The six Sigma methods were used at an Indian foundry to reduce the piston rejection rate in one of the categories (Singh and Khanduja, 2012). Successful operations in Indian SMEs show better customer commitments, as well as increased efficiency and quality (Desai, 2012).

5. Casting Process:

Patterns, moulding or assembly, sand production, core manufacturing, melting, pouring, and shakeout are some of the casting processes. The entire casting process is critical for complex components. Based on many research, the best foundry technique may be identified, which includes all operations.

Process casting is probably the most widely utilized process in the industrial sector. In casting, procedures such as template for mould packing, core of mould assembly, mount designs, gating system, and sand for mould preparation are all utilized. Remove the prepared moulds and fill them with molten metal. Allow the metal to harden before removing the cooled casting. Because of their ease of use, cost-effectiveness, and ability to produce tiny castings, such techniques are sometimes employed.

Casting is a process, and there is a chance that the final product may fail at some point throughout the process. Process casting is made up of dynamic interactions between several factors or processes such as metal composition, design techniques, moulding, melting, pouring, shake-out, fettling, grinding, and so on.

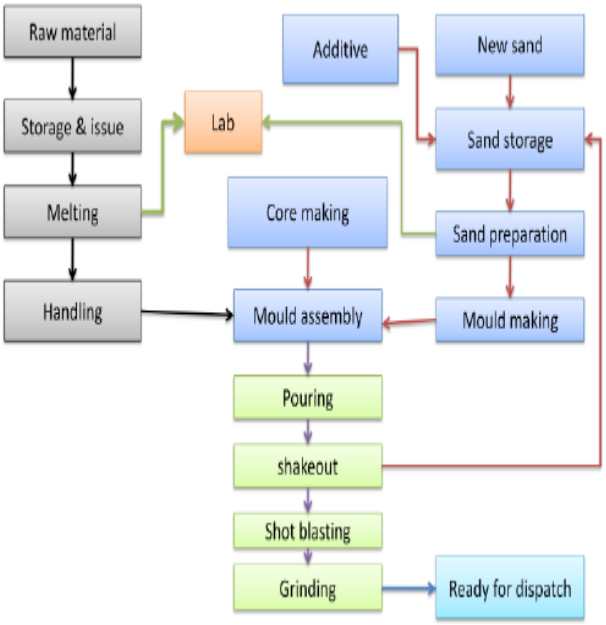

Fig 1. Various casting process from raw material to finish product.

6. Small Scale Foundry-An Overview:

Producing high quality castings multi-directional competition as needed by standards in the age of globalization. Indian foundries are constantly on the brink of becoming competitive. The emphasis, however, is not on operational excellence in general. To thrive globally, foundries must go beyond

'satisfying consumers' to 'pleasing customers,' and embrace and firmly endorse Endeavour.

It wasn't enough to satisfy customer demands; efficiency and efficiency gains may now go above and beyond. For worldwide competitiveness, foundry firms try a variety of methods, including efficiency circles, total quality management (TQM), the International Standardization Organization, and others.

Some of these techniques can produce the intended results, but the darker side of the debate concerns their usage as well as the longer time required to accomplish the desired results. Six Sigma is currently only suited for bigger companies, although it is still appropriate for tiny foundries. There are some myths that are true.

III. RELATED WORKS

According to Ahmad et al (2019) To become globally compatible and to achieve companies and organizational excellence, many product enhancements such as Lean Production, ISO Certification, Total Quality Management, Quality Circle, and others are applied. However, the results of these initiatives were both timely and unprofitable. This entails the development and implementation of a method that may produce significant change in a short period of time. Six Sigma is a similar technique that may provide significant gains in a short period of time, but it is also critical to investigate its use in terms of efficiency, market share, or benefit for quantum advances in customer happiness.

Ahmed et al. (2018) Because of its function as a problem-solving technique, Six Sigma is an excellent tool for helping companies accomplishes their goals. The use of the Six Sigma method in the Egyptian home appliance sector is investigated in this research. The article uses Six Sigma DMAIC techniques to identify and describe systematically the underlying cause(s) of both faults and to offer a dependable strategy for decreasing them (definition, measurement, analysis, improvements, and control).

Furthermore, a design of experiment (DOE) and regression analysis enabled the determination of the optimum temperature for both the aluminums molten metal and the increase in the number of flaws. The research, as well as the statistical study of Six Sigma (DMAIC) technique (DOE and regression analysis), revealed that the aluminums molten metal temperature has a significant impact on defect quantities of aluminums components. After optimizing circumstances, aluminums molten metal defects reduced from 10.49 percent to 6.1 percent, and the Six Sigma ratio improved from 2.8 to 3.06 percent. Six Sigma is also thought to have been an effective technique for reducing mistakes and therefore increasing customer satisfaction and cost savings.

Anuj Kumar et al (2017) has been researching a local Haryana foundry business, and the goal of my research is to: 1. Determine the underlying causes of brake drum casting problems. 2. Increase efficiency by lowering brake drum casting flaws. 3. Examine brake drum problems with and without DMAIC. Compare.

Jaykar Tailor and Kinjal Suthar (2017) Six sigma is a quality assurance system. DMAIC Methodology presented research on defect reduction in several areas. Six Sigma techniques and tactics have been used in a variety of industries in recent years in order to improve the efficiency, cost, and variety of final products. Six Sigma emerged as a natural market evolution to increase profit via fault elimination. Six Sigma is a strong business improvement approach that enables companies to define measure, analyze, improve, and manage (DMAIC) processes using simple but powerful mathematical tools. They look at how the DMAIC technique is used in different research articles throughout this article.

Darshana Kishorbhai Dave (2017) DMAIC was used (Defining, Measuring, analyzing, improving, controlling). The DMAIC parameters were regulated to reduce both the flaws that occur in castings (Blow holes, metal spreads, surface splits, and irregular layer thickness) and the defects that occur in castings (Blow holes, metal spreads, surface splits, and irregular layer thickness). According to the results, defect-related rejection has reduced from 31.703 percent to 12.82 percent.

Borikar et al. (2017) Casting Part Optimization by Reducing Cold Shut Flaw was a project I worked on. Cold shut was shown to be the primary reason of 80% of refusals. For Cold Shut minimization, the authors utilized a variety of techniques. Due to the gas back pressure, this shortcoming may also be

observed in moulds that are not properly vented. Various control tools were responsible for the temperature, phosphorus, and silicon levels. The lowest defect temperature is 1362–1382°C, lowering the Cold Shut to 0.06 percent for the minimum defect between 9% and 5% and the Silicon range between 2.4 and 2.6 percent.

Vivek V. Yadav and Shailesh J. Shaha (2016) A study at the foundry has been presented to reduce casting rejects due to severe flaws. The single cylinder head is a serious issue. The study focuses on blow hole failure studies, which contributes to the total proportion of rejection. To determine the real reasons of the blow holes, the quality analysis necessitates a root cause analysis. Why are analyses employed, and what are the techniques of quality management such as Pareto analysis and the Cause-and-Effect diagram (Ishikawa)?

As a result, corrective and preventative actions are suggested and implemented. Central gas vent cleaning method is included as a control point in the process control check board, and the mounting of wet green sand on the central gas vent during moulds is added as process enforcement. Evaluations of efficiency after these changes show that blow hole rejection, as well as total rejection, has decreased substantially. Between 7.74 percent and 1.81 percent, the blow hole rejection is negligible. It significantly lowers the gross sales loss and increases output by 8,60 percent.

Suraj Dhondiram Patil et al (2016) In order to create green sand casting, a research study was carried out. It is being applied to the component transmission case using the Six Sigma methodology. With the Taguchi strategy and the DMAIC technique, it is possible to eliminate defects throughout the transmission case. DMAIC stands for "Define-Measure-Analysis-Improve-Control."

The project contract, phase map, and cause-and-effect diagram are the most important tools to have on hand throughout the project. Design of experiments (DOE) and analysis of variance (ANOVA) will be used to statistically analyze the connection between faults and mould hardness, green power, and pouring rate, as well as to find the optimal values for reducing/eliminating defects in the cast iron casting process. The results were statistically evaluated or predicted using Taguchi analysis, which was performed. Experimental work was done with changed process parameters based on the findings and it was discovered that the results were much better than the baseline. The purpose of this article is to differentiate between the current and proposed techniques, and the results are given in great depth in the next section.

Singh and Kumar (2016) Valve control problems such as cold shut, shrinkage, and scab were investigated. In research practice, the Taguchi method is utilized to reduce the sources of faults such as flow temperature, permeability, mould toughness, or sand particles L9 orthogonal range is employed for testing reasons.

The S/N Rate response, contribution to various process factors, and connections between S/N ratios both levels with other process parameters are all investigated to obtain optimum process parameters. After a variety of tests and techniques, the optimum validation temperature was determined to be 13400°C, with a permeability of 150(No), a sand particle size of 42 AFS, and mould hardness number of 91.132.

Nimbulkar and Dalu (2016) The casting and removal of these defections were worked on as part of the gating device design to better understand the final solidifying area. For efficiency and malfunction testing, they utilized the Auto-CAST X1 simulation programmed to replicate a previous gating system, after which they made modifications to the current gating system. They discovered that the vertical raising method was no longer appropriate for thick casting components due to the fact that the molten metal flux was not uniform, and gases were quickly escaping into the environment; as a result, they proposed a horizontal raising system for such components. The number of deformities caused by food was decreased by about 30 percent.

Rohit Chandel and Santosh Kumar (2016) Using a definite measure-analysis-improve-control (DMA ICC) method, it focuses on analysing and eliminating process modifications that impact rejection and workflow at different stages of production. DMAIC lowers the rejection rate from 8.79 percent to 5.30 percent and the rework rate from 12.8 percent to 8.2 percent when used as a problem-solving technique. Also obtained is a substantial improvement in sigma from 2.85 to 3.13.

Harvir Singh and Aman Kumar (2016) Taguchi's Casting Defects Minimization Method has been discovered. The author utilized Taguchi's method and Minitab 17 to identify the best answer in his theoretical study. Data for three months was collected from a foundry after research revealed that 80 percent of rejections were due to cold closes, scab, and shrinkage.

The diagram of the fish bone "Pouring Temperature (°C), Sand Particle Size (AFS), Mould Hardness Number, and Permeability Number" was used to investigate the root cause of the inadequacies. For the experiments, the Taguchi L9 orthogonal array technique is employed. MINITAB 17 is used to determine the best solution, which is 1340°C pouring temperature, 150 permeability number, 42 AFS sand particle size, and 91.132 Mould Hardness Number. The number of rejections was decreased from 6.25 percent to 4.416 percent by using the best solution."

Chatrad B et al (2016) Several flaws have been investigated, including metal melting, alloying, pouring, pouring and filling, ladle impurities, and so on. Finally, the optimal parameters with the fewest casting flaws were developed, as well as the economic implications of key manufacturing processes pertinent to those case studies and potential goals.

At 14200c-14800c, the percentage of rejections is lower. At temperatures as low as 14000°C and as high as 14800°C, the percentage of rejections increases. The incidence of rejection rises as the pouring time increases. As a result of the increased handling time, the number of faulty components has risen. Because of the impurity in the ladle and the mould caused by poor cleaning, porosity and inclusions increased.

C.B. Patel and Dr. H.R. Thakkar (2015) analyzed the study work of many researchers to reduce various flaws and increase production. They conclude that quality tools play a significant role in defect analysis decision-making.

Chintan C. Rao and Darshak A. Desai (2015) The primary focus of this research paper is on a general analysis of the publishing and case industry, as well as the methodologies used by the industrial sector. It also discusses the various methods and procedures used by organizations, as well as the benefits to the company of someone who uses the DMAIC methodology. This report details the industry's efforts, as well as a particular publication and case study.

Javedhusen Malek, Darshak Desai (2015) Focused on opening the path for Indian SMEs to implement Six Sigma in their sector. The article examines Six Sigma's dependence on a small Indian unit to improve reject/rework rates in producing materials using the pressure die casting method. The above article covers the phase-in-progress integration of all DMAIC stages, as well as the impact of Six Sigma on quality assurance.

IV. CONCLUSION

Specifically, they examine the potential of Six Sigma in Indian small and medium-sized companies in their research thesis. Six Sigma deployments in small and medium-sized enterprises (SMEs) is a new quality improvement paradigm that has been embraced by many academics. The goal of the research is to implement the Six Sigma roadmap in SMEs, which are typically thought to exist only in big corporations.

This case study will serve as an inspiration for Indian SMEs to embark on activities that would assist in the expansion of their businesses. According to the findings of all six sigma research papers, six sigma is a game-changing improvement approach.

When using six sigma, we should expect a minimum of a 50% improvement if we work hard and have excellent top management engagement.

It can also be deduced that the DMAIC technique is mostly employed by companies to enhance their performance. This research will assist small-scale foundries in implementing Six Sigma initiatives in their businesses to enhance customer satisfaction and financial advantages while increasing competitiveness in the global foundry industry.

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