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USE OF THE DMAIC METHODOLOGY TO OPTIMIZE DEFECTS IN PISTON CASTING

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Abstract— The goal of this research is to employ the DMAIC (Define, Measure, Analyze, Improve, and Control) Six Sigma Approach to minimize defect rates and improve the sigma level of the sand-casting process. This study specifies a step-by-step guide based on the DMAIC Methodology, and its efficacy has been assessed via a case study that shows an overall decrease in defect rejection and an increase in the process' sigma level from 3.32 to 3.47. Employee Job Satisfaction Following Six Sigma Implementation was also investigated. A total of 60 workers responded to the survey, yielding an 83 percent response rate. The findings suggest that participants in Six Sigma saw improvements in the majority of job satisfaction indicators. This program's implications are discussed, as well as future study objectives. Through an experiment, the study discusses how to reduce casting flaws in foundries. The research looks at how six sigma DMAIC (Define-Measure-Analysis-Increase-Control) methodology may be used in the automotive sector to reduce casting errors in the manufacturing of aluminum pistons, optimize process variables, and improve performance.

*Keywords***—** Six Sigma, DMAIC, Pareto, Piston defects, Cause-and-Effect Matrix

I. INTRODUCTION

Being exceedingly disciplined, systematic, customer-centric, and profit-driven, or participating in a company-wide strategic business improvement initiative that supports in the creation and execution of really flawless ideas, goods, or services. Six Sigma, on the other hand, aims to reduce the irregularity of processes that leads to errors. Six Sigma is a competitive corporate endeavour focused at boosting profitability, market share, and customer satisfaction via the use of statistical instruments and methodologies that may lead to significant efficiency benefits. Six Sigma is a process and product improvement strategy that incorporates both financial and methodological accounting elements.

Many quality assurance measures are conducted in order to become globally compatible with and obtain market and organisational excellence sectors, such as bent manufacturing, ISO certification, comprehensive quality management, quality circle, and so on. On the other hand, the outcomes of these activities are both timely and unprofitable. As a consequence, adopting and implementing a strategy that will grow successfully in such a short period of time is crucial. Six Sigma is an abbreviation that stands for "six steps to success." Is the same strategy that can deliver speedy collapse adjustments, and it's vital to look into using it to enhance efficiency, market share, and client retention. Qualitative analysis has a lot of advantages and gains.

Methodology Of Six Sigma

Six Sigma is a Greek letter that means "six." A sigma is a statistical measuring unit that gauges a method's capacity to reach faultless efficiency. Six sigma is the amount of sigma calculated in a process when the change around the objective is so large that only 3.4 out of one million outputs become defects, or in a process where the whole process has now increased to 1.5 standard deviations over time. The term "sigma" refers to the propagation or diffusion of the meaning of a process. Sigma This test assesses if the process is capable of providing error-free work. The consumer will be disappointed if you make a mistake. In actuality, the sigma value is a measurement of how well a company's process functions. A higher sigma level indicates a lesser probability of errors and, as a consequence, better performance.

Six Sigma has two key methodologies:

Both DMAIC and DMADV Methodologies are based on Deming's Plan-Do-Check-Act Cycle.

- **DMAIC**
- **DMADV**

DMAIC:

The abbreviation DMAIC stands for "define, measure, evaluate, improve, and record," and it stands for "define, measure, evaluate, improve, and record." To construct the DMAIC process, they all collaborate. In six sigma, this phase is critical since it assists in the construction of a dynamic team. This encourages them to develop a strategy or model to describe their task and then follow through with it. It is used to assist a company in expanding its current activities.

DMAIC consists of following steps:

- Establishing process transformation goals that are reflective of client demands and corporate strategy.
- Take measurements and gather data on key parts of the present process.
- Examine the data to determine if there are any cause-and-effect relationships. Determine the interactions and make every attempt to incorporate all of the relevant components.
- Using strategies such as experiment design, develop or enhance the process based on data analysis.
- Check for any faults that need to be addressed even before any deviations from the norm. Set up pilot processes, continue production, implement control mechanisms, and keep an eye on the process at all times.

Figure 1: Five Steps to DMAIC approach ((Ahmed, N. et al, 2018).

DMADV:

The definition, measurement, analysis, design, and verification of how DMAIC may be used to enhance an existing business process is referred to as DMADV. The new model or process configuration has been applied via DMADV.

In DMADV, the stages are as follows:

- Establishing design parameters that match client needs and the company's strategy.
- CTQs, product capacities, manufacturing process capacity, and dangers are all assessed and documented. (Critical to Quality Characteristics).
- Evaluate design and development options, produce a high-quality design, and evaluate design capabilities to choose the best designs.
- Specifications, design optimization, and a design verification schedule. Simulations may be required at this point.
- Check the specifications, execute a few test runs, and then begin the manufacturing process.
- In this study, we'll go through the DMAIC approach in detail..

II. CASTING DEFECTS

However advantageous casting may be, there is one big drawback to this process: the faults that may be present in the finished product. A partial list of casting flaws may be summed up as follows: the product pulled out of the mould may have any of the following probable flaws: (AmericanFoundry Society, 2007).

- **Cracks and crushes**

Craters or crushes may occur during removal of the casting from the mould, as can poor pattern design and clamping.

- **Cuts**

Cuts are rough patches caused by mould or core surface erosion. Excessive pouring temperature or soft or non-uniform moulds.

- **Drops**

Drops occur when moulding sand falls over the casting during solidification or when the mould is broken carelessly.

- **Erosion scabs**

Scabs are faulty pieces of cast metal caused by eroding sand from incorrect moulding during the cooling process. High moisture content, high pouring temperature, and interrupted pouring are all common causes.

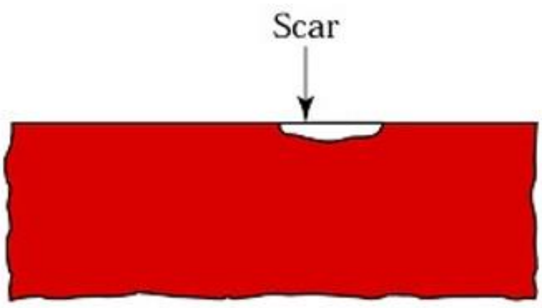

Figure 2: Scabs (Desai et al, 2008)

- **Expansion scabs**

Unwanted roughness Metal layers are applied to the casting. The cause might be due to sand composition or molten metal being poured too slowly.

- **Gas defects:**

The product pulled out of the mould has porosities and gas holes in the cast metal. This might be caused by dissolved gas or a foreign material in the molten metal. Other factors might include a lack of permeability in the moulding material or improperly mixed sand, resulting in excessive gas concentrations in certain locations.

- **Misruns and cold shuts**

Misruns happen when the liquid metal does not fill the mould cavity completely. Cold shuts are undesirable casting discontinuities caused by faulty metal fusion. Insufficient molten metal temperature during pouring or an incorrect metal composition are common causes.

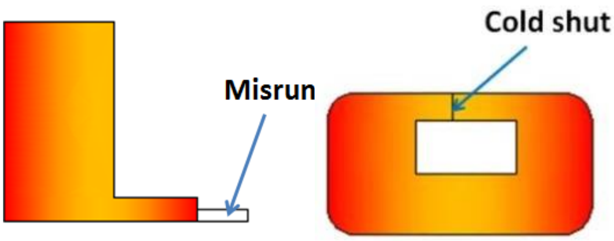

Figure 3: Misruns and cold shut (Gandhi, S,2019)

- **Rough surface**

Casting goods that do not have the requisite surface smoothness Problems with sand grains may be the cause of a rough surface.

- **Shrinkage defects**

Shrinkage may occur for a number of reasons, but it most often occurs when there is a lack of molten metal to correctly feed the cavity when shrinkage occurs due to solidification.

- **Swell**

A swell is the consequence of metal pressure enlarging the mould chamber, resulting in localized and overall casting expansion.

- **Shift**

A shift causes a mismatch in a casting portion, commonly near the parting line. Normally, this flaw is discovered.

III. METHODOLOGY OF SIX SIGMA

Analysis of data using statistical methods, such as Six Sigma, is used to identify the main causes of quality issues and apply controls. Six sigma is often used to boost productivity in the industrial industry. In addition to product creation and supply chain management, the concept may be used in other areas of business.

In the statistical context of six sigma, this means that a process must have a standard deviation of at least six times greater than the process's mean. Six sigma's statistical goals are to decrease process variance and centre the process on the target.

When it comes to quality initiatives, six sigma stands out because of its top-down approach, which requires detailed analysis, fact-based decision making, and a control plan. There is a long-term commitment required for six sigma. Without the full support of senior management, this won't work. Six sigma transforms an organisation by instilling a culture of fact-based decision-making across the organisation. According to Karen riding, a master consultant at the six sigma school, the programme transforms "DNA" of a firm by altering the way leaders think and by strengthening the management pipeline by building management and communication skills in employees.

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).

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.

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 2 depicts each stage, which is discussed in the next part, with the relevant critical tools mentioned in a subsequent section.

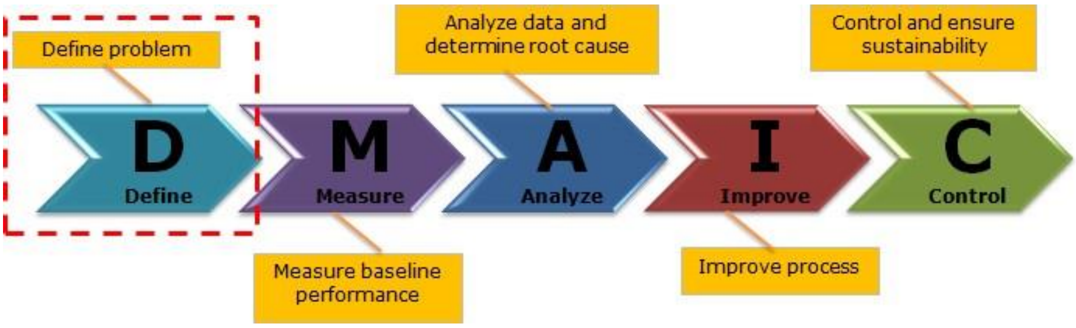

Figure 4: Phases of Six Sigma. (Kumar, D. et al,2015)

- **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.

IV. DATA ANALYSIS AND INTERPRETATION

The measurement phase's purpose is to determine and establish the process's baseline output in terms of process capacity or sigma. As part of this process, they agreed to collect data. Before any data is gathered, it's vital to make sure that the present measuring equipment is adequate to the job. If the measurement equipment isn't completely stable when collecting data, the results won't be reliable, producing issues with the project. The instrument's resilience for information and conversation is assessed using repeatability and reproducibility (R&R) tests. In our situation, the articles were reviewed by two inspectors. The items were just thoroughly scrutinised, with no tools being used in the process. They utilised MINITAB 17 to undertake machine analyses for discrete data since our data is discrete.

- **Data Collection**

On the spot, they collect data. As a consequence, obtaining an appropriate measuring system prior to the commencement of the project is critical. Following the identification of concerns and growth opportunities, a list of issues was compiled-

Table-5.1 Rejection rate of piston

Month	**Production pieces**	**Rejection pieces**	**Gas porosity**	**Inclusion**	**Shrinkage**
Dec.2021	18465	1894	631	778	485
Jan .2022	23218	2629	620	1106	903
Feb .2022	18400	1700	600	630	470
Total	60083	6223	1851	2514	1858

Percentage Rejection in three month (%) = 6223/60083 = 0.1035 X 100 = 10.35%

Table-5.2 Percentage reduction in various defects

Defects	No. of defective piece	Percentage of rejection
Gas porosity	1851	1851/60083 = .03X100 = 3.08%
Inclusion	2514	2514/60083 = .04X100 =4.18%
Shrinkage	1858	1858/60083 = .03X100 =3.09%

Measure phase

The team operating under chartering conducts analysis sessions, and data is gathered for investigating defect reasons. Several influencing and controllable process characteristics are found and assessed after extensive brainstorming. Various faults are assessed quantitatively and subjectively owing to uncontrolled characteristics inherent in the casting process, which are the most important contributors evaluated in the current stage. The most severe flaws evaluated in this study are shown in Figure 5. as a Pareto diagram. Only three primary faults that caused significant alterations (inclusion, gas porosity, and shrinkage defects) are included. Before applying the DMAIC paradigm, the value of Sigma is computed, and it is 3.47.

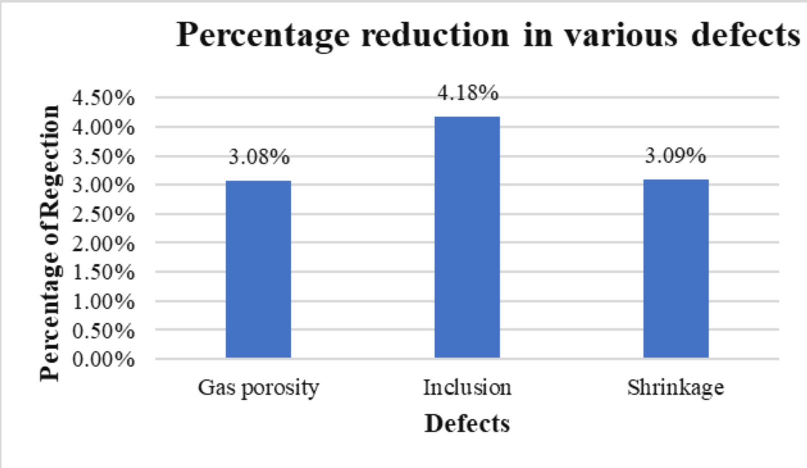

Figure-5. Defects Level

Analyse Phase

It is possible to identify the elements that most significantly affected rejection with the use of a cause-and-effect matrix. The root causes of casting faults are identified and investigated to decrease or eliminate casting flaws. The failure mode and effects analysis (FMEA) is a critical technique for analyzing the impact of failure mode.

Improve phase

During this step, we use the Design of Experiment (DOE) approach to improve the fault that arises during the piston casting process. To optimize the numerous specified parameters, we are employing the Taguchi analysis technique.

Selection of Factor

The replies that piqued our attention were utilized to choose which factors to investigate further. The techniques of cause-and-effect analysis and brainstorming were employed to determine the components that were believed to have an impact on the responses. Table 5.3 contains a list of the variables that were assessed, as well as their levels.

Table-5.3 Selection of parameter

Factor	Level 1	Level 2	Level 3
Pouring temperatureof molten metal (A)	750	770	790
Injection Pressure of molten metal in Kg/cm^2 (B)	170	180	190
Type of coating (C)	Oil coating	Oil + graphite coating	Dycot coating
Type of cooling (D)	Air cooling	Water cooling	Oil cooling

Orthogonal Array

The Taguchi method's great efficiency is due in part to the presence of OA. A sequence of very advanced mathematical procedures, involving combinatorics, finite fields, geometry, and error-correcting codes, are used to obtain OA from factorial design of experiments. The algorithms guarantee that the OA is built in a statistically independent fashion, with each level having an equal number of occurrences within each column, and for any level inside one column, each level within any other column will also occur an equal number of times. The columns are then said to being orthogonal to one another. In the Taguchi technique, OAs are accessible with a range of parameters and intensities. Because each column is orthogonal to the others, if the findings for one level of a certain component vary significantly from those for another, it's because altering that factor from one level to the next has a significant influence on the quality feature being tested.

The number of treatment conditions must be equal to or more than the number of degrees of freedom, and the number of rows in the orthogonal array must be equal to or greater than the number of treatment conditions. After an appropriate orthogonal array has been selected, the factors may be assigned to the various columns in the array. This experiment made use of a L9orthogonal array of five columns and nine rows, as seen in the figure. Therefore, using the L9orthogonal array, only nine tests are required to cover the entire range of casting parameter possibilities. With the L9 orthogonal array, Table 5.4 depicts the experimental setup for determining the casting parameters and their values.

Table 5.4: L9 orthogonal array

Trial no.	Pouring temp	Injection pressure (kg/cm^2)	Coating type	Cooling medium
1	750	170	Oil coating	Air
2	750	180	Oil+ Graphite	Water
3	750	190	Dycot	Oil
4	770	170	Oil + Graphite	Oil
5	770	180	Dycot	Air
6	770	190	Oil coating	Water
7	790	170	Dycot	Water
8	790	180	Oil coating	Oil
9	790	190	Oil + Graphite	Air

V. RESULTS AND DISCUSSION

Signal to Noise Ratio for Response Characteristics

The two types of parameters that have an influence on the result are those that can be controlled and those that cannot be controlled. By assessing the amount of variation in the response, it is possible to quickly identify control factors that may result in a reduction in variance. The uncontrolled factors are the most prevalent causes of variation that are associated with the operational environment in most cases. Table 5.5 is a summary of the response characteristics for this investigation.

Table 5.5: S/N Ratio Response characteristic

Response Name	Response Type	Unit
Density	Higher is better	gm/cm^3
Hardness	Lower is better	HRB
Surface Roughness	Lower is better	Microns

Uncontrolled factors (also known as design variables) have an impact on the output, while controllable factors (also known as design variables) have no impact (also known as noise variables). It is the designer's responsibility to maintain control over design variables, the values of which can be easily changed and updated.

Analysis of Surface Roughness (Ra)

Table 6.6 depicts the results obtained while assessing the surface roughness of a surface.

Table 5.6 Analysis of Surface Roughness

Trial no.	Pouring temp	Injection pressure	Coating type	Cooling type	Surface roughness		Mean (Ra)	S/N ratio
1	750	170	Oil	Air	2.22	2.16	2.19	-6.80970
2	750	180	Oil + graphite	Water	1.6	1.59	1.595	-4.05526
3	750	190	Dycot	Oil	1.32	1.29	1.305	-2.31278
4	770	170	Oil + graphite	Oil	2.26	2.24	2.250	-7.04374
5	770	180	Dycot	Air	1.63	1.61	1.620	-4.19047
6	770	190	Oil	Water	.90	.87	.885	1.05989
7	790	170	Dycot	Water	2.15	2.12	2.135	-6.58817
8	790	180	Oil	Oil	1.75	1.72	1.735	-4.78631
9	790	190	Oil + graphite	Air	1.52	1.55	1.535	-3.72258

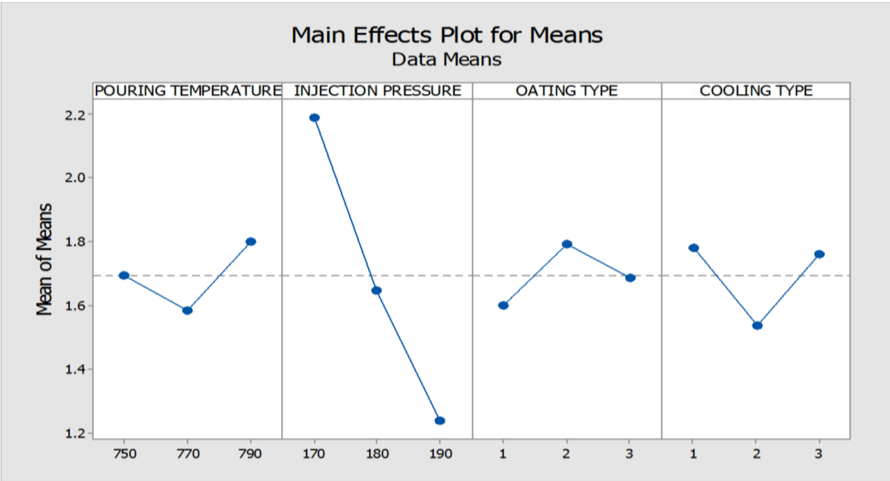

Figure-6: Plot of mean of means and Surface Roughness.

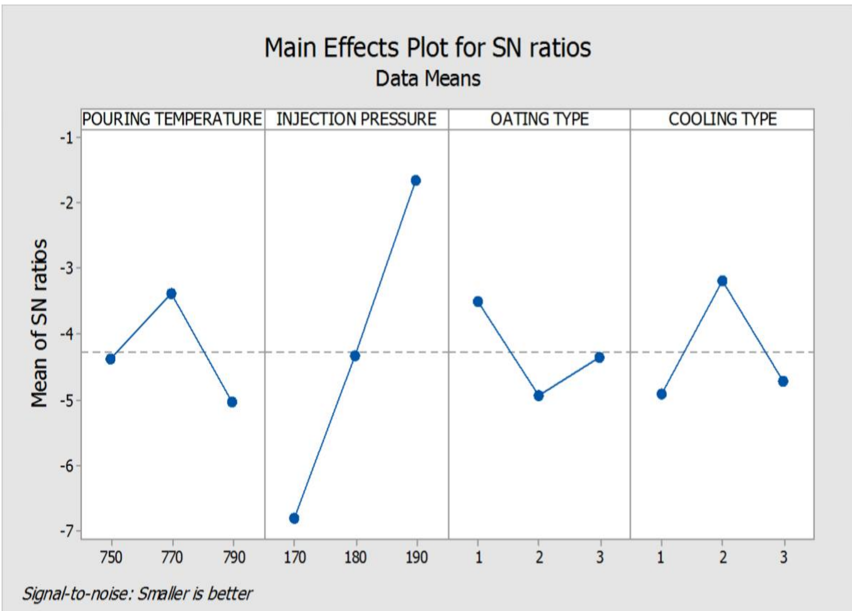

Figure-7: Plot of mean of S/N ratio and Surface Roughness.

Results for S/ N ratio- Surface Roughness

The S/N ratio is a measurement of the degree of variance in a process that combines numerous repetitions into a single number. The S/N ratios were computed to determine the primary contributing components and interactions that produce surface roughness variation. The smaller the surface roughness, is the better.

Table 5.7 Reponses of S/N Ratio with Surface Roughness

Level	Temperature	Pressure	Coating	Cooling
1	- 4.393	-6.814	-3.512	-4.098
2	-3.391	-4.344	-4.941	-3.195
3	-5.032	-1.658	-4.364	-4.714
Delta	1.641	5.155	1.428	1.713
Rank	3	1	4	2

Optimization for Surface Roughness

As a result of these parameters, the lowest roughness was observed in the S/N ratio when the injection pressure was maintained at 190 kg/cm2, the pouring temperature was maintained at 770oC, and cooling water was used during casting since these factors decreased variance Coating is completely irrelevant.

✓ **Analysis of Density**

The response factor for the casting was determined to be the density of the casting (quality characteristic). As a result of the fact that casting density has a direct relationship with casting errors, it was chosen as one of the quality criteria. Internal defects like as porosity, blow holes, and other imperfections are less prevalent with denser castings, which means they are less expensive to produce.

Table -5.8 Analysis of Density of material

Trial no.	Pouring temp	Injection pressure	Coating type	Cooling type	Density		Mean density	S/N ratio
1	750	170	Oil	Air	2.30	2.30	2.30	7.23456
2	750	180	Oil + graphite	Water	2.544	2.542	2.5430	8.10693
3	750	190	Dycot	Oil	2.656	2.569	2.6125	8.33751
4	770	170	Oil + graphite	Oil	2.146	2.143	2.1445	6.62651
5	770	180	Dycot	Air	2.307	2.307	2.307	7.26095
6	770	190	Oil	Water	2.403	2.402	2.4025	7.61327
7	790	170	Dycot	Water	2.222	2.224	2.2230	6.93879
8	790	180	Oil	Oil	2.586	2.590	2.5880	8.25928
9	790	190	Oil+graphite	Air	2.658	2.656	2.6570	8.48783

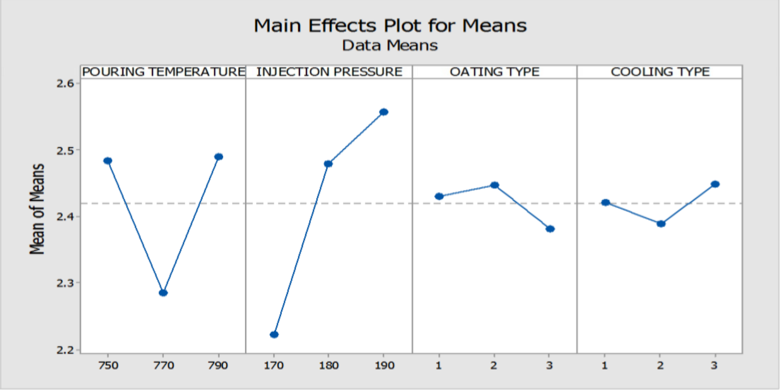

Figure- 8 Graph of mean of means and Density of Material.

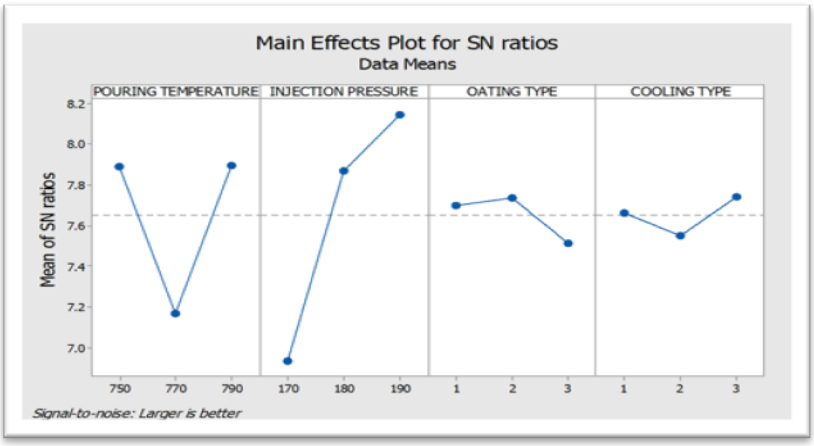

Figure-9 Graph of mean of S/N ratio and Density of Material.

✓ **Result for S/ N ratio – Density**

The S/N ratios were determined in order to determine the primary contributing components and interactions that cause density change. The higher the density, the better.

Table-5.9 Reponses of S/N Ratio with Density

Level	Temperature	Injection	Coating	Cooling
1	2.485	2.223	2.430	2.421
2	2.285	2.479	2.448	2.390
3	2.489	2.557	2.381	2.448
Delta	0.205	0.335	0.067	0.059
Rank	2	1	3	4

✓ **Optimization for Density**

As determined by the S/N ratio, the highest density was obtained when both the injection pressure and the pouring temperature were maintained at 190 kg/cm2 and a temperature of 790oC, respectively. The settings for cooling and coating are completely irrelevant.

Analysis of Hardness

To assess the hardness of the material, a Rockwell Hardness Tester was employed to conduct the test. The hardness of the samples is determined by the diameter of the indentation on the sample surface. The indents in the pyramid-shaped steel ball indenter were measured on a B scale for 20 seconds while a slight force of 10 kg was applied to the indenter. Hardness data are shown in Table 5.10 for each of the nine experiments performed.

Table-5.10 Analysis of Hardness

Trial no.	**Pouring temp**	**Injection pressure**	**Coating type**	**Cooling type**	**Hardness**		**Mean hardness**	**S/N ratio**
1	750	170	Oil	Air	70	71.66	70.83	-37.0049
2	750	180	Oil+graphite	Water	66.62	67.33	66.97	-36.5184
3	750	190	Dycot	Oil	67.33	68.66	67.99	-36.6500
4	770	170	Oil+graphite	Oil	67	67	68	-36.6511
5	770	180	Dycot	Air	75.33	71.33	73.33	-37.3089
6	770	190	Oil	Water	72.66	71.66	72.16	-37.1661
7	790	170	Dycot	Water	70.3	71.0	70.66	-36.9842
8	790	180	Oil	Oil	69.33	71	70.16	-36.9230
9	790	190	Oil+graphite	Air	70.66	71.66	71.16	-37.0449

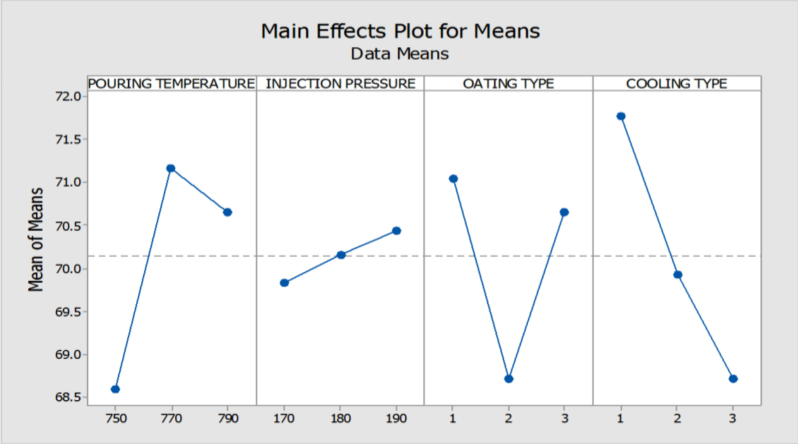

Figure-10 Plot of means of mean and Hardness.

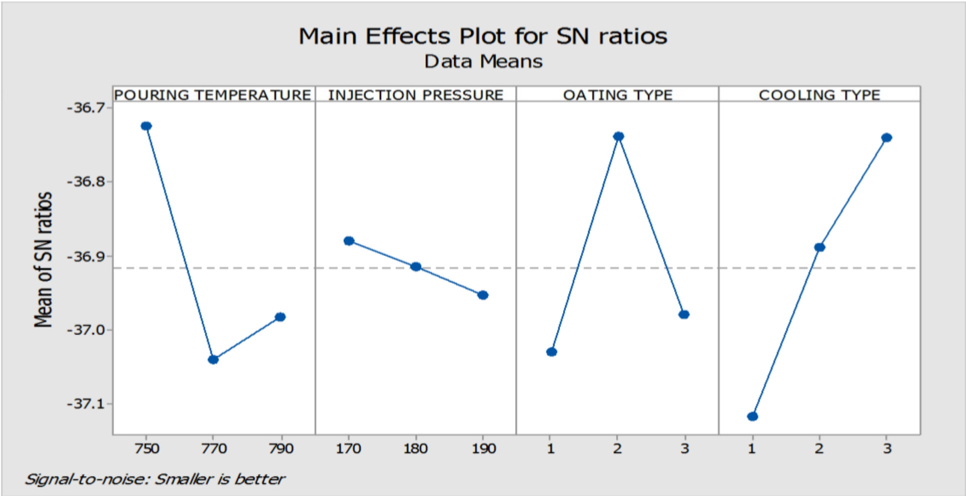

Figure-11: Plot of means of S/N ratio and Hardness.

Result for S/N ratio – Hardness

The S/N ratio is a measurement of the degree of variance in a process that combines numerous repetitions into a single number. Hardness S/N ratios were computed to discover the primary contributing components and interactions that cause hardness variance. The lesser the hardness, more better.

Table 5.11 Reponses of S/N Ratio with Hardness

Level	**Temp**	**Injection**	**Coating**	**Cooling**
1	-36.72	-36.88	-37.03	-37.12
2	-37.04	-36.92	-36.74	-36.89
3	-36.98	-36.95	-36.98	-36.74
Delta	0.32	0.07	0.29	0.38
Rank	2	4	3	1

Optimization for Hardness

It was discovered that the lowest hardness was achieved when the injection pressure was kept to a bare minimum and the pouring temperature was kept at 750oC, and that cooling oil and oil–graphite coating were used during casting to minimize the variation in the casting's hardness, respectively.

Control

The Control stage is the last and most important step, with the only objective of preserving the optimal response acquired throughout the trials. The documentation of the process is recommended for full Six Sigma success. After the answer is found, the process remains under control, and the out-of-control condition is diminished. Before non-conformities are formed, the corresponding reasons are identified, and action is done to address the situation. The intended outcomes and improvements have been accomplished, and a new method is advised. The organization should next record the process and teach employees with the support of the Six Sigma improvement group.

VI. CONCLUSIONS

Their study project is to investigate the possibilities of Six Sigma in Indian small and medium-sized businesses (SMEs). Six Sigma implementation in SMEs is a new quality-improvement methodology that has achieved universal recognition among academics and practitioners. Small and medium-sized enterprises (SMEs) were long assumed to exist primarily in large businesses, and the goal of this study is to examine whether the Six Sigma roadmap can be applied in SMEs. This case study will serve as motivation for SMEs in India to engage in activities that will help them build their company.

A case study from the Pressure Die Casting industry is given as part of this thesis, demonstrating how Six Sigma may be utilised to create considerable increases in both process and business efficiency. The pressured die casting technology has recently made substantial advances that the industry was utterly unaware of. The DMAIC approach was selected to be used throughout the testing process in order to limit the amount of rejection of a casting product known as the bear hub as much as feasible.

- A case study of the DMAIC approach in the Indian Foundry industry is discussed in this work.
- Die Casting quality is controlled by one of the primary Die Casting features, and the proper application of DOE may result in a significant improvement.
- In addition to melting temperature, injection pressure, coating, and cooling type, other factors, such as plunger speed, cooling phase, and so on, may be used to determine the final product.
- As of right now, we're working with the aluminium alloy KS-1275, but we can also make use of the aluminium alloys LM-6, LM-29, and A-351 if necessary.
- Surface Roughness, Hardness, and Density Optimization is a strategy that enhances the quality of components and minimises the number of defects.

VII. FUTURE SCOPE

- It is necessary to conduct a comprehensive analysis of the features of aluminium alloys by modifying process parameters, and it is possible to make significant improvements to the properties of aluminium alloys via research and development.
- It is necessary to conduct a comprehensive analysis of the features of aluminium alloys by modifying process parameters, and it is possible to make significant improvements to the properties of aluminium alloys via research and development.

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