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Casting Defect Reduction in Manufacturing Industry Using Six Sigma

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Abstract- The art of meeting customer specifications, which today is termed as "quality". Quality is the symbol of human civilization, and with the progress of human civilization, quality control will play an incomparable role in the business. It can be said that if there is no quality control, there is no economic benefit. In the current world of continually increasing global competition, it is imperative for all manufacturing and service organizations to improve the quality of their products. In today highly competitive scenario, the markets are becoming global and economic conditions are changing fast. Customers are more quality conscious and demand for high quality product at competitive prices with product variety and reduced lead time. It is a data-driven quality strategy used to improve processes. Therefore, this paper aims to reduce casting defect in manufacturing industry using six sigma.

Keywords- Casting defect, reduction, manufacturing industry, six sigma

I. INTRODUCTION

The art of meeting customer specifications, which today is termed as "quality". Quality is the symbol of human civilization, and with the progress of human civilization, quality control will play an incomparable role in the business. It can be said that if there is no quality control, there is no economic benefit. In the current world of continually increasing global competition, it is imperative for all manufacturing and service organizations to improve the quality of their products [1].

In today highly competitive scenario, the markets are becoming global and economic conditions are changing fast. Customers are more quality conscious and demand for high quality product at competitive prices with product variety and reduced lead time. It is a data-driven quality strategy used to improve processes. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives such as lean [2].Any enterprises that cannot manage the quality of its methods and products have a tendency to fall apart. Quality is crucial to sales, price control, productivity, risk control and compliance. As essential as quality is, there's little agreement as to its definition. The following definitions observe excellent from a control, high-quality guarantee, product, advertising and marketing, production and economic point of view [3].

Because of the negative consequences of poor quality, organizations try to prevent and correct such problems through various approaches to quality control. Broadly speaking, quality control refers to an organization's efforts to prevent or correct defects in its goods or services or to improve them in some way.

Some organizations use the term quality control to refer only to error detection, whereas quality assurance refers to both the prevention and the detection of quality problems. Organizations must

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have a department or employee devoted to identifying defects and promoting high quality. In these cases, the supervisor can benefit from the expertise of quality-control personnel [4].

II. RESEARCH METHODOLOGY

1. Data Measurement

The objective of the measure phase is to understand and establish the baseline performance of the process in terms of process capability or sigma rating. In this phase we decided for data collection to be done. Before going for data collection it is necessary to see that current measurement system is capable. While collecting the data if the measurement system is not robust, the data collected may not be accurate which will resulted into trouble in the project. For continuous data Gauge repeatability and reproducibility (R&R) studies are carried to check the robustness of the instrument under use. In our case two inspectors did the inspection of the products. There was no instrument involved in the inspection process and it was only visual inspection of the products. Since our data are discrete, we have carried out measurement system analysis for discrete data with the help of MINITAB 17 software.

2. Data Collection

In this phase we collect the data. Therefore, it becomes very important to secure a correct measuring system before the project. So, a list of problems better to say opportunities for improvements were identified, following problems were listed down in their operations.

Table 1 Name of casting defects

S.No	Type of efect
1	Pin hole
2	Sand inclusion
3	Shrinkage
4	Sand drop
5	Scabbing

The check sheet is a simple document that is used for collecting data in real-time and at the location where the data is generated. The document is typically a blank form that is designed for the quick, easy, and efficient recording of the desired information, which can be either quantitative or qualitative. Rejection check sheets are generally large data sheets showing the total information about rejected items.

The defects such as blow holes, Misrun, slag inclusion, rough surface have been identified by various method (Table 2) and data of each part was collected (for a specified time span) from the company which shows the production and rejection status of individual part.

Table 2 Detection methods

S.no	Type of defect	Detection	Appearance
1	Pin hole	Visual method	Rounded holes
2	Sand inclusion	Visual method	Pitted surface
3	Shrinkage	Visual method	Unfilled cavity
4	Sand drop	Touching method	Rough surface

Following is the four months data of the total pouring per month. Rejection of bearing hub is given in the following table 3.

Table 3 Data collection (before improvement)

Month	Production	Pin hole	Sand inclusion	Shrinkage	Sand drop
Oct 2022	100	12	9	8	11
Nov 2023	100	23	13	11	10
Dec 2023	100	18	14	9	8
Jan 2024	100	14	17	13	10
Total	400	67	53	41	39

III. RESULTS AND DISCUSSION

Regression analysis to see the relation between % rejection and pouring temperature and after that design of experiment will use to find out the optimum pouring temperature. Data have been collected on single day hour basis.

Table 4: Data collection of pouring temperature

Sr. No.	Temperature °C	Total production	Total Rejection	% Rejection
1	725	50	15	19.23
2	750	50	9	11.54
3	775	50	11	14.10
4	800	50	6	7.69
5	825	50	13	16.67
6	850	50	10	12.82
7	875	50	6	7.69
8	900	50	8	10.26

Regression analysis using above data was carried out with the help of MINITAB 17 software. Result of regression analysis is shown below.

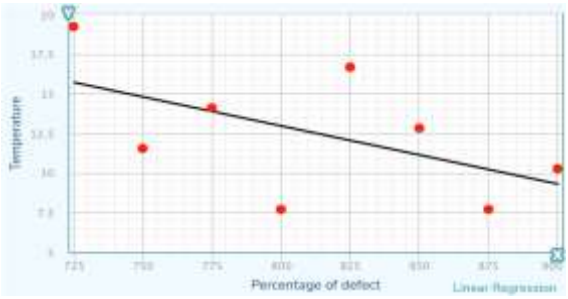

Fig. 1: Temperature vs % rejection

Regression Equation % rejection = -0.036X + 42.25
Where X = no. of defect

Table 5: Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	9522.8	9522.80	9.63	0.021
Error	6	5930.7	988.45		
Total	7	15453.5			

Table 6: Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-75.7	31.9	-2.37	0.055	
Temperature °C	0.1193	0.0384	3.10	0.021	1.00

Table 7: Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
4.77729	61.62%	55.23%	45.34%

From the above analysis it is to be noted that since p value (0.021) is less than 0.05 which indicating that above regression model is significant but since linearity is only 61.62 %, we cannot conclude that variation in temperature is linearly causes % rejection.

IV. CONCLUSION

The aim of this thesis is to explore the possibility of implementing seven quality tools in Indian SMEs. The seven quality tools in SMEs are a new paradigm for improving quality which is practiced by many academics. This thesis is an attempt to provide road map application of seven quality tools in SMEs which are normally presumed to be in the section of large industries. This case study will help the Indian SMEs to carry out such projects which can lead them towards business improvement.

This thesis presents a case study from pressure die casting section demonstrating how the implementation of Six Sigma can bring breakthrough improvement in the performance of the process as well as in business. The industry was not aware about such improvements in the sand casting process which can be carried out. The application of the seven quality tools methodology has been utilized in reducing the rejection of the sand casted product.
From the experiment following conclusions were drawn.

- This study, illustrates the successful implementation of seven quality tools approach. Seven quality tools has been

considered as a revolutionary approach to product and process quality improvement.

- Improved overall management performance.
- Optimum parameters are: Pouring temperature = 750 °C, Silica sand = 6 %.
- P value of pouring temperature and silica sand is below 0.05 which means they are significantly affecting the % rejection. It is also to be noted that P value of pouring temperature is 0.000 which is also can be taken as significant factor because it is almost 0.05.
- The rejection due to blow holes, slag and misrun defects were reduced by reducing the moisture and increasing the permeability of sand.
- After achieving such results, top management of this industry was convinced with such initiation and they have decided to explore the Six Sigma projects in their other processes which is good step toward making them quality conscious.

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