IMPROVEMENT IN PRODUCTION RATE BY REDUCING THE DEFECTS OF INJECTION MOULDING

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Abstract - In the present paper, an attempt has been made to apply DMAIC (Define, Measure, analysis, improve, control) approach. The emphasis was laid down towards reduction in the defects (Blush, Burn, cold flows, cold slug, contamination, peeling, gloss) occurred in the injection moulding by controlling the parameters with DMAIC technique. This Method is very useful to accelerate improvements in its processes, products and services. This approach is a project driven management approach to improve the organization products, services and processes by continually reducing defects in the organization.

Keywords: DMAIC Approach
Sub Area: Plastic Moulding Room
Broad area: Mechanical Engineering & Manufacturing Science

I. INTRODUCTION

The DMAIC is both a philosophy and a methodology that improves quality by analyzing data to find root cause of quality problems and to implement controls. Although DMAIC implemented to improve manufacturing and business, processes such as product design and supply chain management. It is a business improvement strategy used to improve profitability to drive out waste in business process and to improve the efficiency of all operation that meet of exceed customer’s needs and expectation. DMAIC is a customer-focused program where cross functional teams works on project aimed at improving customer satisfaction. It is a scientific method to improve any aspect of a business, organization process. DMAIC is a methodology to

1. Identify improvement opportunities.
2. Define and solve problems
3. Establish measures to sustain the improvement.

Motorola was the first organisation to use the term DMAIC in the 1980s as part of its quality performance measurement and improvement program. Recent DMAIC success stories, primarily from the likes of General Electric, Sony, Allied Signal, and Motorola, have propagated the use of quality tools for gaining the knowledge. Some of the pioneering companies, which use DMAIC methodology, are ABB, General Electric (GE), Allied Signal and Texas Instruments. General Electric spent 500 million dollar on DMAIC projects in 1995 and gained more than 2 billion dollar from that investment.

II. KEY PLAYERS AND METHODOLOGY OF DMAIC

Key players are the persons in the industry who play an important role in the in the industry. Their duties and assignments discussed as below.

Champion: He is the business leader responsible for overall deployment. Champion ensures that process owner support is there during all phases. Champion learns DMAIC philosophies, deployment strategies, which include selecting high impact projects, choosing and managing the right people to become master belt. Champion helps transferring project ownership from black belt to manager who owns the process upon completion of corrective actions.

Black Belt: The Quality leader acts as a team leader in DMAIC project. He is responsible for training and deployment. He is all day problem solver and assist black belt in applying the method correctly in unusual situations. In organization, normally manager acts as a black belt.

Green Belt: These employees in the organization execute DMAIC as a part of their overall job while working with black belt. They gain experience in the practical application of DMAIC methodology and tools. They work as team member in black belt project. Normally shift supervisor’s acts as green belt. The DMAIC methodology has a core process: Define-Measure-Analyze-Improve-Control (DMAIC) methodology. The five steps to DMAIC approach are:

1. Define: The definition of the problem is the first and the most important step of any DMAIC project because a good understanding of the problem makes the job much easier. An average definition may mislead people into trying to achieve goal which are not required or making the problem more complex. Thus, we can say that the definition of the problem forms the backbone of any DMAIC project.
2. Measure: The measure phase identifies the defects in the product, gathers valid baseline information about the process and establishes improvement goals. DMAIC approach is based on measured data. There will be
unfavorable consequences from analysis using quality tools if there is problem with measuring system. Therefore it becomes very important to secure a correct measuring system before the project.

3. **Analyze:** The analyze phase examines the data collected in order to generate a prioritized list of source of variation. It is the key component of any defect reducing program. This is the stage at which new goals are set and route maps created for closing the gap between current and target performance level. The conventional quality technique like brainstorming, root cause analysis, Cause and effect diagram etc. may be used for caring out the analysis.

4. **Improve:** Improve the process to remove cause of defects. Specific problem identified during analysis
   1. Use of brain storming and action workouts
   2. Extracting the vital few factors through screening
   3. Understanding the correlation of the vital few factor

5 **Control:** Control the process to make sure that defects do not recur i.e. remove the root cause of the problem. The control phase is preventive in nature. All the specific identified problems from the analysis phase were tackled in the control phase. It defines control plans specifying process monitoring and corrective action. This phase provides systematic re-allocation of resources to ensure the process continues in a new path of optimization. It also ensures that new process conditions are documented and monitored.

III. **EXPERIMENTAL STUDY**

1 **Define phase**
The present case study deals with reduction of rejection due to moulding defects in a moulding industry. The company is making moulding of textile and automobile components such as plastic battery , car assembly parts, plastic gears in large scale and having rejection in the form of blush, burn, cold flows, cold slug, contamination, peeling, gloss. The important parts of industry were chosen for complete analysis.

2. **Measure (data collection) phase**
Measurement is the second step that leads to control and eventually to improvement. The measurement phase is concerned with selecting one or more product characteristic, mapping the process and recording the data.

**PROCESS MAPPING:** Process map is a graphically representation of how the process is to be performed. All rework operations movements must be included. Process map are created for every project and are never completed. They should be uploaded whenever one of the parameter is changed.

3. **Analyze Phase**
Analyze phase is the important phase of DMAIC methodology. The different tools and methods of DMAIC were used in analyze phase to improve the quality such as cause and effect diagram and sand control test. The existing casting defect were blush, burn, cold flows, cold slug, contamination, peeling, gloss. Factor which have been found to be affected these defects are:

For blush
1. Excessive injection fill speed.
2. Low injection pressure
3. Melt temperature too high or too low.

![Fig.1](image1.png)

For Burn defects
1. High injection pressure.
2. Restrictive flow path
3. High screw rotation speed

![Fig.2](image2.png)

For cold flows
1. Low ram speed
2. Material freezing near the gate
3. Low melt and mold temperature

![Fig.3](image3.png)

For contamination
1. Resin remaining in the molding machine for long periods of time.
2. Melted resin coming into contact with air.
3.1 Cause-and-Effect analysis tool:
A cause-and-effect, or fishbone, diagram depicts potential causes of a problem. The problem (effect) displays on the right side and the list of causes on the left side in a treelike structure. The branches of the tree are often associated with major categories of causes. Each branch has a listing of more specific causes in that category. Although there is no "correct" way to construct a fishbone diagram, some specific types lend themselves well to many different situations. One of these is the "5M" diagram, so called because five of the categories on the branches begin with the letter M ("Personnel" is also referred to as "Man").

3.2 Plastic Control Tests:
Many of the tests were conducted for control defects like Blush ,Burn ,cold flows ,cold slug , contamination ,peeling ,gloss.

Three main tests were conducted:
1. Electron Spectroscopy for Chemical Analysis (ESCA)
2. Auger Electron Spectroscopy (AES, Auger)
3. Green compression strength
Following test were conducted to check whether the sand characteristic as per specifications.

Electron Spectroscopy for Chemical Analysis (ESCA):
One of the most powerful analytical tools for evaluating material surfaces and surface compositions is electron spectroscopy for chemical analysis (ESCA). ESCA, also known as X-ray photoelectron spectroscopy (XPS), is a high-vacuum technique that measures the kinetic energies of photoelectrons emitted from a sample after X-ray bombardment. These energies provide a signature of elements present in the material. Slight energy shifts correlate to the elemental bonding structure, thus also providing molecular information. Since photoelectrons are typically emitted from the top 5 to 10 nanometers of solid surfaces, XPS is one of the most surface-sensitive techniques available for studying adhesion, defects and contamination issues.

Auger Electron Spectroscopy (AES, Auger)test: Auger Electron Spectroscopy (AES, Auger) is a surface-sensitive analytical technique that utilizes a high energy electron beam as an excitation source. Atoms that are excited by the electron beam can relax, leading to the emission of "Auger" electrons. The kinetic energies of the emitted Auger electrons are characteristic of element present within the top 5-10nm of the sample The electron beam can be scanned over a variably sized area, or it can be directly focused on a small surface feature of interest. This ability to focus the electron beam to diameters of 10-20nm makes Auger an extremely useful tool for elemental analysis of small surface features. When used in combination with ion sputter sources, Auger can perform compositional depth profiling.

Fig.4

Fig.5
Scanning Electron Microscopy (SEM) Test:- The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. In most applications, data are collected over a selected area of the surface of the sample, and a 2-dimensional image is generated that displays spatial variations in these properties. Areas ranging from approximately 1 cm to 5 microns in width can be imaged in a scanning mode using conventional SEM techniques (magnification ranging from 20X to approximately 30,000X, spatial resolution of 50 to 100 nm). The SEM is also capable of performing analyses of selected point locations on the sample; this approach is especially useful in qualitatively or semi-quantitatively determining chemical compositions.

4. Improve Phase
Improvement in blush defects: The root factors for blush defects were excessive injection fill speed. The industry was using low injection pressure., After performing the test with 10 kg of plastic sample, it was found that percentage of blush was low. Therefore to improve the blush defects it was necessary to perform the tests. The different results have been obtained
The reduced in the blush from 5% to 6.5%. So these results in reduction of blush. After testing the following results were obtained which were in comparison with the standard results towards achievements of reduction of blush defects.
Improvement in burn defects: The root factors for rough surface defects were poor surface. Therefore some improvements have been done to reduce the rough surface defects.
1. Improve air venting to relieve trapped air and gases.
2. Reduce the material residual time in barrel.
3. Reduce the local high temperature spots in mold by proper cooling.
Improvement in cold flows defects: The root factors for cold flaws defects were low melt temperature, low
injection speed or low injection pressure. So following action has been taken to improve this defect.

1. High melting temperature should be used.
2. Low injection speed & injection pressure.

Improvement in contamination defects: The root factors for contamination defects are:

1. Resin remaining in the molding machine for long periods of time.
2. Melted resin coming into contact with air.
So by using SEM tests there is reduced in the defects at a large scale. This gives improvement in the production rate which is increase in a high rate.

5. Control Phase
After the case study of foundry unit the following recommendations are made to control the reduction of moulding defects of automobile parts.
1. Control the ram speed with material pouring.
2. Control in melting temp of plastic.
3. Use of auger electron beam detect the defect frequently.
4. The ladle may be cleaned after every moulding
5. Soft ramming may be improved by flowing temp suitably. If the above recommendation are implemented the major moulding defects are likely to be reduced.

IV. RESULT AND DISCUSSION
From the result of the application of DMAIC approach in the plastic shop the following results were obtained
The rejection due to blush defects were reduced from 2.5% to 0.86%. The rejection due to burn were reduced from 2.68% to 0.78% by using low injection speed. The rejection due to cold flows was reduced from 1.2% to 0.68% by uniform ram speed. The rejections due to contamination defects were reduced from 1.06% to 0.43% by create vacuum. The overall result of present work is clearly shows that by applying DMAIC approach the rejection has reduced from 7.44% to 2.75%.

V. CONCLUSION
On the basis of the results, the following conclusions have been drawn:
1. This study, illustrates the successful implementation of DMAIC approach. DMAIC has been considered as a revolutionary approach to product and process quality improvement.
2. Improved overall management performance.
3. Inherent discipline with in the DMAIC approach provides structure and a visible road map for work force to systematically create new knowledge.

REFERENCES