DEFECTS REDUCTION IN BRAKE DRUM IN FOUNDRY SHOP USING DMAIC TECHNOLOGY

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ABSTRACT

Now a day's customers are more conscious about qualities and demand for high quality product at minimum prices with different variety in product. The DMAIC technique is an overall strategy 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 and thus reduce the manufacturing cost. DMAIC is a methodology to identify improvement opportunities, define and solve problems and establish measures to sustain the improvement. My study is done on local foundry shop in Haryana and objective of my study are:

1. To identify the root factors causing casting defects in Brake drum.
2. To improve the quality by reducing the casting defects in Brake drum.
3. Compare the defects in Brake drum with and without DMAIC.

Keywords – *Casting, defects, DMAIC, foundry, quality.*

I. INTRODUCTION

In today highly competitive scenario the markets are becoming global and economic conditions are changing fast. The DMAIC technique is an overall strategy to accelerate improvements in its processes, products and services.

Motorola was the first organisation to use the term DMAIC in the 1980s as part of its quality performance measurement and improvement program. Its 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. The DMAIC methodology to root out and eliminate the causes of defects are:

D Define a problem or improvement opportunity.
M Measure process performance.
A Analyze the process to determine the root causes of poor performance; determine whether the process can be improved or should be redesigned.
I Improve the process by attacking root causes
C Control the improved process to hold the gains.

II. LITERATURE REVIEW

The fast changing economic conditions like global competition, reducing profit margin, customer demand for high quality product, product variety and reduced lead–time etc. had a major impact on manufacturing industries. To respond to these needs various industrial engineering and quality management strategies such as ISO 9000, Total Quality Management, Kaizen, Just–in–time manufacturing, Enterprise Resource Planning, Business Process Reengineering, Lean management etc. have been developed. A new paradigm in this area of manufacturing strategies is Six Sigma. The Six Sigma approach has been increasingly adopted world wide in the manufacturing sector in order to enhance productivity and quality performance and to make the process robust to quality variations.

Total Quality Management

Within the last two decades, Total Quality Management (TQM) has evolved as a strategic approach in most of the manufacturing and service organizations to respond to the challenges posed by the competitive business world. Today TQM has become a comprehensive management strategy which is built on foundation of continuous improvement & organization wide involvement, with core focus on quality. TQM is a process of embedding quality awareness at every step of production or service while targeting the end customer.

Six Sigma Philosophy

Six Sigma is a business performance improvement strategy that aims to reduce the number of mistakes/defects to as low as 3.4 occasions per million opportunities. Sigma is a measure of "variation about the average" in a process which could be in manufacturing or service industry. Six Sigma improvement drive is the latest and most effective technique in the quality engineering and management spectrum. It enables organizations to make substantial improvements in their bottom line by designing and monitoring everyday business activities in ways which minimizes all types of wastes and NVA activities and maximizes customer satisfaction. While all the quality improvement drives are useful in their own ways, they often fail to make breakthrough improvements in bottom line and quality.

Snee(2000) defined that the basic concept behind the DMAIC approach is to eliminate product and process variation and he conducted a case study at carriage and wagon works. He eliminate the wrong steps and new suggestion are implemented and then compare with the previous rejection with improvement. He found that 5.9% of rejections were reduced.

Horel(2001) introduced the DMAIC technology in different functional areas such as marketing, engineering, purchasing and servicing. The company Whirlpool has increases its quality by 10% by adopting DMAIC technique.

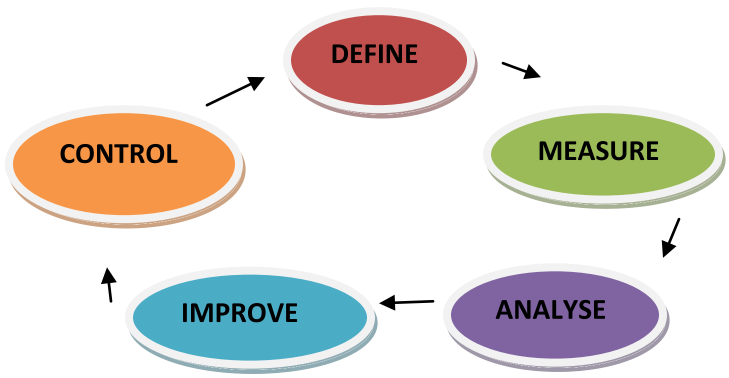
Hack man and Wageman(2003) explained that DMAIC approach provides a way for improving process so that the company can more efficiently produce world class products and services. DMAIC have five phase to take specific problems.

Bendall and Marra(2005) affirmed that in order to reduce quality problems in the industry and to eliminate customer complaints, the DMAIC approach can be applied effectively. DMAIC brings improvement in industry through reducing variation in processes.

Kumar et al. (2006) have explained a case study dealt with the reduction of casting defects in an engine and study how the effective introduction and implementation of DMAIC in organization can lead to a breakthrough in profitability. The dramatic improvement achieved was the result of listening the problem of customer with objective of evaluating and understanding their concerns. The defects rate per unit has been reduced from 19.4% to 2.9%.

Kim Yong et al. (2010) conduct a study into a corporate research library of a telecom company in Korea to identify and remove ineffective components and unnecessary steps in library works and services. They used DMAIC to identify 12 key actors, which have a great effect on information acquisition time and information utilization, and proposed the improvement plans for those factors.

III. THE FIVE STEPS TO DMAIC APPROACH



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.

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 carring out the analysis. Analysis of the variables (causes) and the effect on the defects is the next step. Once the subject matter experts have identified what to measure to improve product performance, it is again time to get management on board. A key issue is the time it will take to measure the process accurately.

4. Improve: Now you have defined the problem, measured the performance gap, and analyzed the reason for the gap, it is time to move over to the Improve phase of the steps in six sigma methodology. During this phase, you will devise a set of possible solutions and then select the best possible solution for the problem identified. Once you have selected the best solution, it is imperative to devise the implementation plan with the time frame for implementation. The main outcome of the improve phase is the designing of the performance improvement plan which will bring about a marked, measured difference in your existing process.

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.

IV. KEY PLAYERS OF DMAIC METHODOLOGY

Champion: He is the business leader responsible for overall deployment. Champion ensures that process owner support is there during all phases. Champion learn 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. A specific Six Sigma term to describe a team leader and one who has achieved accredited 'Black Belt' qualification via an appropriate training course.

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. A Six Sigma team member who has received Green Belt training and who works part-time on Six Sigma projects under the guidance of a Black belt team leader.

WORK DONE

The present work deals with elimination of casting defects in a foundry industry. DMAIC approach is justified when root cause of defect is not traceable. In the present work, an attempt has made to reduce the defects in castings in a foundry shop with the application DMAIC approach. In the case study the sand casting process has divided in the three stages

(A) First stage includes-

- Sand preparation
- Mould making
- Core making

(B) Second stage includes-

Melting and pouring of metal and maintaining accurate chemical composition

(C) Third stage includes-

Fettling, cleaning and machining operation of casting

Detection methods

S. No.	Type of defect	Detection	Appearance
1	Blow holes	Visual method	Rounded holes
2	Slag inclusion	Visual method	Pitted surface
3	Misrun	Visual method	Unfilled cavity
4	Rough Surface	Touching method	Rough surface

Data collection (before improvement) – Brake drum

Month	Production Pieces	Rejection Pieces	Blow holes defects	Misrun defects	Slag inclusion defects	Rough surface defects
Nov.	1479	120	61	14	32	13
Dec.	1488	139	67	19	37	16
Jan.	1498	124	66	14	32	12
Total	4465	383	194	47	101	41

Total production of three months = 4465, Total rejection = 383 pieces

% of rejection = 383/ 4465 = 0.085 x 100 = 8.5 %

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 blow holes, Misrun, Slag inclusion, Rough surface. Factor which have been found to be affected these defect are

For blow holes

1. Low permeability of moulding sand
2. High moisture content of mould
3. Inadequate venting in the mould

For Misrun defects

1. Low pouring temp.
2. Faulty pouring practice
3. Core shift causing uneven thickness

For Slag inclusion

1. Rough ladle lining
2. Skimming metal
3. Unvarying pouring practice

For Rough surface

1. Soft ramming
2. Poor coating practice
3. Moulding sand too course

The root factors which have been found to be affecting these defects are:

For blow Holes:

1. High moisture content
2. Low permeability

For Misrun:

1. Low pouring temp.
2. Core shift

For Slag inclusion:

1. Rough ladle lining
2. Skimming metal

For Rough surface:

1. Soft ramming
2. Poor coating practice

IMPROVE PHASE

Improvement in blow holes defects: The root factors for blow holes defects were high moisture and low permeability. The industry was using 5% of new silica sand and 95% of reuse sand. After performing the test with 100 kg of sand sample, it was found that percentage of moisture was high and percentage of permeability was low. Therefore to improve the blow holes defects it was necessary to increase the percentage of new silica sand to reduce the moisture and increased the permeability. The different results have been obtained by increasing the new silica sand as below.

Percentage recorded of moisture and permeability

S.N	Addition of new silica sand	Moisture	Permeability
1	5 %	6.01 %	125 cc / min
2	5.5 %	5.45 %	131 cc / min
3	6 %	4.92 %	138 cc / min
4	6.5 %	4.32 %	145 cc/ min

Moisture content has been reduced in the sand by adding new sand from 5% to 6.5%. So these results in reduction of moisture contact and permeability have been increased. After testing the sand the following results were obtained which were in comparison with the standard results towards achievements of reduction of casting defects.

Improvement in Rough surface defects: The root factors for rough surface defects were poor coating of pattern, loose ramming so to remove this defects it was very necessary to correct the coating of patterns and loose ramming. Therefore some improvements have been done to reduce the rough surface defects.

1. soft ramming has been improved by addition of coal dust from 0.9% to 1.1%.
2. varnish coating on the pattern has been used.
3. coating of mould inner surface by zirconium paste.

Improvement in Misrun defects: The root factors for Misrun defects were core shift and low pouring temp .Therefore to remove this casting defect temp. has been improved and core shift has been controlled. So following action has been taken to improve this defect.

1. Misrun defects have been minimized by increasing tapping temp. 1195 degree to 1235 degree centigrade with addition of flux (lime stone) from 0.2% to 0.3%.
2. To avoid core shift chaplets have used to reduce Misrun defects

Improvement in slag defects: The root factors for slag defects were rough ladle lining and skimming metal. Therefore to reduce the slag inclusion defect some new material has been added which was not used by the company before applying technique.

1. Slag defects have minimized by addition of slax-30 (Foseco foundry data hand book pp. 229) material up to 2%

2. By using clean ladle

After implementation of these improvements, the data of the company was collected again.

Data collection (after improvement) – Brake drum

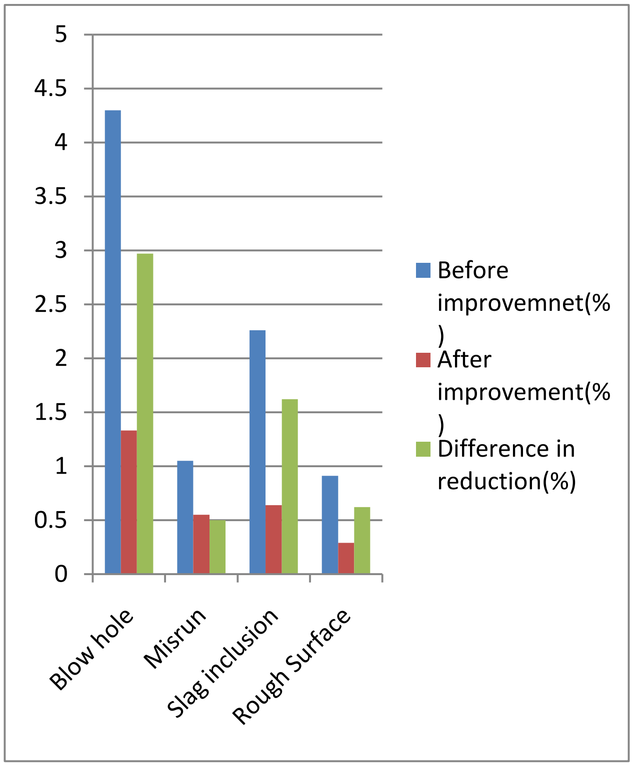
Month	Production Pieces	Rejection Pieces	Blow holes defects	Misrun defects	Slag inclusion defects	Rough surface defects
Feb	1512	40	20	7	9	4
March	1535	47	22	8	12	5
April	1512	41	19	10	8	4
Total	4559	128	61	25	29	13

Total production of Three months = 4559, Total rejection =128 pieces

% of rejection = 128/ 4559= 0.0280 x 100 =2.80%

Reduction in Defects

S.No.	Types of Defects	Rejection(Before improvement) %	Rejection (After improvement) %	Reduction in rejection,%
1	Blow hole	194/4465= .0430*100 = 4.3%	61/4559= .0133*100 = 1.33%	4.3 – 1.33= 2.97%
2	Misrun	47/4465= .0105*100 = 1.05%	25/4559= .0055*100 = .55%	1.05 - .55= 0.5%
3	Slag inclusion	101/4465= .0226*100 = 2.26%	29/4559= .0064*100 =.64%	2.26 - .64= 1.62%
4	Rough surface	41/4465= .0091*100 =.91%	13/4559= .0029*100 = .29%	.91 - .29= .62%



V. RESULTS AND DISCUSSION

From DMAIC approach result in the foundry shop the following results were obtained

The rejection in defect due to DMAIC technology eliminated from 8.5% to 2.8%. In this the Blow hole defect, Misrun, Slag inclusion and Rough surface reduce to 2.97%, 0.5%, 1.62% and 0.62%.

SCOPE FOR FUTURE WORK

1. Integrating and comparing principles and characteristics of DMAIC with Total Quality Management.
2. The work can be integrating with lean manufacturing and supply chain management technique then it will become ideal solution for achieving good quality
3. The work can be integrated with other existing innovative management practices.

VI. CONCLUSIONS

On the basis of the results, the following conclusions have been drawn:

1. Improved overall management performance.
2. This study, illustrates the successful implementation of DMAIC approach.
3. Inherent discipline within the DMAIC approach provides structure and a visible road map for work force to systematically create new knowledge.

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REFERENCES

1. Mahesh, F. and Rai Singh, P., "*DMAIC Concepts and Applications*", Journal of Management System, Vol. 105, N o. 4, 2005, pp. 6-9.
2. Taylor, W., "*Theory of the Solidification of Castings*", Journal of Premium Strength Cast Iron Alloys, Vol. 23, No. 2, 1999, pp. 398-399.
3. Hollish, F., "*A Study of Factors Affecting the Pouring Rates of Casting*", International Journal of Cast Steel, Vol. 63, No. 5, 2000, pp. 418-420
4. Snee, R., "*Impact of Six Sigma on Quality Technology*", Journal of Quality Technology, Vol. 12, No. 1, 2000, pp. 2-5
5. Catherwood, P., "*What Different about Six Sigma*", Journal of Manufacturing Technology, Vol.8, No. 3, 2003, pp. 2-5
6. Horel, H., "*Putting Six Sigma in Prospective", Quality Engineering Magazine*", Vol. 40, No. 10, 2001, pp. 58-62
7. Anthony, R. and Banualas, W., "*Design for Six Sigma*", Journal of Research Technology and Management, Vol. 65, No. 1, 2002, pp. 23-25.
8. Hackman, F. and Wageman, G., "*Why Should Statisticians Pay Attention to Six Sigma*", Journal of Productivity, Vol. 14, No. 2, 2003, pp. 100-103.
9. Hallance, J., "*How Fast a Mold Should Be Poured*", Journal of Steel Foundry Technology, Vol. 35, No 3, 1998, pp. 177-225
10. J. P. C. Tong Æ F. Tsung Æ B. P. C. YenBendall, F.and Marra, T., "A DMAIC approach to printed circuit board quality improvement" 2004
11. Breyfogle, F., "*Featured Company Bechtel*", ASQ Six Sigma Discussion Magazine, Vol. 3, No. 1, 2004, pp. 4-6.
12. Desai and Srivastav, , "A New Direction to Quality and Productivity Management", , Vol. 12, No. 3, 2004,
13. Joseph., "*Key Ingredients for Effective Implementation of Six Sigma Program*", Business Excellence Magazine, Vol. 6, No. 4, 2004, pp. 20-27.
14. Montgomery, T., "*Design for six sigma*", Quality progress Magazine, Vol.2, No.1, 2004, pp 82-86.
15. Edward, D. and John, K., "*Integration of Lean and Six Sigma*", TQM Magazine, Vol. 5, No.1, 2005, pp 5-8.
16. Ahire, M. and Landeroj, P., "*Total Quality Management: A Review and Agenda for Future Research*", Journal of Production and Operation Management, Vol.4, No. 3, 1998, pp. 227-229.