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A Review of Six Sigma Implementation in Small Scale Foundry

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ABSTRACT: Now A Days In The Global Market Competition Is Very High And If Maintain The Place In Global Market Quality Is Very Important And For Improvement The Quality The Breakthrough Improvement Methodology Is Available Named Six Sigma. With The Use of Six Sigma In To the Foundry Rejection Rate Is Reduced, Customer Satisfaction Is Improved And Financial Benefits Also Increase. In This Paper Author Review The Previous Published Papers, And Give The Where The Industry Have To Work, This Paper Mainly Focusing On The General Overview Of Publication And The Case Industry, This Paper Gives Which Methodology Adopted By Industry, Discuss On The Various Tools And Techniques Used By The Company And How Much Benefits Got By The Company By Using DMAIC Methodology.

KEYWORDS: Six Sigma Definitions, Small Scale Foundry, DMAIC Methodology, Tools and Techniques, Benefits

I. INTRODUCTION

A. SIX SIGMA DEFINITION:

Before 1980's, Many Industries Find Defects in Production And Find out Reasons For Defects By Using Defect Detection Concepts, But They Could Not Prevent The Defects. But Now A Day It Is Necessary To Achieve The Global Quality And Hence Many Companies Follow The Defect Prevention Concepts. Six Sigma Is an Improvement Methodology, Developed by Motorola in the 1980s, Whose Benefits and Financial Results Are Well Documented in Many Areas [4]. Six Sigma Main Concept Is Based on DMAIC Approach. DMAIC Is A Data-Driven Quality Strategy Used To Improve Processes [5]. DMAIC Methodology of Six Sigma Is A Problem Solving Method Where Six Sigma Tools Are Used To Analyze The Process Data And Finally The Root Causes Behind The Defects Produce In The Product Are Identified [11]. In Statistical Terms, Sigma (Σ) Is A Letter In The Greek Alphabet That Has Become The Statistical Symbol And Metric Of Process Variation. The Sigma Scale of Measure Is Perfectly Correlated To Such Characteristics as Defects-Per-Unit, Parts-Per-Million Defectives, And the Probability of A Failure [15]. The Term Six Sigma Is Defined As Having Less Than 3.4 Defects Per Million Opportunities Or A Success Rate Of 99.9997% [20].

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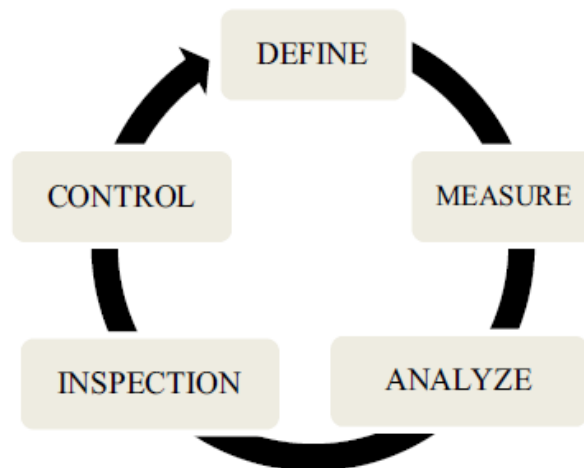


Fig. 1. This is the main step of six sigma methodology 1) define 2) measure 3) analyse 4) improve 5) control this is a six sigma step circle [4].

The Relationship Between DPMO And Process Sigma Assumes The Normal Distribution. Currently The Concept of The Six Sigma Is Proposed As A Management Tool For Achieving Process Improvement, Reduced Cost, Reduced Wastage, Increased Customer Satisfaction And Above All, Increased Profitability [4]. Six Sigma Quality Level Allows An Off-Centering of The Process Up To 1.5σ . As Can Be Seen From Fig. 2, The Properties of Normal Distribution:

- 68.27% of the area lies within mean $\mu \pm 1\sigma$
- 99.73% of the area lies within mean $\mu \pm 3\sigma$
- 99.999998% of the area lies within mean $\mu \pm 6\sigma$ [39].

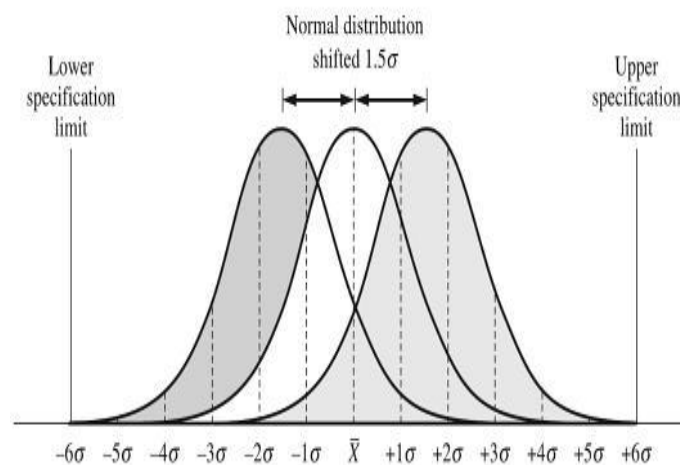


Fig. 2. This is the figure of process spread on both side of the mean it means here in the figure both side shows the six sigma and it shows upper specification limit, lower specification limit and normal distribution that shifted at 1.5

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TABLE 1 , Is for the performance measure here in the table sigma level, percent output and DPMO were shown here if defects and sigma levels are inversely proportional. It means if defects increased sigma level decreased and if defects decreased sigma level increase.

Sigma Level	Percent Output	DPMO
1σ	30.23	697700
2σ	69.13	308700
3σ	93.32	66810
4σ	99.379	6210
5σ	99.9767	233
6σ	99.99966	3.4

Six Sigma implies three things: statistical measurement, management strategy and quality culture. It tells us how good products, services and processes really are, through statistical measuring of quality level [1]. It is also a quality culture. It provides the way to do things right the first time and to work smarter by using data information [2]. Six Sigma helps to identify hidden waste and costs, eliminate defects, increase profit margins, customer satisfaction, employee’s satisfaction and level of commitment, and expand the business. In short, Six Sigma is about eliminating process defects and human defects [6].

B. SMALL SCALE FOUNDRY-AN OVERVIEW:

In the era of globalization, producing good quality castings as per the standards needs multidirectional competitiveness [1]. Indian foundry industries are constantly on the alert to gain a competitive edge. Yet, the Focus is deviating from overall operational excellence. To compete globally, foundry men have to move ahead from the slogan of ‘satisfying customer’ and adopt and rigorously Endeavour for ‘customer delight’. Meeting customer demands will not be sufficient, requirements will be to exceeding them through quality and productivity improvement [2]. For global competitiveness, foundry industries are trying many techniques such as quality circles, total quality management (TQM), International Organization for Standardization certifications, etc. All these techniques are well capable of producing the desired results, but the darker side of the coin is the issues related with their implementation and longer time span to realize the benefits [1]. There are myths that Six Sigma is suitable for large organizations only but, Six Sigma is equally suitable for Small scale foundry too [41].

TABLE 2 , is phase wise process here in the table all the step 1) define 2) measure 3) analyse 4) improve 5) control all the things explain in shortly the main aim of this table to give shortly detail of six sigma each phase

Define	<ul style="list-style-type: none"> Identification of suitable projects based on business objectives Define the scope and goals of the improvement project in terms of customer requirement Development of project charter and critical to quality issues
Measure	<ul style="list-style-type: none"> Selecting product characteristics and measurement system analysis Mapping the respective processes and data collection Recording the results with process capabilities and exploring the performance gap

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Analyze	<ul style="list-style-type: none"> • Detailed analysis to find out various root causes • Validation of the root causes • Prioritizing of most affecting root causes
Improve	<ul style="list-style-type: none"> • Brainstorming possible alternative improvements for implementation • Implementation of the selected improvements • Verification of key process variables for improved conditions
Control	<ul style="list-style-type: none"> • Control process variations to meet customer requirement • Develop a strategy to monitor and control the improved process • Verify the project objectives

II. RESEARCH METHODOLOGY

The aim of this study is to give find out the benefits which Six Sigma provides to the small scale foundry for reduce the casting defects and improve the quality and productivity. It is an attempt to show road map to small scale foundry for initiation of Six Sigma projects. Here the strategy is to collect relevant information about six sigma collect the different literature and case studies where Six Sigma approach is successfully implemented in small scale foundry. All the case studies (available from established publications) to show the real research and give impactful path to small scale foundry.. These case studies are taken from the established journals and publications. However most of the research studies are not disclosed easily by the authors, we have taken case studies from small scale foundry to explore the concept. The study of all the cases is then compared and is presented in the following sequence

- 1) General overview of publication and the case industry.
- 2) Methodology adopted by the cases industries
- 3) Tools and Techniques used in various phase by them
- 4) Benefits reaped by each of them

III. GENERAL OVERVIEW OF PUBLICATIONS AND CASE INDUSTRY

For the detail view, different case studies are preferred that shows in table 3. it indicates referred name, title of the paper, full journal name and the year of published the research paper, author name who published the paper, and the product name where DMAIC methodology applied.

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TABLE 3 is general overview of publications and case industry here in the table all research paper that author studied for casting only, and give all the details, about title ,journal year authors and product name.

Referred Name	Title	Journal, Year	Author/Authors	Products
A	Increasing Bottom-Line Through Six Sigma Quality Improvement Drive: Case Of Small Scale Foundry Industry	UdhygPragati, Vol. 36 No. 2,2012	Darshak A. Desai	Cooler Plate, Hammer, Nose –Ring Segment
B	Quality And Productivity Improvement Through Six Sigma In Foundry Industry	Int. J. Productivity And Quality Management, Vol. 9, No. 2.2012	Darshak A. Desai	Flange
C	Application Of Six Sigma Methodology In Small Scale Foundry Industry	International Journal Of Lean Six Sigma,2013	E.V. Gijo,Shreeranga Bhat,N.A. Jnanesh	Leaf Springs
D	Empirical Study On Employee Job Satisfaction Upon Implementing Six Sigma DMAIC Methodology In Indian Foundry – A Case Study	"International Journal Of Engineering, Science And Technology Vol. 3,No. 4, 2011"	A. Kumaravadivel,U. Natarajan	Gate Valves, Flywheel Outer Casings
E	Utilization Of Six Sigma(DMAIC) Approach For Reducing Casting Defects	International Journal Of Engineering Research And General Science Volume 2, Issue 6,2014	Virender Verma,Amit Sharma, Deepak Juneja	Upper Gear, Lower Gear, Key, Roller Sporting Arm, Worm Gear
F	Application Of Six Sigma Method To Reduce Defects In Green Sand Casting Process: A Case Study	International Journal On Recent Technologies In Mechanical And Electrical Engineering (Ijrnee) Volume: 2 Issue: 6,2015	Suraj Dhondiram Patil, M M Ganganallimath, Roopa B Math, Yamanappa Karigar	Transmission Case Casting
G	A Systematic Methodology For The Creation Of Six Sigma Projects: A Case Study Of Semiconductor Foundry	Expert Systems With Applications (Elsevier),2008	Chao-Ton Su , Chia-Jen Chou	Semiconductor

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IV. METHODOLOGY ADOPTED BY CASE INDUSTRIES

As Discussed earlier six sigma concept that there is two methodology DFSS and DMAIC mostly industry applied DMAIC Methodology. In our 7 research paper of casting there was applied six sigma methodology and that all the methodology shown in table in the detail.

TABLE 4 is for methodology adopted by case industries name of the research paper, methodology, and goals are in the table here table shown that what is the methodology of the case industry and what is the goal of the industry after applying six sigma methodology

Name	Methodology	GOAL
A	DMAIC	Reducing rejection in casted products in foundry
B	DMAIC	Improving rejection rate and cycle time of the flange casting
C	DMAIC	Reducing rejection in the hardening process of leaf spring leaf spring manufacturing
D	DMAIC	Reduce the incidence of defects and increase the sigma level of the sand casting process.
E	DMAIC	Reducing rejection in defects in all types of bearing
F	DMAIC	reducing the defects in transmission case casting
G	DMAIC	reducing rejection rate in semiconductor

V. TOOLS AND TECHNIQUES USED IN VARIOUS PHASE BY THEM

In the DMAIC Methodology the most important thing is tools and techniques. In each phase of DMAIC they have different-different tools and techniques. The table shows all the tools and techniques that were used in the small scale foundry with the use of Six Sigma. General tools and technique which are used in different phases are shown below:

Define Phase: Project Charter, Pareto Diagram, Flow Chart, CTQ Tree, Process Map, and Supplier-Input-Process-Output-Customer (SIPOC) Diagram.

Measure Phase: Pareto Diagram, Data Collection form, Control Charts, Gauge R & R, and Detailed Process Map, Process capability analysis

Analyze Phase: Histogram, Run Chart, Control Charts, Scatter Chart, Cause and Effect Diagram, Analysis of Variance (ANOVA), Design of Experiment (DOE), Failure Mode and Effect Analysis (FMEA), Regression Analysis, Hypothesis Testing, Multivariate Chart, Interrelations Diagram.

Improve Phase: Brainstorming, Affinity Diagram, Multi Voting, Suitability Matrix, DOE.

Control Phase: Related Activity Chart, Standard Operating Procedure (SOP), Control Charts [41].

TABLE 5 is for tools and techniques used in various phase by the industries here the analysis of 7 research paper and also shown all the tools and techniques that used in to the six sigma that was arranged as per applied tools in each phase

Phase Wise Use of Tools and Techniques (where, D=Define, M=Measure, A=Analyse, I=Improve and C=Control)							
Tools and techniques	A	B	C	D	E	F	G
Affinity diagram							
Analysis of variance			I			I	
Arrow Diagram							

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Benchmarking							
Brainstorming							
Cause & Effect diagram	A	A	A		M	A	
Check sheet							
Control chart	C	C	C	C			
Correlation analysis							
Critical to Quality matrix				I		A	
Descriptive statistics							
Design of Experiments						I	
Flow chart			D				
FMEA							
Gantt chart							
Gauge R & R							
Histogram							
Hypothesis testing							
KANO model							
Matrix data analysis							
Matrix Diagram							
Multivoting	A	A					A
Non-parametric tests							
Pareto Diagram	A	A		M		M	
Pie, bar charts					M		
Poka yoke							
Prioritization matrix							
Project Charter			D			D	D
Process capability analysis				C			
Process decision Program Chart							
Process map		A					
QFD							
Regression analysis							
Relation diagram							
Root Cause analysis							
Run charts							
Scatter diagram							
SIPOC diagram		D	M				
Statistical Process Control							
SWOT analysis							

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Voice of customer	D	D					
Why-why analysis	A	A					

VI. BENEFITS GAINED BY CASE INDUSTRIES

The main aim of the industries to apply any kind of tools and techniques was to gain benefits. Same as six sigma application is also one of the most important technique from that we get a benefits and the table shows the benefit in to the foundry industry that applied Six Sigma Methodology. In Six Sigma Methodology benefits are kind of reduced rejection rate or improve sigma level that all thing shown in to the table.

TABLE 6 is benefits gained by case industries here company name that applied six sigma in the foundry and after applying six sigma what was the benefits gained by the industries was shown in to the table

Name	Benefits
A	Annual financial savings cooler plate 44%, Hammer 45%, Nose-ring segment 22.5%
B	The sigma level of grey iron flange casting improved from 1.979 to 2.260 and S.G. iron flange casting from 1.638 to 1.954.
C	Rejection was reduced from 48.33 to 0.79 per cent, the reduction in rejection and was to the tune of USD 8,000 per year.
D	sigma level of the process being increased from 3.32 to 3.47
E	The rejection due to Blow holes defects were reduced from 2.74% to 0.11%, The rejection due to slag defects were reduced from 2.52% to 0.89%, The rejection due to Misrun defects was reduced from 0.96 % to 0.68%, The rejections due to rough surface defects were reduced from 0.73 % to 0.42%, saving of cost Rs 2.35 lac app.
F	the casting defects of the moulding process were 9.58 % of the Transmission Case castings was reduced to the 5.6%
G	Increase of machine utilization in photo module 0.130%, Establish CAR systems 0.066% , Polishing of wafer project 0.134 % , Recruit advanced manpower 0.042%

VII. CONCLUSION

From the study of all the research paper of six sigma conclude that six sigma is a breakthrough improvement methodology with the use of six sigma it is confirm that we get a min.50% improvement, if we work hard and top management involvement is good. It can also be concluded that DMAIC methodology is mostly used by the industries for their performance improvement. This study will help small scale foundry to initiate Six Sigma projects in their organizations and improve their performance in terms of customer satisfaction as well as financial benefits with increase in competitiveness in worldwide market of foundry.

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