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Six Sigma Implementation Efficiency in an Automobile Firm

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Abstract: ***Six Sigma a new paradigm and fast growing manufacturing strategy executed and streamlined across recent automobile firms. This methodology have been faster pace of growth worldwide which helps to enhance productivity and quality improvement on existing process robust to monitor quality variations across manufacturing firms. To respond to quality changes happening every firm within the industry aligning themselves to show continuous process changes by building their existing infrastructure through Kaizen, JIT manufacturing, Business Process Reengineering practices to attain global competitive advantage and also to meet changing global customer demands by providing high quality products.***

This study results discussed six sigma implementation practices and various defects analysis methods followed in an automobile firm for quality and productivity improvement. This study used systematic literature review approach by analyzing existing major defective parts from the overall manufacturing products of the firm and has been analyzed using quality tools like Pareto analysis, Cause and Effect Analysis, 5 - Why analysis and Scatter diagram.

The findings from this study definitely allow future researchers to progress their research activity in this field of activity helps them to open up new opportunities on six implementation issues to develop and evolve. Overall this study concluded with the suggestion of implementing Six Sigma DMAIC (Define–Measure-Analyze-Improve-Control) methodology which provides a framework to identify, quantify and eliminate sources of variation by optimizing operation variables which helps the firm to improve and sustain performance. The motive of this study is to achieve higher quality level for mutual benefits of organization and customer.

Keywords: ***process capability, defects, continuous improvement, reengineering, sigma levels***

I. INTRODUCTION

Six-Sigma is well-structured methodologies that can help a company achieve expected goals through continuous improvement. Practically, six-sigma may reduce defects to as low as 3.4 Parts Per Million (PPM) in any organization [3]. Every automobile firms reengineering themselves from process by human to process to machine (or process by robot). The entire industry principle and goal is no machine down time, maximizing lifecycle and throughout and zero defects.

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Six sigma make use of highly advanced statistical methods and special management techniques which allows automobile firms to identify the errors and defects in the existing business processes and also by continuously improving quality of process outputs to build happier and healthy business organizations.

In order to promote six sigma culture automobile firms creating many black belt / yellow belt / master black belt certification holders in this widely acclaimed methodology. It is new, emerging, approach to quality assurance and quality management with focused on continuous quality enhancements.

The main goal of this approach where firms may reach level of quality and responsibleness continuously over a period which will satisfy and even exceed demands and expectations of today's changing organizations. Basically the term six sigma quality level is employed as an indicator of process improvement goodness. Lower six sigma quality level means that larger risk of defective items, while, higher six sigma quality level means that smaller risk of defective items within the process. [4]

From the statistical point of view, the term 'Six Sigma' is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% (by assumption the process mean shifted by 1.5 and accountable long-term variation of 1.5) where Sigma is a term used to represent the variation about the process average. There are many other benefits that can also be obtained from the application of Six Sigma such as an increase in operations knowledge and participation of staffs in Six Sigma projects [1] [9].

Building a suitable infrastructure every automobile industry should compulsorily makes use of six sigma principles and pillar by laying proper foundation in implementing / deploying six sigma methodologies. The pillar includes VOC or Voice of Customer, CTQ or Critical to Quality characteristics and value marketing. These elements guarantee automobile firms to deliver quality service with much customer satisfaction, attain competitive edge across global markets within industry and produce higher return on investment of their existing / new product and services.

Six-Sigma has been widely adopted in a variety of industries worldwide and it has become one of the most important subjects of debate in productivity management. It is nearly impossible to develop formal conceptual definition of Six Sigma because it is driven by the changing needs of the organization and consultant needs to always offer something new and distinctive.

There is an evidence stating that, "Six Sigma continues to draw tools and concepts such as Kano Analysis from marketing research, change management from Organisation Behaviour, Supply Chain Optimization from operations research and Hosin Planning from Toyota" [12].

The purpose of this research is:

1. To examine the various statistical process control tools used for the quality improvement.
2. To identify the major defective products from the overall production.
3. To analyze the exact root cause for most frequent defects and problems.
4. To find out the sigma level of the company.
5. To suggest the possibilities for implementing DMAIC approach for achieving Targeted and achieved PPM the same.

II. SIMILAR IMPLEMENTATIONS

An interesting aspect made on systematic implementation of the Six Sigma DMAIC methodology as a case study in solving the problem of poor wafer yields in semiconductor manufacturing conducted. This study described well-known industry standard business processes to be implemented and benchmarked in a semiconductor wafer fabrication facility to manage defect and yield issues while executing a Six Sigma project. The execution of Six Sigma enabled identification of the key process factors, root cause analysis, desired performance levels, and Cpk improvement opportunities. Implementing multilevel factorial design of experiments (DOE) study revealed critical input parameters on process tools contributing to defect formation. This study shown results based on the improvement performed on these process tools which resulted in in-line defect reduction and ultimately improving final yields. [7]

Another interesting implementation made on casting unit experiencing a rejection rate of 30%. The main purpose of this study helps to spot out varied causes of incidence of blowholes and identify corresponding remedies for these defects by systematic implementation of DMAIC cycle. Preventive and corrective actions were counseled to scale back the blowholes defect and overall improvement was valid through two-proportion take a look at. The results of investigation demonstrated the net significant reduction of blowhole defect from 28,111 to 9,708 Parts Per Million (PPM) which resulted in net savings of 1,256,640 annually. [3]

Two authors used six sigma methodology for achieving, maintaining and maximizing the business success. Six-sigma is based on understanding the customer needs and expectation. This study mainly focused on six sigma quality philosophy and other related philosophy that is implemented in these studies to identify the rejection problem which are facing by a manufacturing industry. The six sigma philosophy provides a step-wise quality improvement methodology in which statistical techniques is used for check the changes in the process. [6]

Through Six sigma a study had been conducted in a residential building to which Six Sigma principles were applied for internal finishing work (tiling work). The researchers prepared defect assessment sheet for the existing process and the level of the process found to be 3.37 with corresponding yield of 95.76%. The study adopted DMAIC [Define-Measure-Analyze-Improve-Control] approach to enhance the quality of the existing process by analyzing the process defects, their percentage of occurrence, the possible causes and effect of defects and depicts recommendations to overcome them. The findings suggested the proper training, management support and minor changes that is required in current work procedure which would help to improve the quality and ultimately enhancing the customer satisfaction which is of prime importance. [10]

The concept **of** six sigma capabilities analyzed through SIPOC [Supplier-Input-Process-Output- Customer] to monitor product and services provision for customer satisfaction. Process capability, gauge repeatability and reproducibility, one-way and two-way analysis of variance, cause-and-effect analysis, Pareto chart, FMEA and DOEs have been used to implement Six Sigma [8] [5] [11] [2]

III. METHODOLOGY

The study followed DMAIC approach help in quantify and eliminate root cause of waste or rejections which allow the firm to sustain improved performance with well executed control plans in future. DMAIC methodology provides teams to use self-diagnosis to fulfil goals of each phase.

This section presents the process observation results that show the rate of Six Sigma utilization within the automobile firm structured according to the various domain areas, departments, company size, and product types. The study period is between **January – December 2018.**

The study identified some of the critical process through defect analysis calculations of DPMO, process efficiency and various six sigma levels. Among various products from the overall production, few major defective products have been taken to analyze it to find out reasons for the defects. Selected products are:

- Roll rod insulator (193058)
- Roll rod insulator (193059)
- Radiator hose (515867)
- Radiator hose (515870)
- Damper pulley(191NR1)

The above identified defective items are analyzed through process control tools such as Pareto analysis, Root cause analysis, Fish bone diagram and scatter charts.

Table showing Total numbers of production and defects for the year 2018

S.NO	TOTAL NO OF PRODUCTION	NO OF DEFECTS
1	27,527,131	149,639

(Source: PHI Records Jan-Dec 2018)

DPMO FORMULA:

$$\textbf{DPMO} = \frac{No.of\ rejection}{No.of\ production quantity} \textbf{ x 1000000}$$

$$\textbf{DPMO} = \frac{149639}{2752131} \textbf{ x 1000000}$$

DPMO = 5436.0

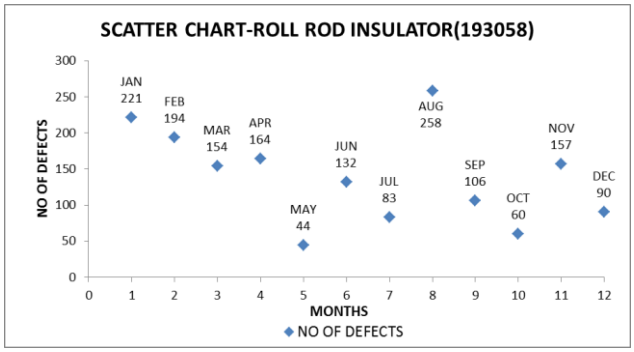
From the above sigma level calculation, it is recorded that the firm is having 4.5 σ (app) level in the year of 2018 on the basis of defective product / service which shows a big improvement to the bottom line. This improvement definitely reflects in the outcome of the results which helps the firms to translate not only into cost reductions but also into increase in sales and quantum leaps in profitability.

Table No. 1 Table showing month wise defect quantities of selected products

Part Name/ Months	Roll Rod Insulator -193058	Roll Rod Insulator -193059	Radiator Hose -5158670	Radiator Hose -5158700	Damper Pulley (191nr1)
JAN	221	111	376	805	183
FEB	194	98	772	951	327
MAR	154	134	329	329	277
APR	164	141	495	457	211
MAY	44	227	236	369	111
JUN	132	194	316	279	215
JULY	83	139	212	289	176
AUG	258	172	623	328	280
SEP	106	140	408	304	120
OCT	60	298	597	342	118
NOV	157	105	568	450	128
DEC	90	237	746	521	93

(Source: PHI Records Jan-Dec 2018)

The Above Table Shows Month-Wise Defective Quantities Of The Selected Products For A Period Between Jan – Dec 2018. The Process Teams Within The Manufacturing Unit Analyzed Through Brainstorming And Identified Some Of The Reasons Why The Products Are Frequently Occur Defects. The Reasons Are Related With The Respective Defective Products. The Major Reasons Identified Are: ***Short Fill, Rubber Damage, Materials And Others, Gas / Cut Mark, Rubber And Others, Rubber Under Curing, Rubber Over Curing And Bubbles***.



From The Above Chart It Is Observed That From The Month January To December 2018, Major Number Of Defects Occurred In The Month January. The Number Of Defect In The Month January Is 221 Numbers Of Product.

Table No. 2 Table Showing No Of Defects And Its Reason Of Roll Rod Insulator (193058)

Defects Reason	No Of Defects	Cumulative (%)	Percentage
SHORT FILL	952	57.90%	58%
RUBBER & OTHERS	331	78.03%	20%
RUBBER DAMAGE	244	92.87%	15%
MATERIAL & OTHERS	76	97.49%	5%
RUBBER OVER CURING	21	98.76%	1%
RUBBER UNDER CURING	12	99.49%	1%
GAS CUT MARK	4	99.73%	0%
BUBBLES	4	100%	0%
TOTAL	1644		100%

(Source: PHI Records Jan-Dec 2018)

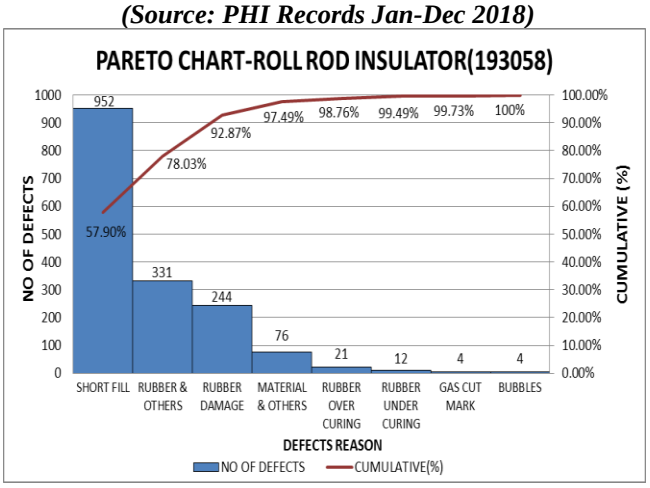
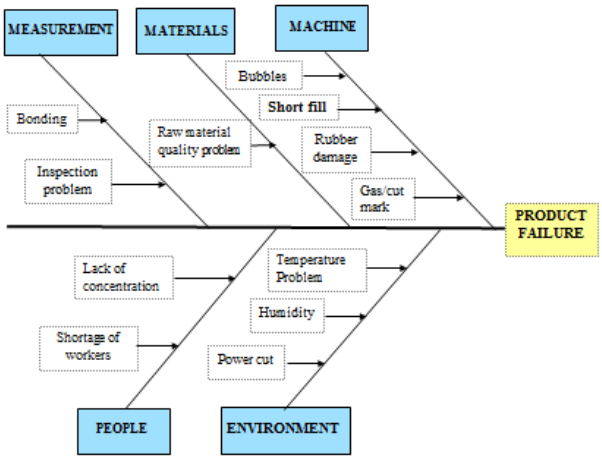


Exhibit: Pareto Chart – Roll Rod Insulator (193058)



From the above analysis it is observed that failure of the product Roll Rod Insulator may be due to short fill and rubber damage because this product handled by the new operator by operating more than one machine simultaneously. The reasons for the failure may also be analyzed by root cause analysis for the same product.

Exhibit: Short Fill

Exhibit: Rubber Damage

Root Causes	Root Causes
Why: Due to reduction in the rubber quantity flow to the mould empty cavity.	Why: Rubber flash not removed while moulding.
Why: Rubber flown in the empty cavity in mould.	Why: Improper cleaning of rubber flash.
Why: One cavity runner point block in the rubber area.	Why: Runner Area releasing agent not applied properly.
Why: New operator handled the work.	Why: Single person operated multiple machine.
Why: Assigning work to new operator	

Table No. 3 Table showing month wise Total Production, Rejection, Target and Achieved PPM

MONTHS	TARGET PPM	ACHIEVED PPM	DEVIATIONS
JAN	5,200	5,008	192
FEB	5,200	5,017	183
MAR	5,200	4,810	390
APR	4,900	5,341	441
MAY	4,900	4,747	153
JUN	4,900	4,836	64
JUL	4,400	5,179	779
AUG	4,400	5,044	644
SEP	4,400	5,887	1487
OCT	3,800	6,196	2396
NOV	3,800	5,539	1739
DEC	1,745	7,681	5936

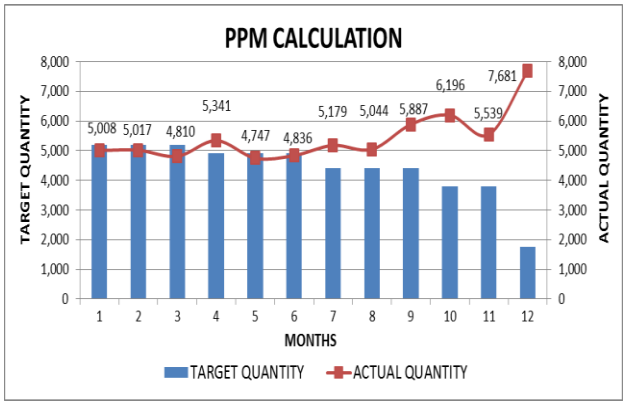


Exhibit: PPM Calculation

IV. MAJOR FINDINGS FROM THE RESEARCH

Tools/ Products	Pareto Analysis	Cause & Effect Analysis
Roll rod insulator (193058)	Short Fill Is Considered As The Major Defect Reason Having 58% Among Various Other Reasons.	'Short Fill' Is The Major Cause Leads To Failure Of The Product.
Roll rod insulator (193059)	Short Fill Is Considered As The Major Defect Reason Having 60% Among Various Other Reasons.	'Short Fill' Is The Major Cause Leads To Failure Of The Product.
Radiator hose (515867)	Scorch Problem Is Considered As The Major Defect Reason Having 32% Among Various Other Reasons.	'Scorch Problem' Is The Major Cause Leads To Failure Of The Product.
Radiator hose (515870)	Scorch Problem Is Considered As The Major Defect Reason Having 33% Among Various Other Reasons.	'Scorch Problem' Is The Major Cause Leads To Failure Of The Product.

Tools/ Products	5 - Why Analysis	Scatter Chart
Roll Rod Insulator (193058)	New Operator Handled The Work Is The Root Cause For The Failure Of Product To Achieve The Required Sq.	Major Number Of Defects Occurred In The Month January With 221 Numbers Of Product
Roll Rod Insulator (193059)	Single Person Operated Multiple Machine Is The Root Cause For The Failure Of Product To Achieve The Required Sq.	Major Number Of Defects Occurred In The Month October With 298 Numbers Of Product.
Radiator Hose (515867)	New Unskilled Labor Staffing Is The Root Cause For The Failure Of Product To Achieve The Required Sq.	Major Number Of Defects Occurred In The Month February With 772 Numbers Of Product.
Radiator Hose (515870)	Cmb Condition Base Rubber Not Mixed Properly Is The Root Cause For The Failure Of Product To Achieve The Required Sq.	Major Number Of Defects Occurred In The Month January With 805 Numbers Of Product.
Pulley Damper (191nr1)	Reduction In The Quality Of Raw Materials Purchased Is The Root Cause For The Failure Of Product To Achieve The Required Sq.	Major Number Of Defects Occurred In The Month February With 327 Numbers Of Product.

V. RECOMMENDATIONS FROM THIS RESEARCH

It is recommended from this study that Six Sigma alone not sufficient in incorporating recent developments and enhancements in production area. It is better organizations need to integrate Lean and Six Sigma to obtain better results and productivity. Firm need to create more Six sigma process champions like Black Belt, Green Belt, Master Black Belt in future deployment six sigma projects where the firm easily translate their mission, vision and values [4].

All automotive firms need to attain competitive advantage may make use of integrated solution like Lean Six Sigma which can help them to collaborate their existing business areas like service, production, marketing, sales and procurements etc. In order to eliminate more defective items during production process and to overcome the defects principles like MUDA wastes may be incorporated which includes motion, inventory, transportation etc. allowing automotive firms to face barriers facing currently in the manufacturing segments. Tools like SIPOC Chart analysis, process mapping tools like value stream mapping, Milestone tracker diagrams may help firms to segregate easily Non value added items by mapping core business process easily in work place areas [6]. As continuous process improvement move preventive and corrective actions have defined in advance which boost existing manufacturers practice allow them to decrease process capability measurements [9]. Change Management culture need to be incorporated amongst individuals by continuously converting their old mindset problem solving techniques to goal seeking problem solving methods.

VI. CONCLUSION

To survive in 21st century competitive world six sigma is a new paradigm measurement tool which allow firms to monitor process variations, quality and productivity measurements. The results from this study aid organization managers to undertake both strategic and tactical decisions by continuous review mechanisms through visualization by comparing themselves with others within automotive sector by analyzing their existing benchmarking practices.

If the firms want to see biggest success in Six Sigma deployment it requires focused employee commitment and 100% contribution by dramatically outperform their peers through continuous metric analysis by aligning Voice of Customer (VOC) which helps firms to improve firms overall competitive value proposition through increased market share and profitability. Since DMAIC (Define, Measure, Analyze, Improve and Control) is a continuous chain process – a single journey of this phases should not help firm to reach final destination / milestone. Since the output of one phase normally given it has an input for the other phase. This single journey does not make an organization to move towards the excellence path.

It is concluded Six Sigma methodology played a decisive role in existing business environment in achieving their existing organization mission and core values, which ensures a systematic and disciplined approach to the issues at hand through the inbuilt DMAIC cycle

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Dr. N. Venkateswaran currently working as Professor in the Department of Management Studies, Panimalar Engineering College, Chennai. Doctoral degree in the field Management and had 26 years of teaching experience in management discipline. He has published more than 150 papers both in national and international journals and authored 10 text books in the field of management**.** Editoral Board member and reviewer in various National and International Journals. His research interest is mainly on ERP, Six Sigma, Supply Chain and Operations Management.