International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 5
May 2018

Using Six Sigma Methodology to Improve the in Process Quality of 6A Multi Socket at an Enterprise

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ABSTRACT

Indian Electrical switch enterprises are one of the swift growing within the mid-sized and small group of industries which are providing many business products. These enterprises develop highly energy-efficient, state-of-the-art products and try to provide customers a safe and luxurious life style with an aim to reduce carbon emission in households and manufacturing products to make the world a better place to live and for enjoying the life. To improve the quality of their process and products for embellishing competitive advantages Six Sigma is employed. This paper focuses on an improvement of an aesthetic product by employing Six Sigma (SS) methodologies to elevate towards the dream of SS quality level. The methodology is executed on one of product assembly for pushing down defects level that are critical to customers and in turn a direct financial benefit to the enterprise.

KEYWORDS

Six Sigma, DMAIC, CTQ (Critical To Customers), Process yield, DPMO (Defect Per Million Opportunity), VOC (Voice Of Customer), Process Improvement.

I .INTRODUCTION

Manufacturing industries are interested in improving their products and process by reducing the variation from the start of the industrial revolution and they are still interested in the same and they will be interested forever. This is due to some of the reasons like increasing global competition, declining profit margin, variation in customer demands for high quality product, product variety and reduced lead–time etc. To respond to these needs various industrial engineering and quality management strategies such as ISO 9000, Total Quality Management, Just–in–time manufacturing, Enterprise Resource Planning, Business Process Reengineering, Lean management etc. have been developed over a period of time and undoubtly, these are doing great.

A new paradigm in the area of manufacturing, Six Sigma was introduced in late 80s by Motorola Industry to reduce the process variations and in turn to enhance the quality performance. The Six Sigma approach has been increasingly adopted worldwide in the manufacturing sector in order to enhance productivity and quality performance and to make the process robust to quality variations.

Usually, for any Company, policy is conducted mainly along the following lines, increase the quality of staff, steady decrease in non-quality costs, react better to meet customers' requirements and to solve problems, regulatory compliance for the environment, optimizing natural resource consumption, better waste management, prevent any type of pollution, chronic or accidental.

Six Sigma initiatives are planned and implemented in organizations on "Project by Project" basis. Each project aims not only to improve a chosen performance metric but also sustain the improvement achieved. Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified financial targets (revenue increase, cost reduction or profit increase). Six Sigma projects follow two project methodologies inspired by Deming's Plan-Do-Check-Act Cycle. These methodologies, composed of five phases each, bear the acronyms DMAIC and DMADV

a) DMAIC (Define, Measure, Analyze, Improve, Control). This is used for projects aimed at improving an existing business process

b) DMADV (Define, Measure, Analyze, Design, Verify). This is used for projects aimed at creating new product or process designs.

Statistical thinking is a method used as part of Six Sigma methodology. Statistical thinking relates processes and statistics, and is based on the following ideas: action occurs in a system of interconnected processes, variation exists in all processes and is very important to understand and deal with it (reducing variation is the key to success), understand and use the appropriate statistical tools for a systematic approach to process improvement

2. SIX SIGMA IMPLEMENTATION- CASE STUDY

SIX SIGMA

Kumi et. al., (2006) defined Six Sigma is a statistical measure of the performance of a process or product. It is used as a quality control mechanism, which seeks to reduce defects or variations in a process to 3.4 per million opportunities thereby optimizing output and increasing customer satisfaction. This is as close to perfection as possible as 99.99966 per cent of the time it would be perfect. In addition to Six Sigma is uniquely driven by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes (Pande, P., et. al. 2000)

2.1 THE DMAIC SIX SIGMA METHODOLOGY

The Six Sigma is not merely a quality improvement strategy in theory, as it features a well defined methodical approach of application in DMAIC and DMADV which can be used to improve the quality of production. At the core of DMAIC, the framework is a formalized improvement strategy with the following five facets i.e. define measure, analyze, improve and control (DMAIC). The methodology is acknowledged with different facets (Fig. 1) which is portrayed in I, II, III, IV and V and accomplished for this case.

2.1.1 THE DEFINE PHASE

1. PROJECT CHARTER

1.1 PROBLEM SELECTED: Production of 6A Multi Socket / day is around 7,000 in which some of the sockets are found defective. Defects are in terms of shutter out, screw free, scratch on cover, pillar hole block, base damage by screw driver and damage in sealing machine present in the final product. It a major issue as it is directly concern with the loss in business & market reputation of the company.

1.2 VOICE OF CUSTOMER:

Table 1. Voice of customer

Customer	**Customer Comments**	**Customer (CTQ's)**
Champion Technical Head(Quality & Testing)	The objective of the project is to enhance the process quality and improve the overall quality of the product without compromising the productivity of the same. It is expected to meet at least 95.5% percent to meet or exceed the process quality.	Reduction of overall defects
		Process Productivity
Production Manager	Looking towards a target of 95.5% of meeting or exceeding the quality target. This project will lead to increasing the Quality /Efficiency/Client satisfaction/cost saving/productivity.	Client satisfaction

2. THE MEASURE PHASE

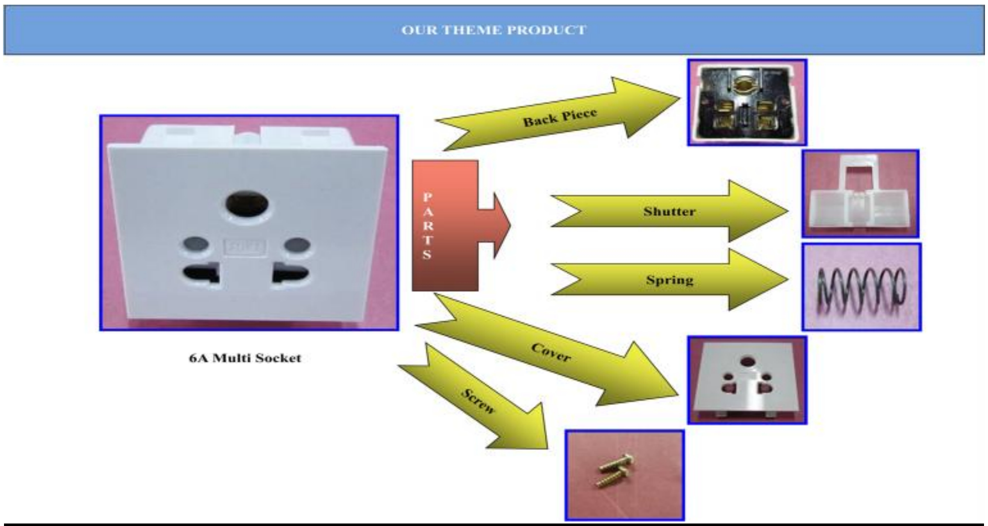

Fig.1 : Observation on the Manufacturing Process: Sub parts of the Product

2.1PROCESS FLOW: The process of manufacturing of a 6A Multi Socket is divided into eight steps. That is given as follows.

1) Place back piece on fixture
2) Place spring in slot
3) Put shutter on spring
4) Put cover in its place
5) Reverse the assembled piece
6) Put screws inside hole
7) Tighten the screws
8) Plug top insertion and visual check.

2.2PROCESS MAPPING:

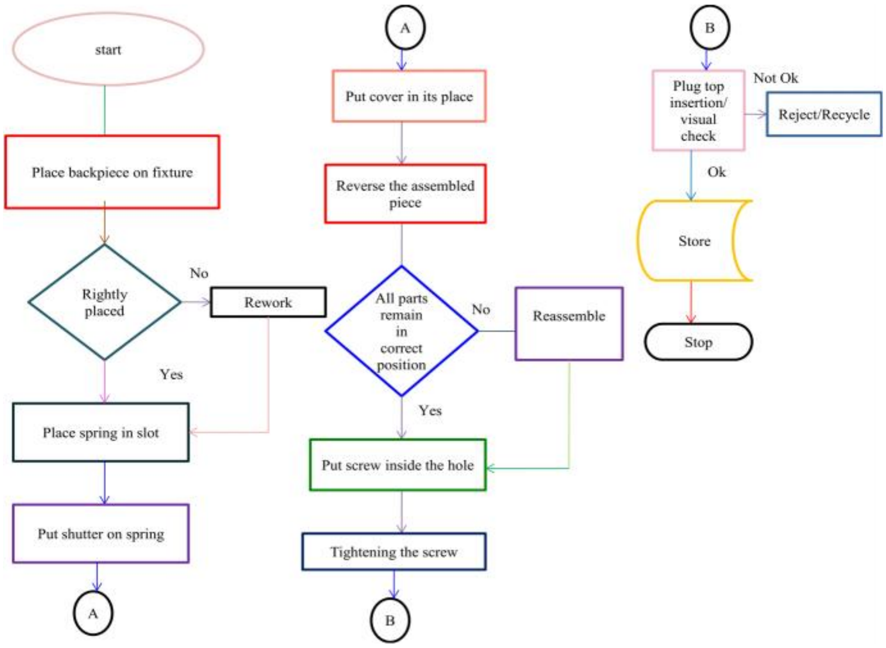

Fig.2: Process Mapping

2.3 CHECK – PERFORMANCE LEVELS / CAPABILITY OF CURRENT PROCESS:

No of inspection = 1000

No of defects (D) = 200

No of defectives = 180

Defects per unit (DPU) = D/N = 200/1000 = 0.20

No. of Opportunities for the defects occur = 6

Total No. of Opportunities for defects = 6x1000 = 6000

Defects per opportunity (DPO) = 200/6000 = 0.033

DPMO = DPO $x10^6$ = $0.03x10^6$ = 33000ppm

PPM for defects = 180000 ppm

Yield % = 96.7%

Sigma Value for defects: 3.3

Sigma Value for defectives: 2.4

2.4 TARGET PERFORMANCE LEVEL:

Sigma Value (Sigma Rating for defects) = **4.0**

Sigma Value (Sigma Rating for defectives) = **3.5**

3. ANALYSIS PHASE

3.1 OBSERVATION OF SYMPTOMS OF BAD QUALITY. Data collection is done by the project team of the 6A Multi Socket. It is observed from the data that there are six types of defects responsible for bad quality i.e.

1) Shutter out
2) Screw free
3) Scratch on cover
4) Pillar hole block
5) Base damage by screw driver and
6) Damage in sealing machine

3.2 OBSERVATION OF VARIATION: Data is collected from line and it is plotted on the

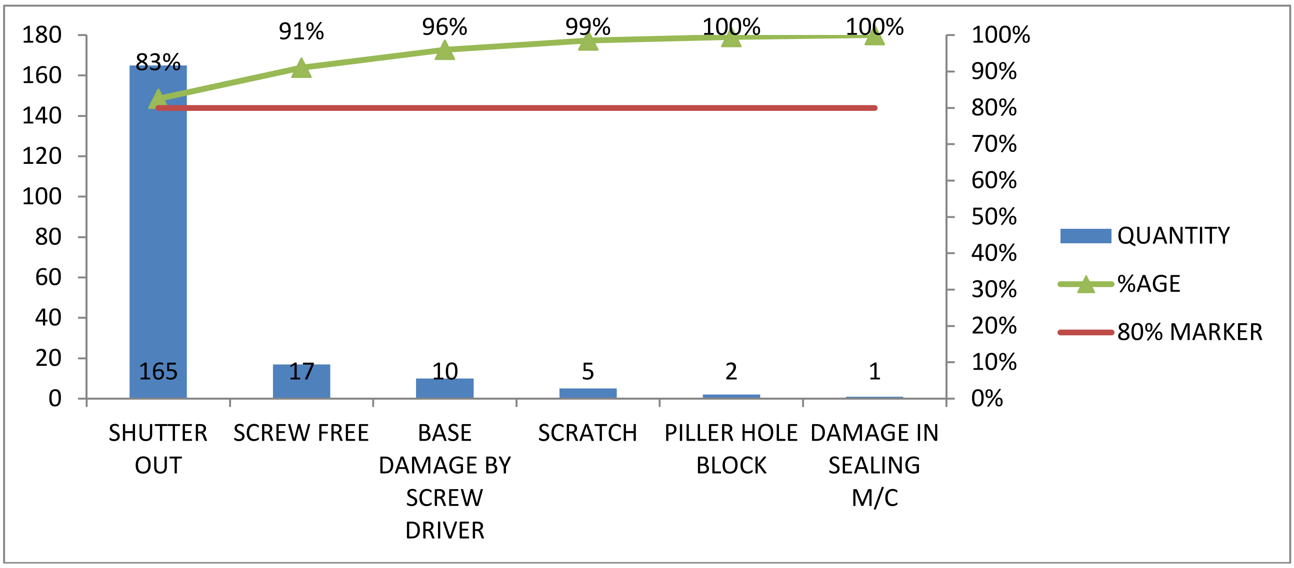

Fig.3:Pareto Chart.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 5
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From the study of the Pareto Chart it is clear that main defect is the **Shutter Out** problem which is responsible for more than 80% of rejection. So our main target is to rectify this defect to reduce the rejection level to the target level.

3.3 SHUTTER OUT PROBLEM: These sockets are used to provide power to external devices like home appliances, irons TVs etc. If the shutter is not working it will cover the holes provided in the sockets. Children can put their fingers in it can be a source of health hazard. So it is necessary to rectify the problem.

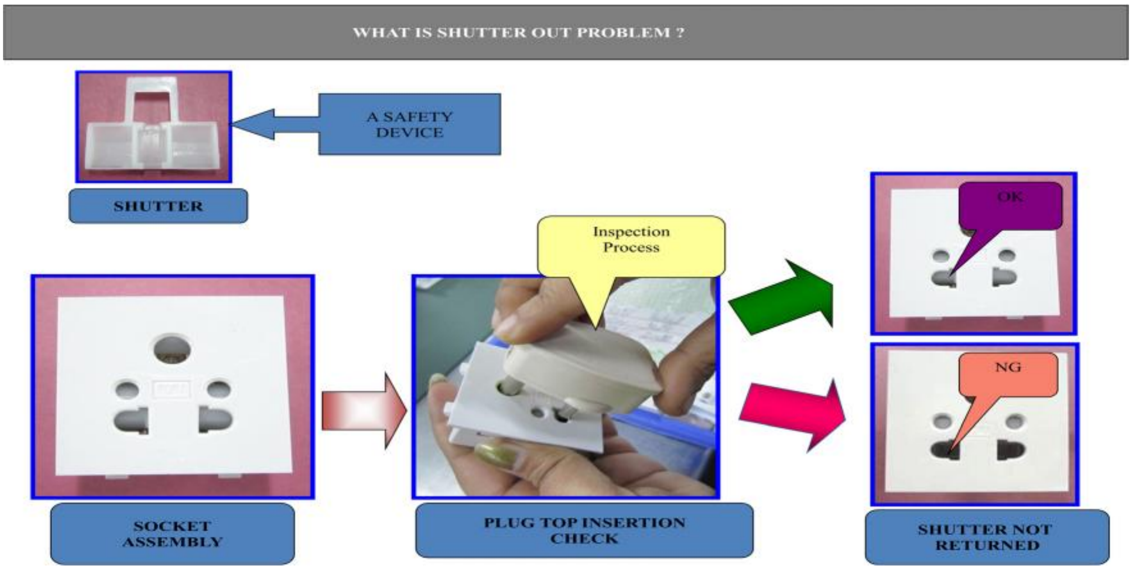

Fig.4: What is Shutter out Problem

3.4 FISHBONE DIAGRAM: To study the various causes due to which the **Shutter Out** defect could be occur a Fishbone Diagram is produced through brainstorming.

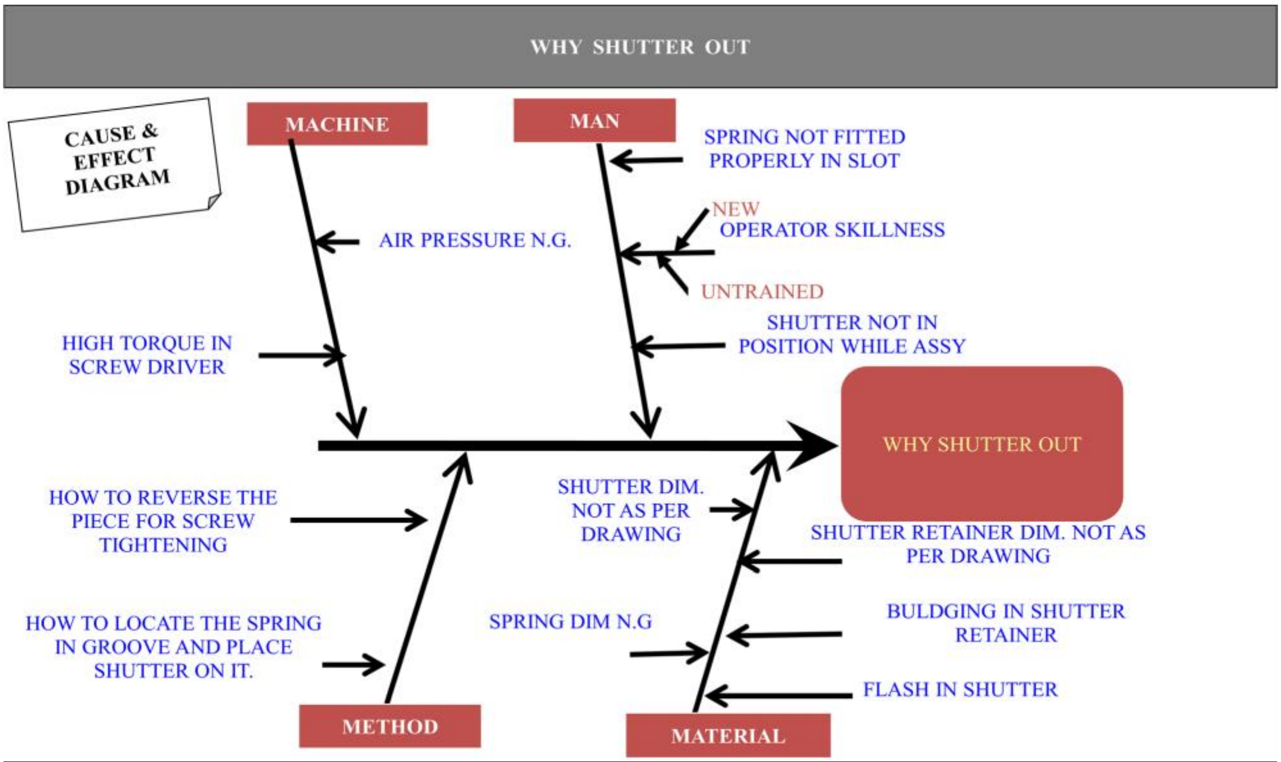

Fig.5: Fishbone Diagram

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ISSN 2394 – 3386
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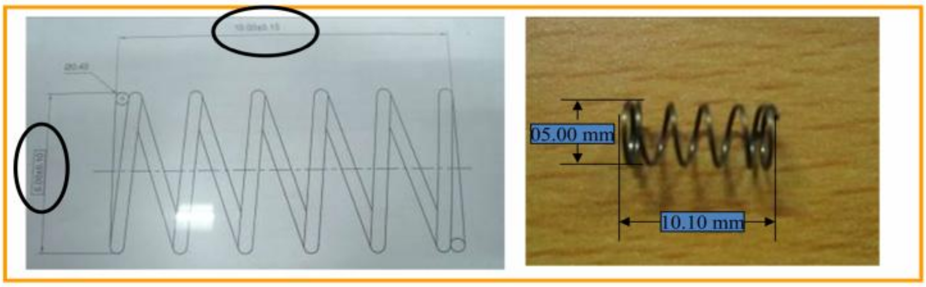
3.5 ACTIONS TAKEN: The dimensions of the parts are measured. Following observations are made.

SPRING DIMENSIONS VERIFICATION



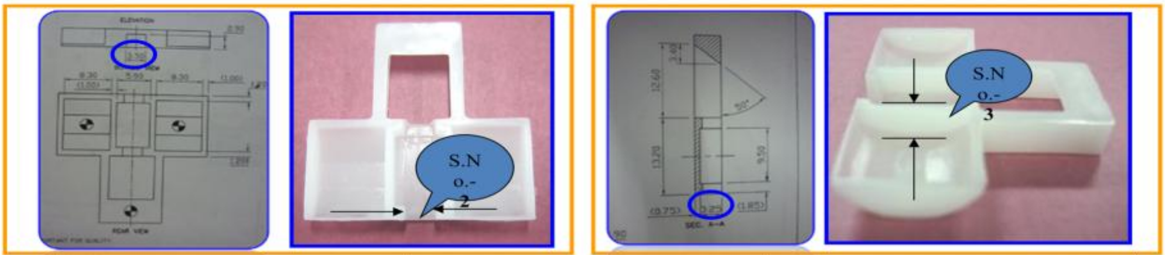
S.No.	CHECK POINT	SPECIFICATION	ACTUAL	JUDGE MENT
1	Wire Dia	0.40 +/-0.01	0.41	O
2	Outer Dia	5.00 +/-0.1	4.92	O
3	Free Length	10.00 +/-0.15	10.10	O
4	No. of Coils	6.50	6.50	O

ALL THE DIMENSIONS OF SPRING ARE AS PER SPECIFICATION.

Fig.6: Snap shot of Action Taken

No correction is required.

SHUTTER DIMENSIONS VERIFICATION



S.N.	CHECK POINT	SPECIFICATION	ACTUAL	JUDGE MENT
1	TOTAL WIDTH	26.5 +/-0.1	26.5	O
2	SPRING SLOT	3.5 +/-0.1	3.7~4.2	X
3	RIB HEIGHT	3.25	2.75	X
4	WIDTH	11.0 +/-0.1	10.9	O
5	TOTAL THICKNESS	4.0 +/-0.1.	4.1	O

CONCLUSION: AS ABOVE TWO DIMENSIONS ARE NG.
SO WE NEED TO SEND THE MOULD FOR MODIFICATION.

Fig.7: Snap Shot of Shutter Dimension Verification

3.6 WHY WHY ANALYSIS:

Table.2 Why Why analysis

PROBLEM	WHY	Steps1	WHY	Recommendations
Shutter out	Two dimensions not as per drawing	These dimensions not checked before	PQC Inspection standard not available	PQC Inspection standard made available
Shutter out	Escaped during inspection.	Checked for all dimensions	Workers are not aware about these dimensions	These dimensions should be added. Workers should be trained.

4. IMPROVEMENT PHASE

4.1 ACTIONS DECIDED: Some of the actions are decided that are as follows

1) Mold sent to tool room for rectification.
2) Inspection standard to be prepared.
3) Preventive maintenance schedule of the mold to be prepared.

SHUTTER DIMENSIONS AFTER RECTIFICATION OF MOULD

S.N.	CHECK POINT	SPECIFICATION	ACTUAL	JUDGE MENT
1	TOTAL WIDTH	26.5 +/-0.1	26.5	
2	SPRING SLOT	3.5 +/-0.1	3.4~3.5	
3	RIB HEIGHT	3.25 +/-0.1	3.15~3.3	
4	WIDTH	11.0 +/-0.1	10.9	
5	TOTAL THICKNESS	4.0 +/-0.1.	4.1	

NOW ALL DIMENSIONS OK.
NEW SHUTTER FED TO LINE FOR PRODUCTION

Fig.8: Snap shot of Shutter Dimensions after Rectification of module

4.2 AFTER MODIFICATIONS: After the suggested modifications and rectifications in the dimensions of the required part again the data has been collected and the following was found there is some decrease in the rejection but is far from the required level.

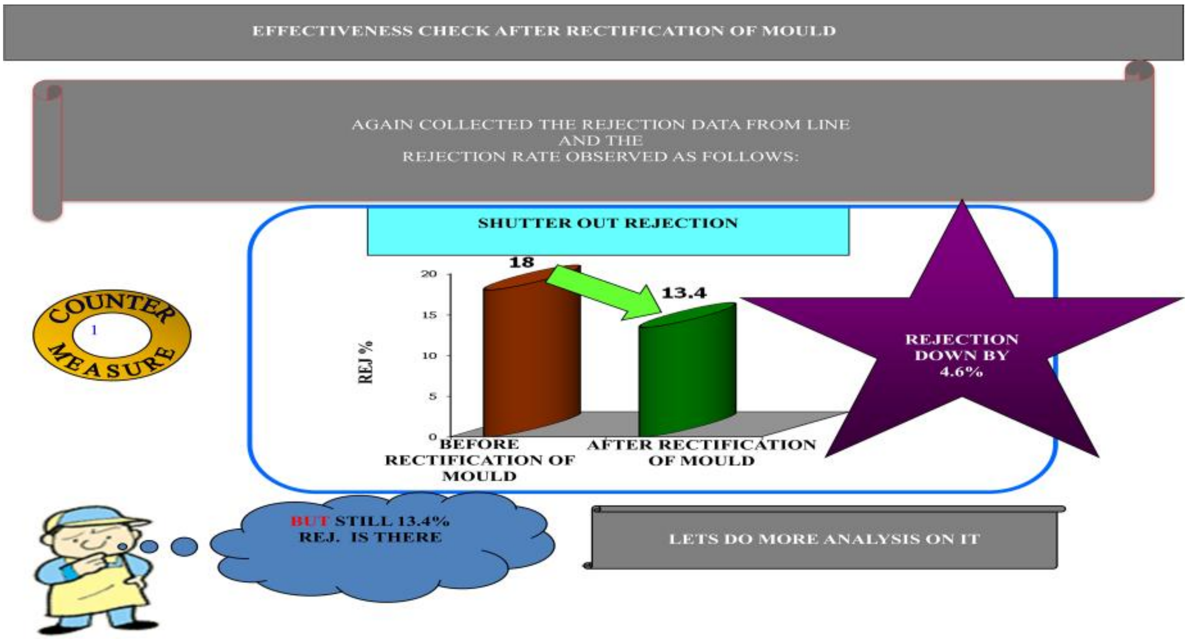


Fig.9: Effectiveness Check after Rectification of module

4.3FURTHER ANALYSIS:_ The rectification in part dimensions does not provide the required results. So we started further analysis to control the problem. For that we took 200 Pecs of the part which only have shutter out problem, analyzed and plot the findings on the Pareto Chart.

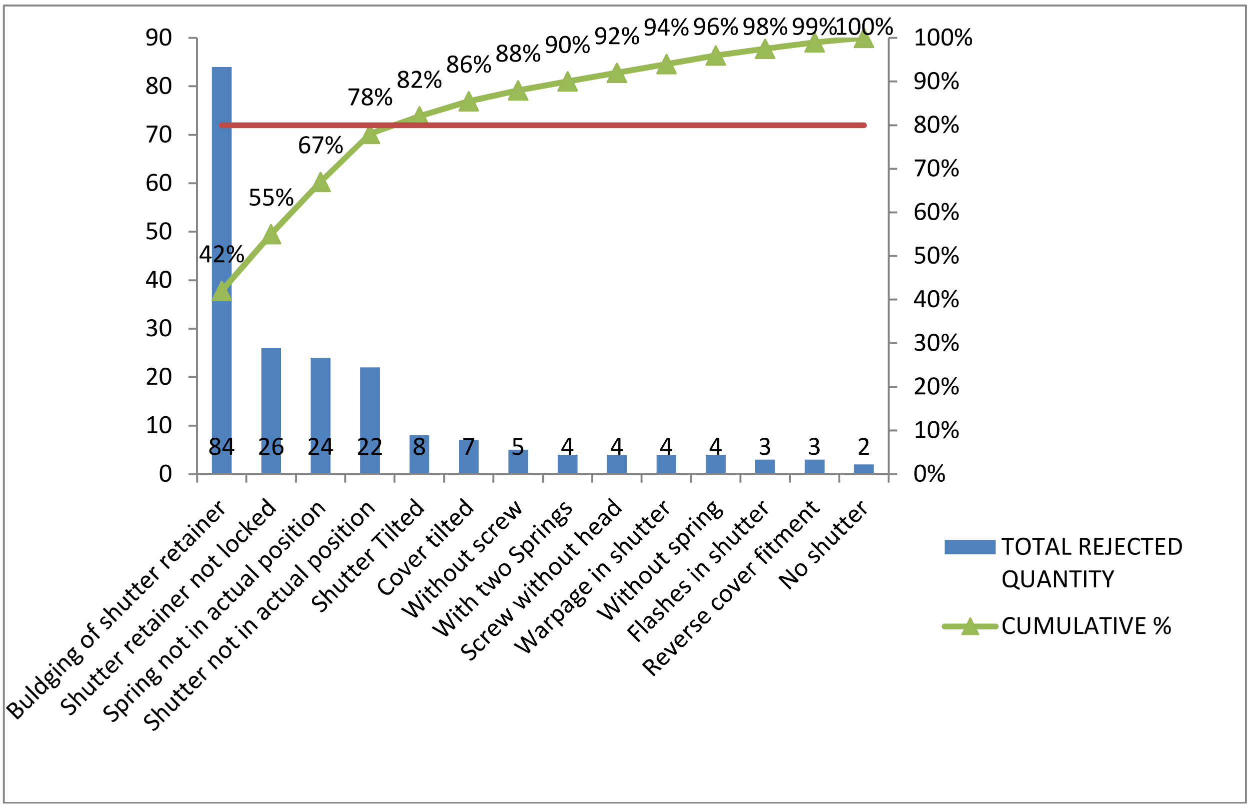


Fig.10: Pareto Chart

From the analysis we found that major problem occurred due to assembly issues which are due to the operator inefficiency. We plot these observations on the Pie chart.

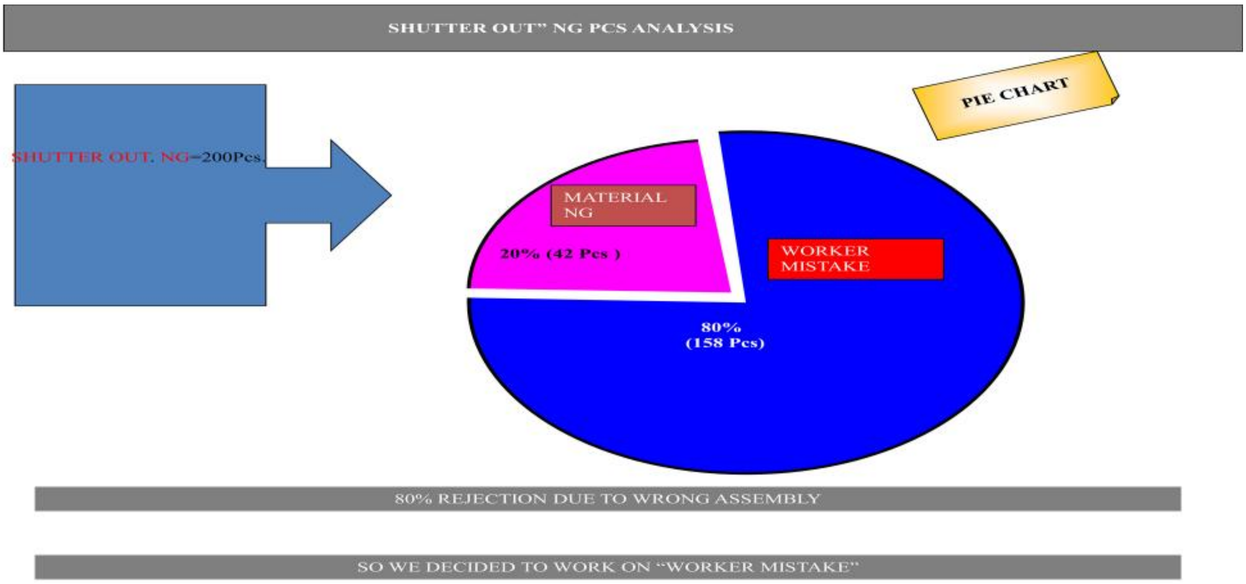


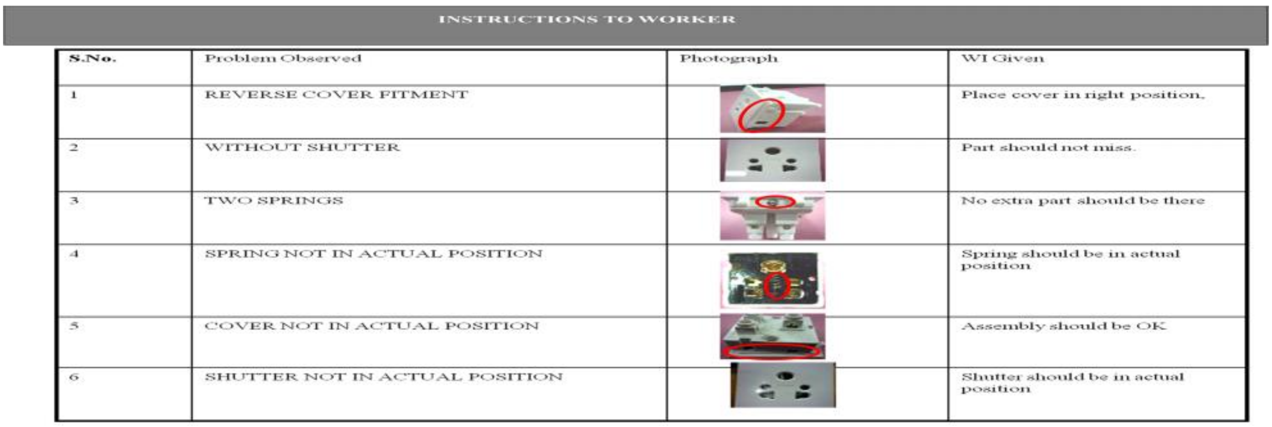
Fig.11: Shutter out NG PCS Analysis

4.4 WHY WHY ANALYSIS: We analyzed the wrong assembled components and try to study the actual process in line and observed as follows.

Table.3 Why Why analysis

PROBLEM	WHY	Steps1	WHY	Recommendations
Shutter or spring not placed in its proper position	Worker is not well trained.	Working speed some time very fast, some time slow	Due to no control in hourly production	Prepared control chart
Less concentration on work.	Worker is not well trained.	Continuous training and motivation	No individual responsibility for wrong assembly	Rejection segregation cell wise .

4.5 INSTRUCTIONS TO WORKER FOR IMPROVEMENT:



INSTRUCTIONS TO WORKER

S.No.	Problem Observed	Photograph	WI Given
1	REVERSE COVER FITMENT		Place cover in right position.
2	WITHOUT SHUTTER		Part should not miss.
3	TWO SPRINGS		No extra part should be there
4	SPRING NOT IN ACTUAL POSITION		Spring should be in actual position
5	COVER NOT IN ACTUAL POSITION		Assembly should be OK
6	SHUTTER NOT IN ACTUAL POSITION		Shutter should be in actual position

Fig.12 Instructions to Worker

International Journal of Engineering Technology Science and Research
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ISSN 2394 – 3386
Volume 5, Issue 5
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4.6 ACTIONS TAKEN (COUNTER MEASURES) FOR SHUTTER OUT PROBLEM:

1) **Training to Worker:** Started to provide training to workers regarding their mistakes and effect on components.

2) **Hourly Production Control:** Implemented "Hourly Production Chart" in line

4.7 IMPROVEMENT: After successfully applying the all the three counter measures to the process again data has been collected from the line and the following observations are found.

4.7.1 BEFORE IMPROVEMENTS:

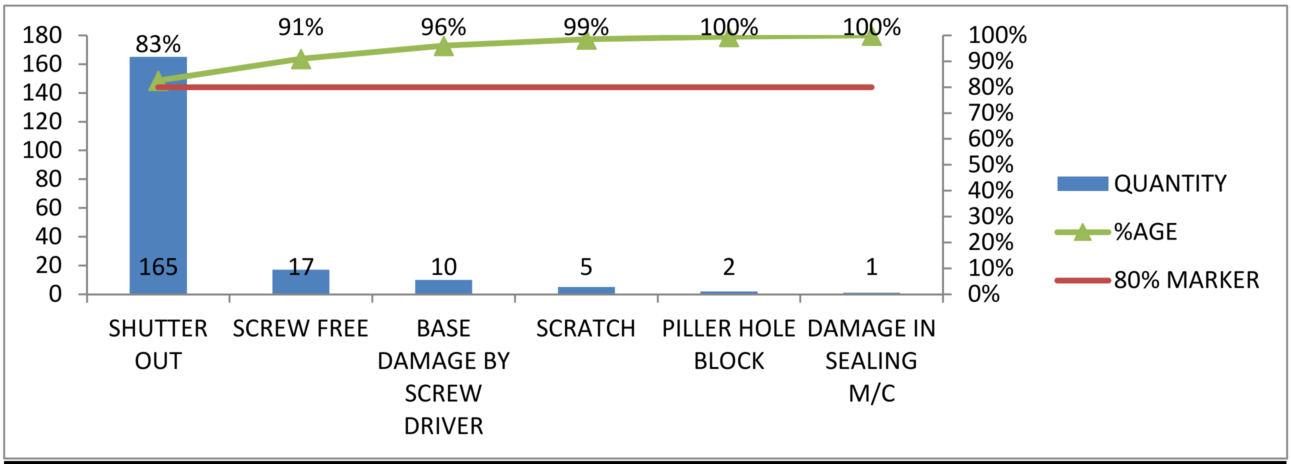

Fig.13: Pareto Chart before improvements

4.7.2 AFTER IMPROVEMENTS: Fresh lot of 1000 Pecs is taken (After all improvements) and the results are plot on a Pareto Chart. Total number of defects is found to be 63 and total defective components are 55.

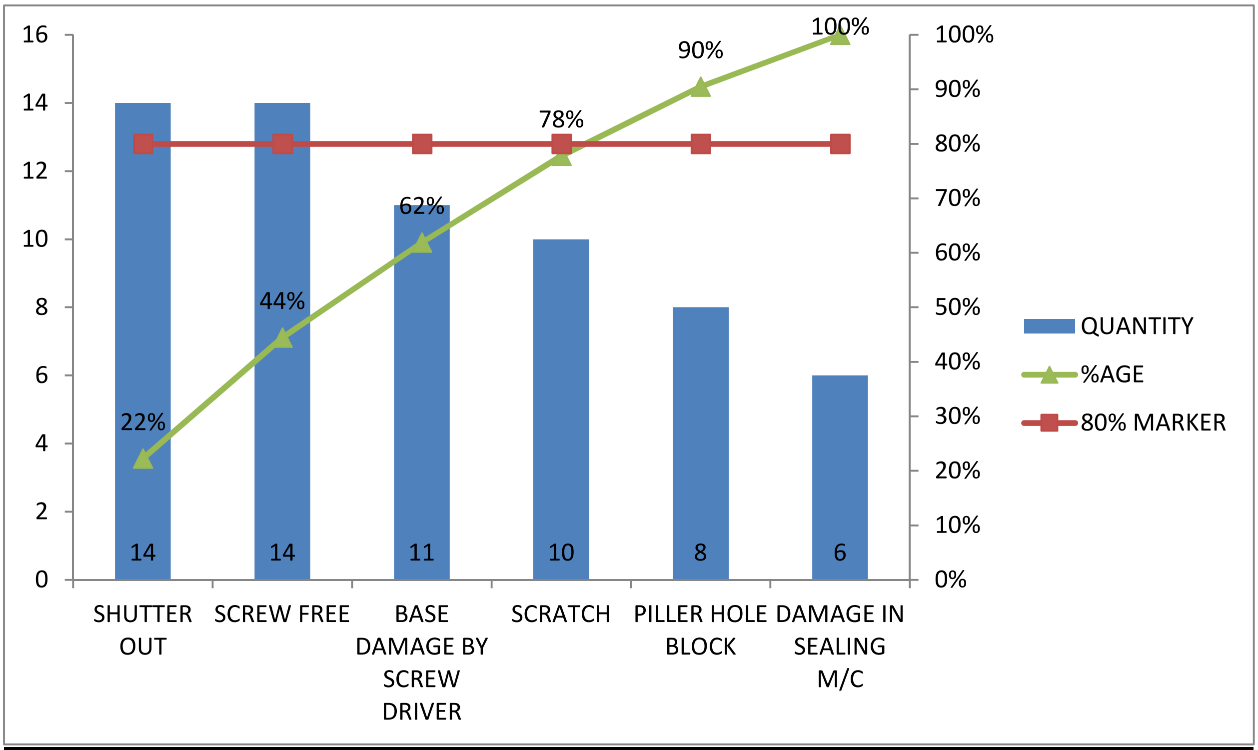

Fig.14: Pareto Chart after improvements

4.8 EFFECTIVENESS OF THE PROCESS AFTER THE IMPROVEMENTS

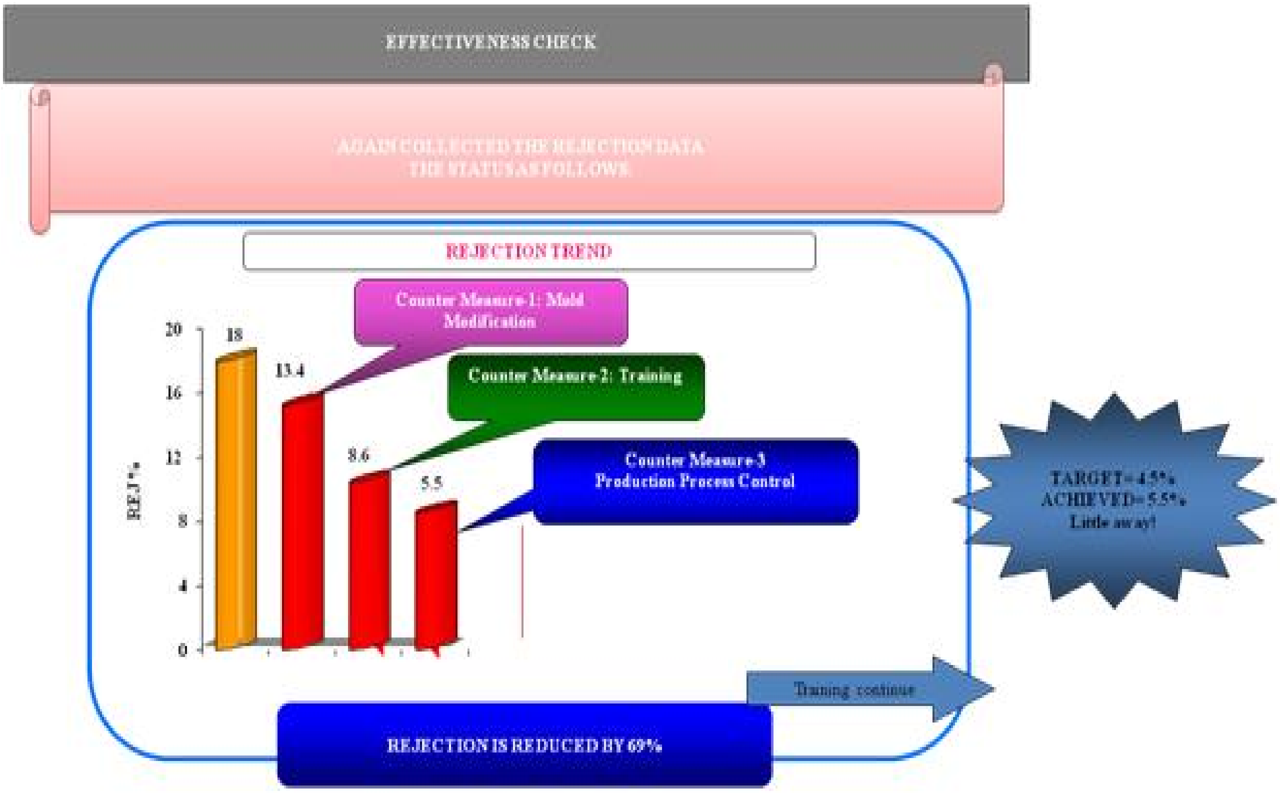

Fig.15: Effectiveness Bar Chart

4.9 CHECK – PERFORMANCE LEVELS / CAPABILITY (POST IMPLEMENTATION):

No of Inspected (N) = 1000

No of defects (D) = 63

No of defectives = 55

Defect per unit (DPU) = D/N = 63/1000 = 0.063

No. of Opportunities for the defects occur = 6

Total No. of Opportunities for defects = 6x1000 = 6000

Defects per opportunity (D.P.O) = 63/6000 = 0.0105

DPMO = D.P.O $x10^6$ = $0.0105x10^6$ = 10500ppm

PPM for defectives = 55000 ppm

Sigma Value for defects: 3.8

Sigma Value for defectives: 3.1

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5 CONTROL PHASE

5.1 CONTROL PLAN:

Table.4 Control plan

Actionable Items	Periodicity	Owner
Quality award started for the top performer of the week	weekly	Team Leader
Preventive maintenance of the dies to check the sensitive dimensions.	Monthly	Manager/Line In charge/standard room
Process knowledge test may conducted on monthly basis Test scores will be a added in performance	Monthly/Ongoing	Trainer & Team Leader
Work Standard modification according to new process	Monthly	Manager/Line In charge
Training program has been established for Bottom performer and new joining	Monthly/Ongoing	Manager/Line In charge
Calibration process has been initiated between client and Team Leader. This will ensure the adequate process understanding	Monthly	Team Leader & Client team

5.2 STANDARDIZATION :

1) Shutter dimensions added in the inspection standard sothat no dimension to be missed for checking.
2) Prepare preventive maintenance schedule for the mold sothat the mold can be rectify before major deformation.
3) Implement hourly production plan chart to maintain normal working speed and avoid assembly mistakes
4) Regular training to operator to motivate and enhance the skill level of the operator.

6 CONCLUSION

6.1 IMPROVEMENT IN PRODUCT QUALITY:

Table.5 Improvement in product Quality

Parameter	Before Improvement	After Improvement
DPMO	33000 ppm	10510 ppm
Sigma Rating for defects	3.35	3.8
Defectives PPM	180000 ppm	55000 ppm
Sigma Rating for defectives	2.4	3.1

International Journal of Engineering Technology Science and Research
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www.ijetsr.com
ISSN 2394 – 3386
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6.2 COPQ (COST OF POOR QUALITY):[Baseline DPMO – Target DPMO / 1000000] x Yearly production quantity x [(Average Repair cost per unit + Labor Man-hour Cost) x No. of manpower]

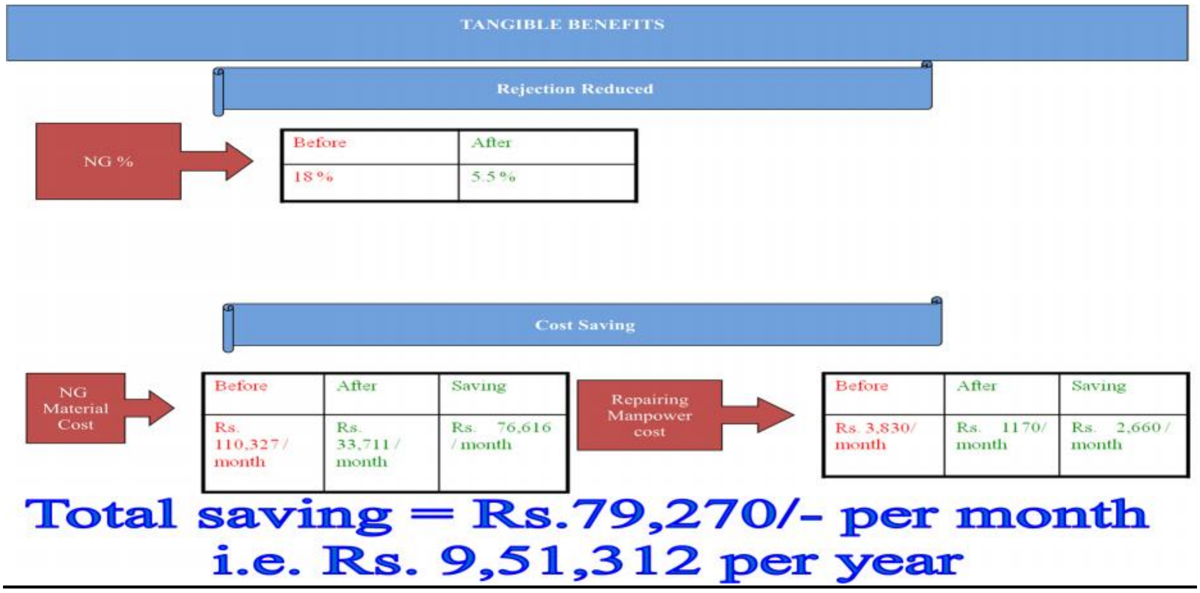

Fig.16: Tangible Benefits

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