Minimization Of Rewok In Belt Industry Using Dmaic

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Abstract— ***The fast changing economic conditions such as global competition, declining 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 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.***

This paper discusses the quality and productivity improvement in a manufacturing enterprise through a case study. The paper deals with an application of Six Sigma DMAIC(Define–Measure-Analyze-Improve-Control) methodology in an industry which provides a framework to identify, quantify and eliminate sources of variation in an operational process in question, to optimize the operation variables, improve and sustain performance viz. process yield with well-executed control plans. Six Sigma improves the process performance (process yield) of the critical operational process, leading to better utilization of resources, decreases variations & maintains consistent quality of the process output.

Keywords— **Six Sigma; Raw Edge Cog Belt Manufacturing Industry**

I. INTRODUCTION

A. *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. It is a management strategy to embed awareness of quality in all organizational processes. By pursuing the process of continuous improvement and never-ending improvement the companies can outdistance their competitors by enticing the customers with high quality products at low price. TQM has culminated Six Sigma, Which targets 99.99927% defect free manufacturing.

B. *Six Sigma*

Six Sigma is considered as a methodology of implementing TQM. Six Sigma is an innovative approach to continuous process improvement and a TQM methodology. Since quality improvement is the prime ingredient of TQM, adding a Six Sigma program to the company's current business system covers almost all the elements of TQM. Six Sigma has become a much broader umbrella compared to TQM.

***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. Voelkel, J.G. contents that Six Sigma blends correct management, financial and methodological elements to make improvement in process and products in ways that surpass other approaches. Mostly led by practitioners, Six Sigma has acquired a strong perspective stance with practices often being advocated as universally applicable. Six Sigma has a major impact on the quality management approach, while still based in the fundamental methods & tools of traditional quality management (Goh & Xie, 2004). Six Sigma is a strategic initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools that can lead to breakthrough quantum gains in quality; Mike Harry (2000). Park (1999) believes that Six Sigma is a new paradigm of management innovation for company's survival in this 21st century, which implies three things: Statistical Measurement, Management Strategy and Quality Culture Six Sigma is a business improvement strategy used to improve profitability, to drive out waste, to reduce quality

costs & improve the effectiveness and efficiency of all operational processes that meet or exceed customers' needs & expectations (Antony & Banuelas, 2001). Tomkins (1997) defines Six Sigma as a program aimed at the near-elimi-nation of defects from every product, process and transaction. Snee (2004) defines Six Sigma as a business improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on process outputs that are of critical importance to customers. Kuei and Madu (2003) define Six Sigma as:
Six Sigma quality = meeting the very specific goal provided by the 6σ metric and
Management = enhancing process capabilities for Six Sigma quality.

2. Problem Definition and Methodology

In the Belt Manufacturing Industry, main raw material is rubber; others are biased fabric, and cord. From many years consumption of raw material was not taken seriously as rubber is reusable. Operational wastages in the Belt manufacturing process are- top surface rework, printed label rework, cog rework, pin hole rework, fabric rework and other reworks. Out of these rework, fabric rework is observered continuously in REC Belt from past time and it affects the rate of rework.
By minimizing fabric rework, rate of production can be maximizing. The scope of our project the minimization of fabric rough problem to reduce the total number of rework.

3. Six Sigma DMAIC Methodology

DMAIC is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applied technology for continuous improvement. Implementation of DMAIC Methodology took place in five phases as outlined earlier and established at Motorola. Problem identification and definition takes place in define phase. After identifying main processes, their performance is calculated in measure phase with the help of data collection. Root causes of the problem are found out in analysis phase. Solutions to solve problem and implementing them are in improve phase. Improvement is maintained in control phase.

ROADMAP TO SIX SIGMA –

- **DEFINE**- Set project goals and objectives
- **MEASURE -** Measure the defects where they occur.
- **ANALYZE -** Evaluate data/information for trends, pattern and root causes,
- **IMPROVE -** Develop, implement and evaluate solution targeted at identified root causes
- **CONTROL -** Make sure that almost the problems have cleared, and method is improving.

4. Define Phase

This phase determines the objective and scope of the study. Information about the present processes is collected, determination of customers and deliverables to customers are also determined.

4.1 Project Charter, Project Plan and Process Flow Map

The Project Charter defines the scope, objectives, deliverables and overall approach for the work to be completed. It is a critical element for initiating, planning, executing, controlling, and monitoring the study. Following table shows the details of project title, business case, problem statement, in scope, out scope, expected customer benefit.

Table 1: Scope, Objectives and Deliverables for Belt Manufacturing Industry

Project Title	Reduction of rework in belt.
Business Case	Due to excess rework production cost increases, reduces the profit margin.
Problem Statement	Fabric rough in belt manufacturing from period April 2010 to July 2010, Fabric rough = 6.19% (Avg.)
In Scope	Rework : Fabric rough
Out Scope	All other manufacturing process
Expected Customer Benefit	Reduction in manufacturing cost.

- **Project Plan:**

Define phase: 1st Aug.2010 to 30th Sept. 2010;
Measure phase: 1st Oct 2010 to 30th Nov. 2010;
Analyze phase: 1st Dec. 2010 to 31st Jan. 2011;
Improve phase: 1st Feb. 2011 to 31st Mar 2011;
Control phase: 1st Apr 2011 to 15th Apr 2011

- **Value-added and non-value added activity analysis:**

For this complete analysis, lead time of each activity is collected and analysis of each activity is given in the last column of the Figures. Based on the analysis, activities are classified into value added and non-value added activities. Non-value added activities include rework and re-inspection of REC Belt.

Total Process Time for REC Belt = 140.97min/sleeve
Value Added Time= 122.57min/sleeve
Non-value Added Time =18.4min/sleeve

Some activities are needed to be eliminated such as rework and re-inspection. If non-value added activities eliminated by applying proposed solution for fabric rough then 14% reduction is possible in complete process cycle of REC Belt.

4.2 SIPOC Diagram:

Table : SIPOC of Belt Manufacturing

Supplier	Input	Process	Output	Customer
Planning	Planning sheet	Belt Manufacturing	BELT of define specification	End Customer
Stores	Bias fabric		Production Yield Reports	B.S.R.
HR	Man power		Test Report	-
R & D	specification		Rework Report	-
Engineering	Spares for machine		In process wastage report	-
Purchase	Cord		-	-

After focusing on the operations in Belt manufacturing unit, belt cutting is found as pain area where fabric rough was occurred. After finding the pain area, we found critical factors responsible for rework. Critical to quality (CTQ) of the rework and critical factors are summarized in following table.

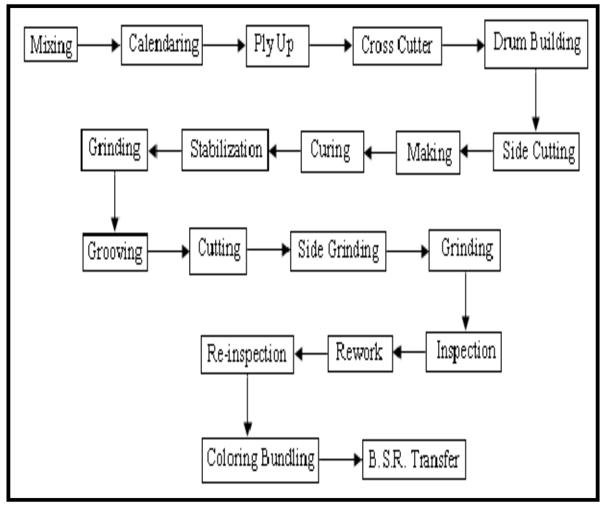
Table : CTQ Specification Table

CTQ	Operation Definition	Driver	Defect Definition
Rework (Fabric Rough)	(No. of belts for rework /Total no. of belt manufactured) x 100	Belt cutting section	No. of rework belt

- **Scope of the project:**

Sr. No.	Parameters	Present Status	Approximated Status
01	Average REC Belt mfg./ Month	167484	210000
02	Avg. Rejection (%) FR	5.93%	3.00%
03	REC Belt Processing Time	140.97min	122.57min
04	Cost of poor quality	Acc. to defects	Acc. to defects
05	Sigma Level	2.7	3.3

- **Manufacturing Process: REC Belt**



5. Measure Phase:

This phase presents the detailed process mapping, operational definition, data collection chart, evaluation of the existing system, assessment of the current level of process performance etc. In the measure phase, performance of process in pain areas is determined and operations data was collected.

5.1 Normality Test:

Data collected for cord wastage according to data collection plan is tested whether it is normal or not. Minitab-15 software is used for this purpose. Anderson Normality Test is used to determine the normality of cord wastage data. It is found that data of cord wastage was normal as *p* value for the data is greater than 0.05.

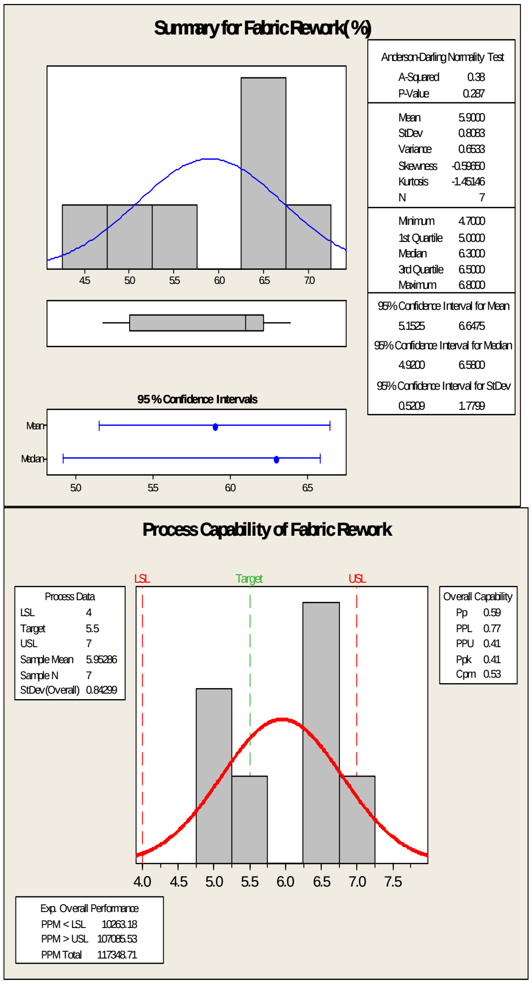


Fig. Process Capability Test of Fabric Rework before DMAIC Methodology

5.4 Cost of Poor Quality before DMAIC:

Companies typically suffer from huge hidden plants, which manifest as the cost of poor quality. By halving this cost, the companies can double their profits without making any capital investments.

CPQ for defect inconsistent fabric rough is Rs.76.073 / belt. If production data on December-2010 is used, for which it was produced 257851 belts, and the performance of the process was 2.7σ, where the defect was 6.14%, thus the rework products are 257851 x 6.14% = 15832 belts. Hence in December 2010, the total cost spent for defect of fabric rough was 15832 belts x Rs.76.073 = Rs.1209374 /-

6. Analyze Phase:

The analyze phase is the third step in the DMAIC improvement cycle. This section describes the work and result of the cause and effect diagram to identify probable causes. This phase describes the potential causes identified which have the maximum impact on the operational wastages

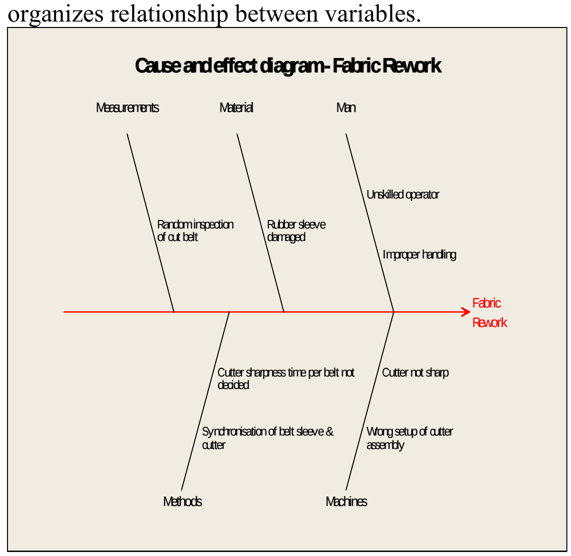
It is found that P-value = 0.287 (>0.05). So, it is clear that the collected data of fabric rough was normal.

5.3 Process Capability Test:

After the normality test, performance of the belt cutting process is calculated with respect to fabric rework by taking the help of process capability test. DPMO is calculated by process capability test as 117338. From this DPMO value, Sigma level was found as 2.7 with 88.0% yielding.

6.1 Cause and Effect Diagram:

A cause and effect diagram for fabric rework presents a chain of causes and an effect sort out causes and organizes relationship between variables.



The relationship between CTQ and root causes is represented by-

$Y = f(X1, X_2, X_3 \ldots X_N)$

Where, Y = CTQ, & $X_1, X_2, X_3, \ldots, X_N$ = Potential root causes Fabric Rework (Y)

$Y = f(X)$

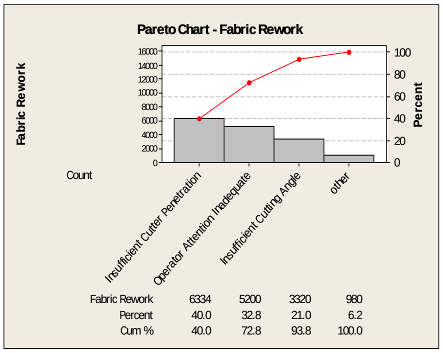
X_1 = Insufficient cutter penetration

X_2 = Operator attention inadequate

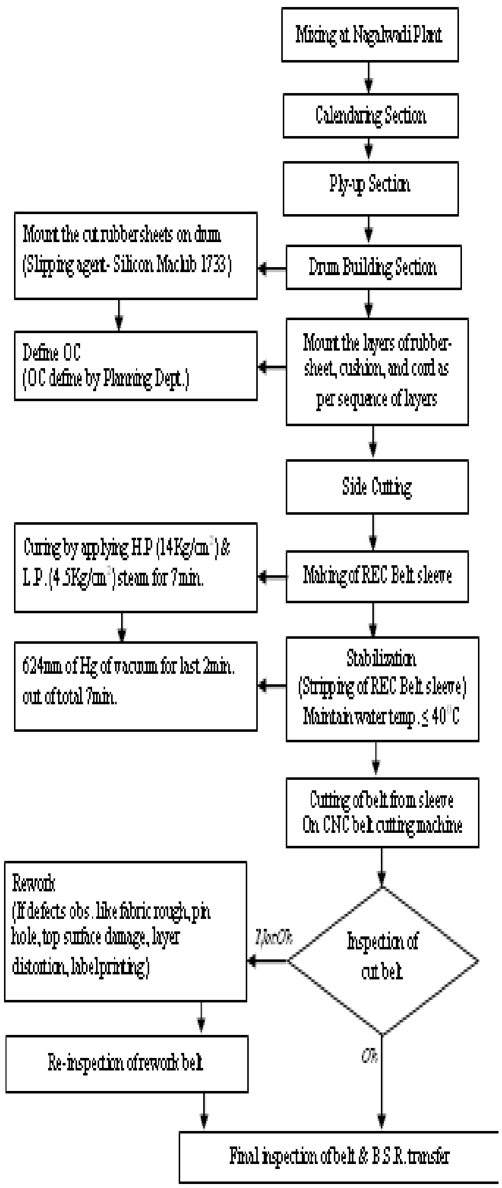
X_3 = Insufficient cutting angle

X_4 = Other (Cutter blunt & Rubber sleeve damage)

6.2 Pareto Chart:



- **Process Flow : REC Belt**



6.3 FMEA:

The major causes, prioritized on the basis of risk priority number (RPN), are operator attention, insufficient cutter penetration and insufficient cutting angle while cutter blunt, etc.; which are responsible for fabric rough on REC belt.

The initial causes are divided into two categories:

1. Direct implementation causes- These are the causes for which the actual solution can be implemented directly by the team and need no further analysis. These are- insufficient cutter penetration, insufficient cutting angle & cutter blunt.
2. Likely & controllable causes- These are the causes that are within the control of the present boundaries of team and need further analysis. These are- operator attentions inadequate.

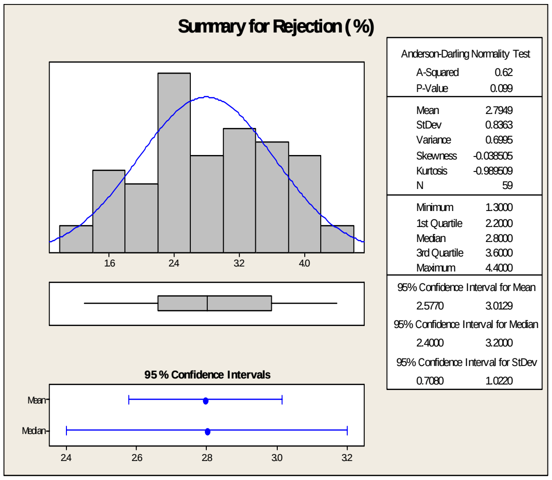
7. Improve Phase:

The Improve phase is the fourth step in DMAIC improvement cycle and its aim is to find and implement measures that would solve the problem. Proposed solutions to the cord wastages are given in Table

CTQ	Cause Validated	Proposed Solution
Fabric Rough	Insufficient cutter penetration during the cutting of REC belt from rubber sleeve	For that proper instructions must be given to operators to carry out quality cutting of REC belt.
	Operator attention inadequate	Focus supervision must be given to operators from supervisor in night shifts. Monitoring operator wise shift wise and machine wise should be carried out.
	Insufficient cutting angle	Proper instructions given to operator for specification about different cutting angles.
	Sharpness of cutter decreases during the cutting of REC belt	Standard time will be decided for sharpening of cutter after cutting of 10 REC belt.

After discussing above solutions with the Company's Manager and Engineers, these solutions are rigorously implemented. Within the target dates, the implemented solutions provided the desired results.

6.1 Normality Test after DMAIC:



After implementing solutions, cord wastage data collected from 1st Feb. 2011 to 31st April 2011 is analyzed. Its normality test is carried out with the help of Minitab-15 Software. It is found that data was normal because *p* value in the normality test is greater than 0.05.

6.2 Process Capability Test after DMAIC:

After the normality test, performance of the belt cutting process is calculated with respect to fabric rework by taking the help of process capability test. DPMO is calculated by process capability test as 37480.

From this DPMO value, Sigma level was found as 3.2 with 95.5% yielding.

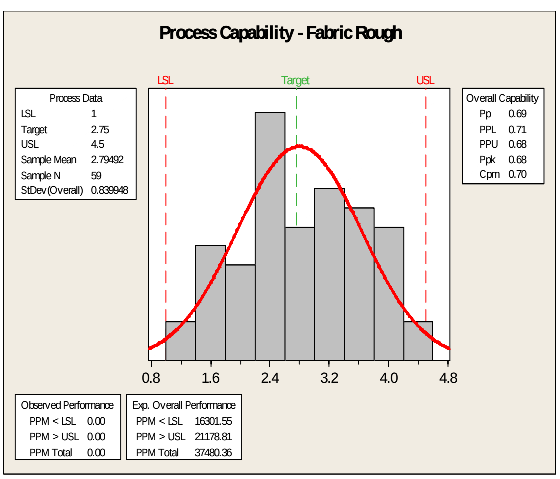


Fig. Process Capability Test of Fabric Rework after DMAIC Methodology

6.3 Cost of Poor Quality for Fabric Rough after DMAIC:

CPQ for defect inconsistent fabric rough is Rs.70.041 / belt. If production data on Mar-2011 is used, for which it was produced 219583 belts, and the defect was 2.7%, thus the rework products are 219583 x 2.7% = 5928 belts. Hence in Mar. 2011, the total cost spent for defect of fabric rough was 5928 belts x Rs.70.041 = Rs.415203 /-

7. Control Phase:

The last phase of DMAIC is control, which is the phase in which we ensure that the processes continue to work well, produce desired output results, and maintain quality levels. This is about holding the gains which have been achieved by the project team. Implementing all improvement measures during the improve phase, periodic reviews of various solutions and strict adherence on the process yield is carried out. The Business Quality Council executed strategic controls by an ongoing process of reviewing the goals and progress of the targets. The council met periodically and reviewed the progress of improvement measures and their impacts on the overall business goals.

8. Result and Conclusion:

The Six Sigma based methodology has been used to optimize the variables of cord wastage. The results obtained are in the form of improvement for fabric Rough in Sigma level (Previous =2.7, Improved=3.2). It has been found that organization achieved breakthrough in reducing fabric rework due to Six Sigma DMAIC Methodology. Six Sigma was found to be the greatest motivator behind moving everyone in the organization and bringing radical transformation. People in the workplace have developed the required statistical thinking with their involvement in this particular study. Benefits of implementation have been found to be enormous in this case study. However further research is possible in the direction of what the people and organization has to sacrifice for getting this breakthrough in their process. As no gains possible without companying improvement in work habit Six Sigma is continues improvement process involving all operations in the work place and more such opportunities are potentially available in the workplace.

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