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IN-PROCESS WASTAGE REDUCTION IN BELT INDUSTRY BY DMAIC METHODOLOGY

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Abstract

Operational wastages are occurred due to various reasons and play important role in belt manufacturing industry. Operational wastages includes fabric wastage, in-process wastage and cord wastage. DMAIC methodology (Define, Measure, Analyse, Improve and Control) is very helpful to reduce in-process wastage by identifying reasons and eliminating them. In belt manufacturing industry, processes related to in-process wastages were identified to find out main causes and pain areas for formulation of the problem. After identification of the processes, data was collected about related processes to determine the actual performance of the processes and process capability, as well as root causes were found out. Creations of technical solutions were carried to achieve the improvement. To sustain this improvement, several tools were appropriately employed for tracing the concerned processes. In belt production, in-process wastages was reduced from 507133 DPMO (Defects per Million Opportunities) to 126213 with improvement in Sigma Level from 1.48 to 2.75

Keywords: Six Sigma; DMAIC methodology; Belt Industry; In-process Wastages.

INTRODUCTION

Production with minimum wastage is goal for every manufacturing industry. To be in the competition, price and performance of the products are the major concerned areas for the industries. Profit level is to be affected by price of the products. Price of the products used to be increased by the operational waste. To maintain the profit level, industries try to minimize the operational wastages. 100% final products cannot be achieved by any process. There are always some undesirables' bi-products. Final cost of the product is going to be increased by these undesirables bi-products. Such undesirables bi-products are named as operational wastages. DMAIC methodology of Six Sigma is to be used to solve operational wastage problem. Six-Sigma is statistical process enhancement method which deals with the finding the defects as well as eradicating their reasons in every operation. This methodology is useful to focus the goal which is most important to costumers. DMAIC methodology was used in belt manufacturing industry as a industrial case study. This belt manufacturing industry is major one in Maharashtra. To reduce operational wastages different tools of Six Sigma were used including DMAIC.

LITERATURE REVIEW

Six Sigma methodology is applied to achieve customer delight by decreasing number of defects to a level of 3.4 defects per million opportunities. These defects may be in products, processes and service. (Rathore R. et al. (2021)). Sigma is a measure of "variation about the average." Six sigma improvement drives is the newest and furthermost effective method in quality engineering and management field. To analyse the major reasons of business glitches, Six Sigma is used as full technique which is high-performance and data-driven approach. (Rout I. et al. 2004)). DMAIC and DFSS are two tools in Six Sigma approach. Khan et al.(2020) applied DMAIC methodology to minimize the defect percentage in the fabric section of a firm. In this paper, there was reduction in defect percentage from 10.07% to 7.87% with upgradation in sigma level from 2.78 to 2.91. Bora et al.(2018) implemented DMAIC model and presented proposed productivity improvement by suggesting various possibilities to minimize wastage of the identified packing material. Henny et al. utilized Lean Six Sigma method to reduce the occurrence of waste in chilli sauce production processes by analysing the problems of the production process. Zaman et al.(2017) implemented DMAIC methodology of six sigma to decrease the defect rate in sewing section of FCI (BD) LTD by reducing defects from 11.67 to 9.672 and up gradation of six sigma from 2.69 to 2.8. DMAIC methodology is complete technique to resolve problem by translating real-world problem in to statistical problem. It also helps to find the statistical solution. These solutions are used to be transformed into practical. Execution of these practical solutions are properly conducted in the organizations (Mittal A. et al. (2023)). Daniyan et al. (2022) implemented DMAIC Lea Six Sigma in the railcar industry due to which process cycle efficiency was improved by 46.8%, lead time was reduced by 27.9%, value added time was increased by 59.3% and increase in the and non-value added time was reduced by 71.9%.

PROBLEM DEFINITION

During the processes carried in the Belt Manufacturing Industry, major raw materials are rubber compound, biased fabric and chord. At first, there was not any serious approach about utilization of these raw material, because some of these are reprocessable. This leaded to the excessive utilization of these raw materials. Excess utilization of raw material was not considered seriously due to its reusability. Due to drastic increase in consumption of raw material like rubber compound, biased fabric and cord increased the Manufacturing cost of the belts. Cord, In-process and fabric were the major wastages in the Belt manufacturing process. These wastages decreased the margin of profit. In-process wastage is selected for this project.

METHODOLOGY

To minimize the fabric wastage, DMAIC of six sigma methodology was decided after discussion with management of the plant. DMAIC is technology applied for continuous improvement which is also closed-loop process that eliminates unproductive steps (Mittal A. et al. (2023)). To solve the problem of wastages, information about all processes and their primary data was collected with due permission of the authority. Define, Measure, Analyse, Improvement and Control are the steps of DMAIC Methodology which were implemented to reduce the fabric wastage. DMAIC is an innovative measurements and realistic technology for continuous enhancement with the purpose of eliminating the unproductive steps (Khekale S. et al. (2010)). DMAIC Methodology is to be implemented in 5 steps. It was recognized by Motorola. Define step consists of identification and definition of the problem. Main processes are identified and then data collection has to carry for calculating the performance in the measure step. Root causes of the identified problem are acknowledged in analysis step. In control step, solutions for problem are identified and implementations of the solutions are carried out. Improvement is retained in this step. DMAIC methodology of Six Sigma is standard and commanding approaches to haste up enhancements in product, service, and to improve competitiveness. The main focus of DMAIC is on reduction in variation with elimination of wastes which results in improvement in the process as well as reduction in variation (Schmidt et al., (2018)).

DEFINE STEP

This is the first step in which determination of the objective and scope was carried by using different six sigma tools like Project Charter, Project Plan and Process Flow Map. (Desai T. N. et al. (2008)). At the same time end customers and deliverables to customers were determined. Project was completed within 10 months including Define (2 Month), Measure(2Month) Analyse (2 Month), Improve (2 Month) and Control (2 Month). Suppliers, Inputs/Requirements, Key Process Steps, Outputs/ Requirements, Customers, and Critical-to-Quality elements of a business process (SIPOC) are to be determined and structured in SIPOC diagram which is a standard method for recording key process information at crucial level. This SIPOC Diagram develops a thorough thoughtfulness of the procedure, procedure steps (sub procedure) and their corelation (Khekale S. et al. (2010)). Table 1 explains the SIPOC of Belt Manufacturing.

Table 1: SIPOC of Belt Manufacturing

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

Pain areas where in-process wastage was occurred were identified. Key reasons responsible for wastages were identified after finding the pain areas which were obtained after studying and analyzing the processes in Belt manufacturing unit. Belt cutting was found as pain areas where in-process wastage was happened. Table 2 shows Critical to quality (CTQ) of the In-process wastage and critical factors.

Table 2: CTQ Specification Table

Critical to quality	Definition of operation	Driver	Definition of defect
In-process waste	Wt. of in process waste/) wt. of total sleeve) x100	Cutting	Wt. of in-process

MEASURE STEP

In this second step, Performance of processes in pain areas was determined by collection of data regarding the respected processes. The data for In-process wastage was collected during May 2021 to November 2021 which is given in Table 3.

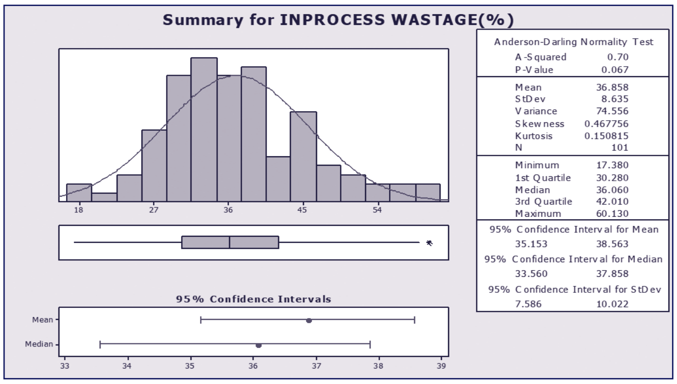
Table 3: In-process Wastage

Month	May	June	July	August	September	October	November
In-process wastage (%) kg	39.1	38.4	39.6	40.8	41	39.84	39.1

NORMALITY TEST

Collected data of In-process wastage was analysed by normality test by using Minitab-14 software (Anderson Normality Test) and presented in Figure 1. Data for In-process wastage was normal as value of p for the in-process wastage data is higher as compare to 0.05

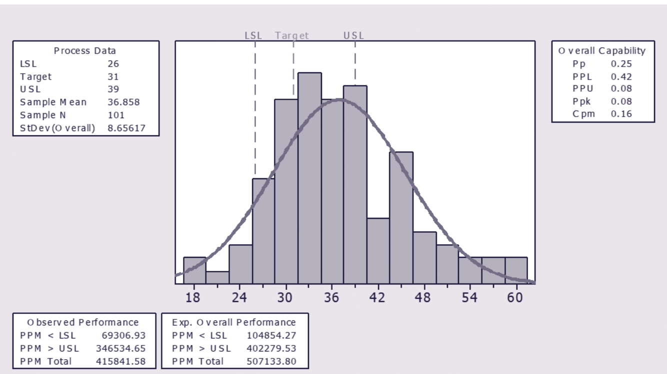
Figure 1: Normality Test of In-process Wastage



PROCESS CAPABILITY TEST

Process capability test (Figure 2) was used to determine the performance of the belt cutting process for In-process wastage after the normality test. DPMO is calculated by process capability test as 507133. Sigma level was found as 1.48 as per DPMO value.

Figure 2: Process Capability Test of In-process Wastage



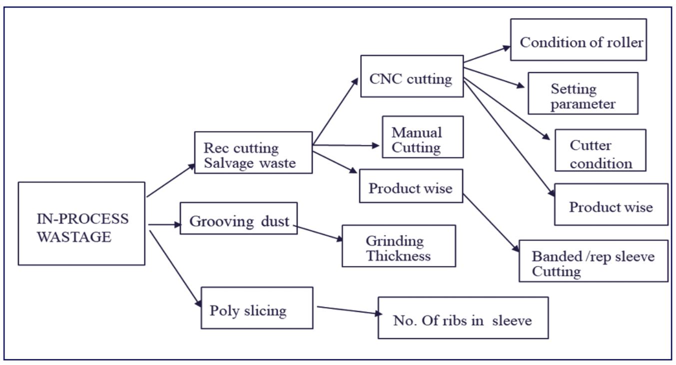
ANALYSE STEP

This third step consists of cause-and-effect diagram to find out the probable causes having major impact on the In-process wastages.

CAUSE AND EFFECT DIAGRAM

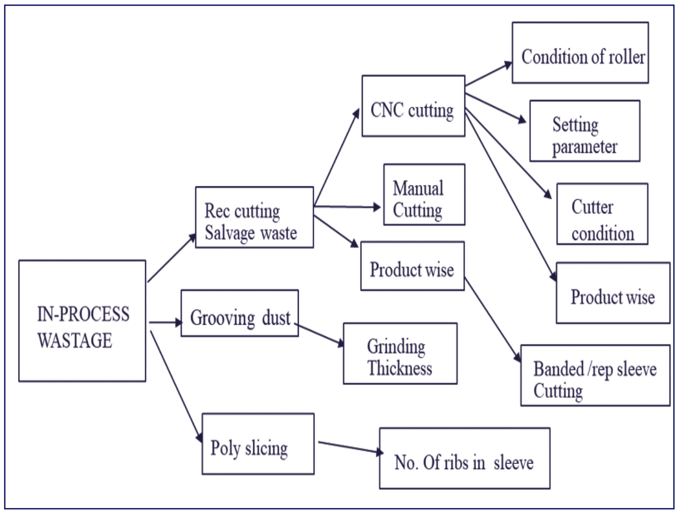
A cause-and-effect diagram (Figure 3) for In-process wastage elaborated the effect of man, material, machine, environment and method on In-process wastage.

Figure 3: Cause and Effect Diagram of In-process Wastage



Tree Diagram of In-process Wastage (Figure4) elaborated various causes for in-process wastage.

Figure 4: Tree Diagram of In-process Wastage



Cortical to quality (Y) and root causes (Z) are corelated as follows

$Y = F(z)$

Z_1 = Manual cutting

Z_2 = CNC cutting

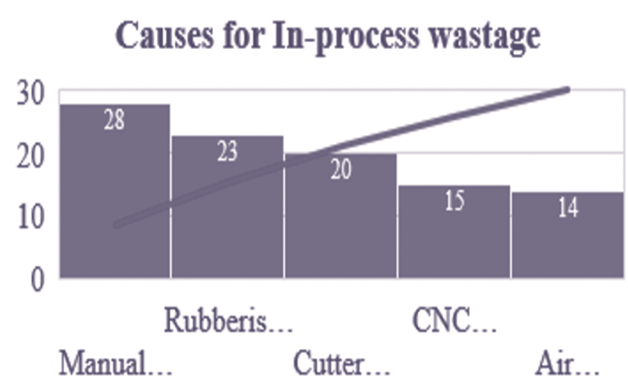
Z_3 = Rubberized roller

Z_4 = Cutter condition and position

Z_5 = Air Pressure

Following Pareto chart (figure 5) describes the influence of different causes of the wastages. Manual cutting and CNC cutting were major for In-process wastage.

Figure 5: The Pareto Chart for various causes of In-process Wastages



IMPROVE STEP

This step was used to acknowledge the causes for in-process wastage. Implementation of these measures to solve the problem was conducted.

Table 4: represents the suggested solutions to the fabric wastages.

Critical to quality	Cause authenticated	Suggested solutions
In process wastage	Manual cutting	1. Proper quality of end cap converts 3 part cutting to 2 part cutting. 2. Monitoring of operators not to do excess side cutting (more than 10mm).
	CNC cutting	1. Monitoring of operators not to do side cutting. 2. Regular checking of hydraulic pressure 3. Regular checking of center 4. Checking of cutters pulley after every 6 sleeves
	Rubberized Roller	1. Uniform thickness of rubber coating (sleeve) on roller must be checked before use. 2. Use of proper material for rubberized roller. 3. After 24 hr. use of rubberized roller, it's condition must be checked. 4. Regular checking of Rubberized roller whether it is our or not.
	Cutter condition and position	1. Regular cutter sharpening at regular interval of time and use of new cutter after blunt cutter. 2. Checking of cutter position at regular interval of time.
	Air Pressure	1. Continuous air supply at required pressure.

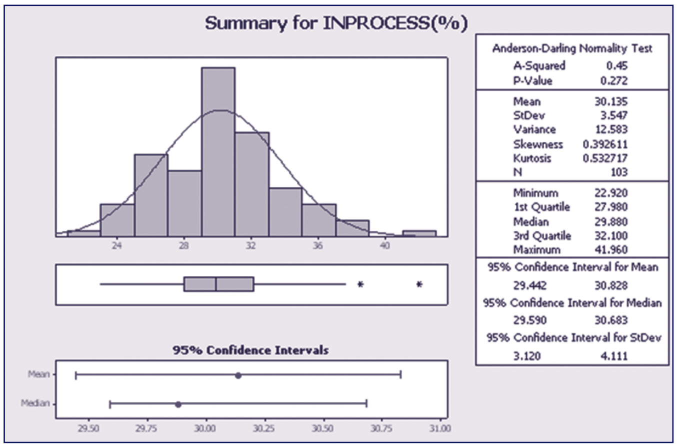
Solution Prioritization Matrix was used to categorize the solutions as per different criteria by consulting the Company's Manager and Engineers by using the brainstorming session. Solution Prioritization Matrix is shown in Table 5 as per weightage criterion. Execution of these solutions were thoroughly executed.

Table 5: Solution Prioritization Matrix of In-process Wastages

Solution	Easy	Cost effective	Quick	Impact on CTQ	Total
Square cutting belts	13.5	14.7	8.4	32.2	68.8
Maximum utilization of CNC cutting machine	7.5	12.6	10.5	16.1	46.7
Optimization of width in cushion and base	10.5	18.9	21	13.8	64.2
Optimization offsetting in single drum	7.5	14.7	8.4	13.8	44.4
Stop extra side cutting	3	14.7	8.4	13.8	39.9

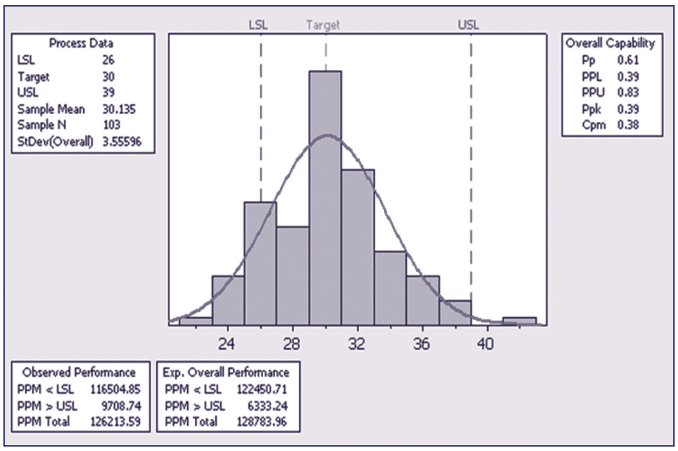
Collected data for In-process wastage was analysed for normality test using Anderson Normality Test (Figure 6) of Minitab-14 software. It was found that value of p for the collected data was greater than 0.05, the data was normal.

Figure 6: Normality Test of In-process Wastage



Again process capability test was used to determine the performance of the belt cutting process for In-process wastage after the normality test. DPMO is calculated by process capability test as 17240. Sigma level was found as 3.6 as per DPMO value.

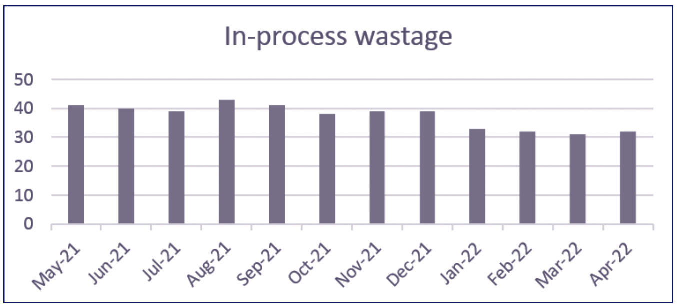
Figure 7: Process capability Test of In-process Wastage



CONTROL STEP

Control step is last one which includes implementation of proposed solutions. In this step, focus was given for continuous observation for implementing the solutions in the suggested processes by continuous inspection of check charts. Intensive care was taken for pain area as per shift, day and month. Staff training, employing facilities were executed for achieving and sustaining the improvements. In-process wastage is shown in graph (Figure 8). Figure 8 (Observations) show reduction in In-process wastage from January to April.

Figure 8: Month-wise In-process wastage



RESULT AND DISCUSSION

DMAIC was implemented to reduce effects of performance variable of in-process wastage. DPMO in terms of in-process wastage was reduced from 507133 to 126213 with improvement in Sigma level from 1.5 to 2.7. This belt organization successfully attained breakthrough in decreasing in-process wastage by implementing DMAIC methodology. DMAIC approach was already recognized to be the greatest motivational methodology for every person in the organization resulting in continuous improvement. Due to implementation of this case study, important statistical thinking was successfully adapted by all employees at workplace. In this case study, many benefits of proper implications was found to be enormous. For getting the minimum wastages in belt manufacturing processes, further research is possible with maximum production with least possible wastages.

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