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IMPLEMENTATION OF SIX-SIGMA DMAIC FOR IMPROVISING THE PROCESS BY DECREASING RPN VALUE

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Abstract

Six Sigma is observed as a very promising quality management tool for any organization to make its presence felt in the corporate world as it emphasizes on obtaining a fruitful solution to improve accuracy, reduce defects which there by reduces the cost and improve profits. This paper introducing about such concepts which is mainly focused on reducing the RPN value by adopting standard failure classifier and FMEA concept.

Reduction or elimination of RPN value will yield to smooth flow of production process by eliminating non-value-added activities which is focused on minimum material waste and lead time reduction. Thereby, improving efficiency and productivity of an organization.

Keywords: Six Sigma, DMAIC, FMEA, RPN, Swim-line diagram, Lead time, Flush doors.

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1. Introduction

In any industry, organization or daily process, when you are un-aware of what knowledge you don't possess, it's going to cost big. At present for many industries the costs of defects and waste generated during processing are huge. For processes where errors occur occasionally may not have a major impact on the industry. But when we consider how many errors may take place in company-wide processes, the monetary impact on overall profitability, productivity and customer satisfaction multiplies dramatically!

The Six Sigma approach to managing is all about helping organizations identify what they don't know as well as emphasizing on what they should know and taking action to reduce the errors and rework that cost them time, money, opportunities and customers. Six Sigma provides opportunities for business growth and guide the companies in being ahead of competition [1].

Sigma as defined in statistics represents standard deviation, it indicates the degree of variation in a set of measurements or a process. Whereas Six Sigma is a statistical concept that measures a process in terms of defects – at the Six Sigma level there are only 3.4 defects per million opportunities.

Define, Measure, Analyze, Improve and Control (DMAIC) is a part of Six Sigma, it is the key to problem-solving method, it helps in identifying the vital few factors that matter most for improving the quality of processes. It involves necessary steps in a sequence, each of which are essential to achieving the desired out-come [5].

1.1 DMAIC USABILITY CONSIDERATION

1.1.1 Define:

a) Identification of all the processes carried on at flush door manufacturing sector.
b) Analysis of all the critical processes that are meant to be improvised.
c) Defining of objective and framework i.e.: Failure classifier, FMEA – RPN value, Lead time, Swim-line diagram.

1.1.2 Measure:

a) Collection of all the initial data such as: Processes that are subjected to failures.
b) Calculation of RPN value using a standard ranking procedure.
c) Total lead time of each process.

1.1.3 Analyze:

a) Determination of all the failures and arranging them in the standard format.
b) Analyzing the reasons for problem arising (RPN Concept).
c) Estimation of difference between current and target performance.

1.1.4 Improve:

a) Implementation of solution for the identified problems in process areas.
b) Troubleshooting of various causes that leads to unexpected results.
c) Elimination or reduction of RPN value by SOD factor.
d) Verification of the recommended solution.

1.1.5 Control:

a) Control of changes made in the critical processes.
b) Monitoring and evaluation of results.
c) Documentation of the plan.

2. Methodology

A flush door manufacturing industry has eight major processes involved in producing a flush door. By analysing the processes and after several brainstorming sessions it is found that, the industry is not performing to its capacity and also particularly found that there is large amount of waste produced during furniture manufacturing due to improper production process and inappropriate material handling. In order to address these issues and to ensure that industry adopts continuous improvement for good profit and sustainability in the market we adopted the DMAIC methodology that is focused on reducing the RPN number using the framework shown below for continuous improvement.

2.1 Failure Classifier:

In this work we have used the failure classifier framework shown in fig 1. There are 7 major divisions and each has sub-divisions. The basic goal of this framework is to define the problems or causes that can occur for each work station during the production process and identify them under the failure classifier in-order to correct them [2].

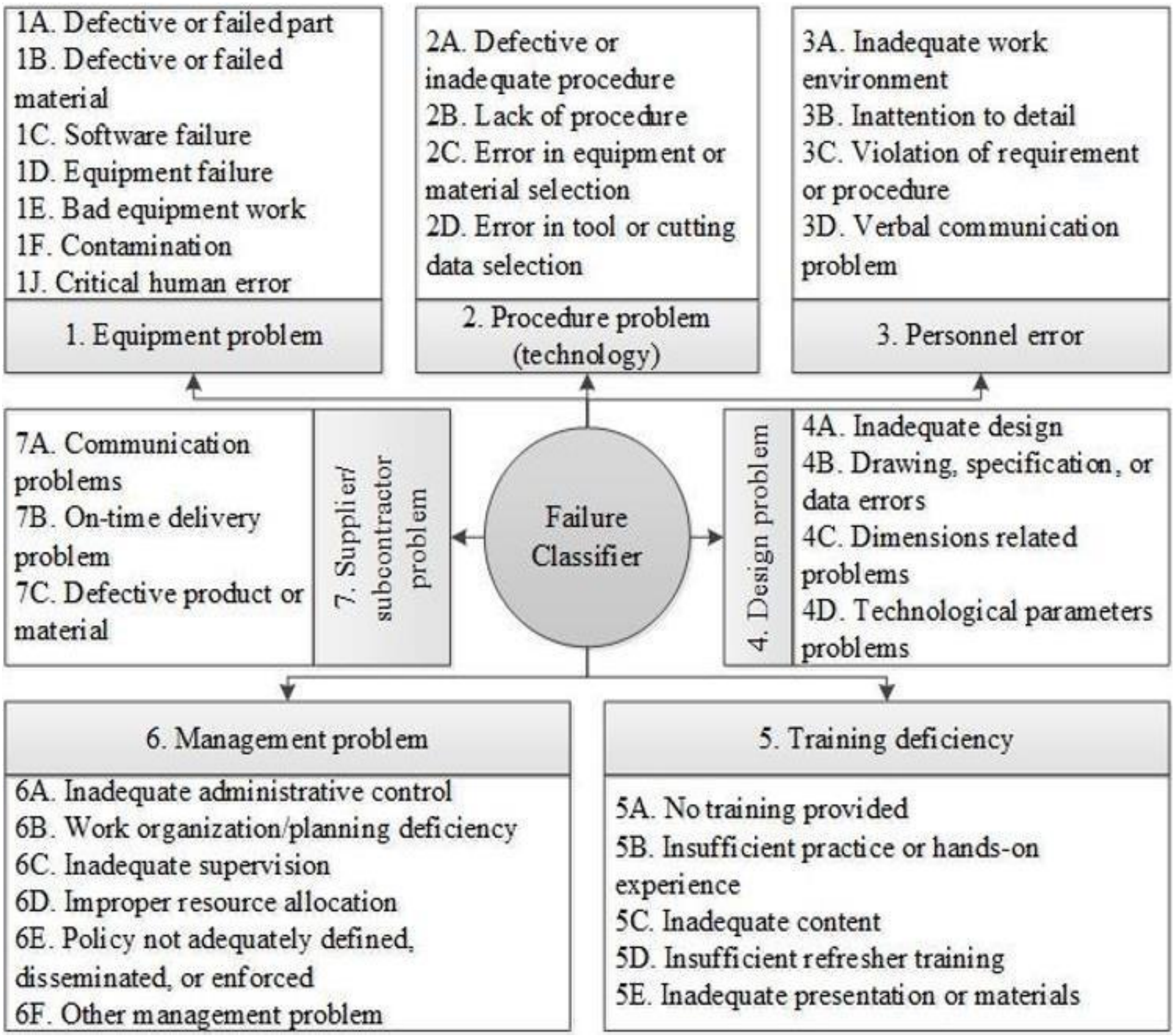


Figure 1. *Failure Classifier*

2.2 Failure Mode Effect Analysis (FMEA):

FMEA is a method of identifying a part or process which fails to meet the performance specification, creating non-conformance or defect and the impact on the customer it might have if that failure mode is not corrected. It is focused on enhancing safety and reducing defects. In recent times, organizations are opting for FMEA to intensify the reliability and quality of their products and also to improve business activities.

FMEA has three factors which determine the risk of failure and its effects:

Severity (S) – How bad the effect of a failure would be. (1=None, 10=Deadly)

Occurrence (O) – How likely is the defect to occur. (1=unlikely, 10=very often)

Detection (D) – Noticing the failure before the impact of the effect is realized. (1= always detected, 10= never detected)

Every likely failure mode and effect is evaluated by these 3 factors on a scale ranging from 1 to 10 [4]. By multiplying these ratings, a Risk Priority Number (RPN) value is calculated as in the formula (1) below. This RPN value is used to determine the effect of a failure.

$$RPN = S \times O \times D \ldots (1)$$

The RPN value should range between 1 to 1000 for each failure mode which exist in every workstation comprising of many operations [1]. It is used to evaluate the need for corrective actions to eliminate or reduce the potential effect of failures. Higher RPN value indicates more risk, so the RPN value must be reduced for a process. RPN value must be below 100 for good performance of operations [4].

2.3 Manufacturing Lead Time

Manufacturing Lead Time is the total time taken from initiation till completion of a process. For any organization to stay competitive in the market, lead time plays an important role which basically deals with the time period between date of customer order till the delivery of the finished product to the customer. The scope scale of lead time consists of 5 steps and is represented in detail in fig 2 [2].

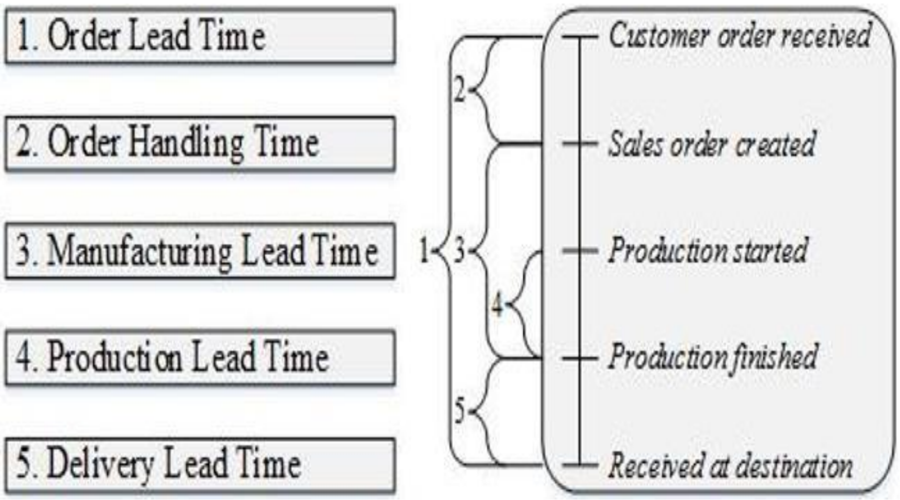


Figure 2. *Manufacturing lead time scale*

2.4 Swim Line Diagram

The swim line diagram is a type of flow-chart. It illustrates a process from start to finish and divides these steps into categories to help distinguish which department or employees are responsible for each set of actions. The swim line diagram consists of data regarding failure classifier (FC), failure mode effect analysis (FMEA) and production route card (PR card) which consists of work station, operation name and duration. It represents total RPN value and total time taken with respect to the defined workstations as shown in fig 3. This process conceptualizes what type of failures that occurs should be eliminated or reduced in particular work-station to minimize production lead time that consequently increases efficiency of the process.

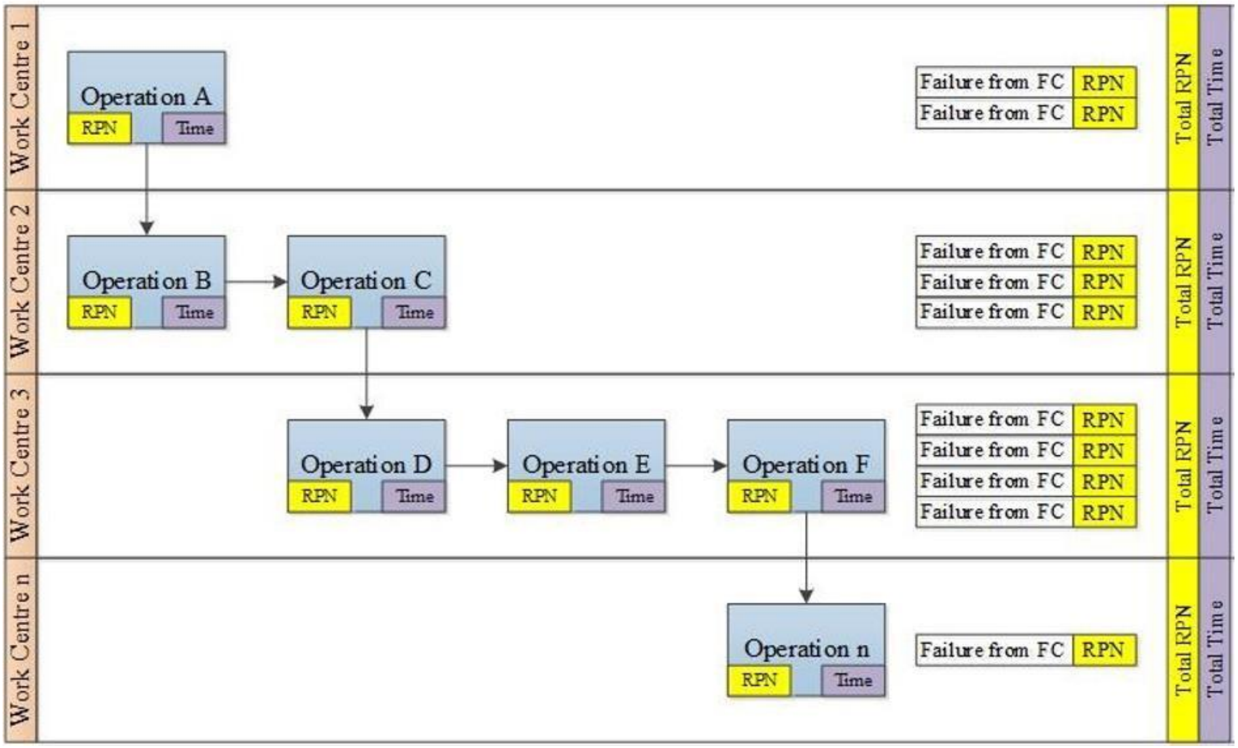


Figure 3. *Swim line diagram*

3.Case Study

In this case study for implementation of six sigma DMAIC for improvising the processes by decreasing RPN value is selected with data from the production floor of a flush door manufacturing industry, where the flush doors are widely used for domestic (household) and as well as commercial purposes (schools, offices, hospitals).

The production of flush door consists of 8 processes as shown in fig 4. The failure classifiers (FC) is applied to production process to identify the type of failures for individual operations. Also, FMEA concept is used to evaluate the weights of each failure by means of severity (S), occurrence (O) and detection (D) rated between 1-10 to calculate the Risk Priority Number (RPN) value [4]. The data regarding original lead time for each work-station was collected and the data is represented in fig 5.

Workstation 1 comprises of chemical treatment operation. Workstation 2 comprises of air seasoning and artificial seasoning where in the wooden planks are loaded inside the heat room of 100°C-150°C to remove the moisture content from the wood planks. Workstation 3 comprises of slicing operation to form lipping and door framework. Workstation 4 comprises of assembly operation for manufacturing flush doors followed by veneering. Workstation 5 comprises of hydraulic pressure treatment (150 Pascal's), one cycle covers manufacturing of 3 flush doors followed by finishing operation.

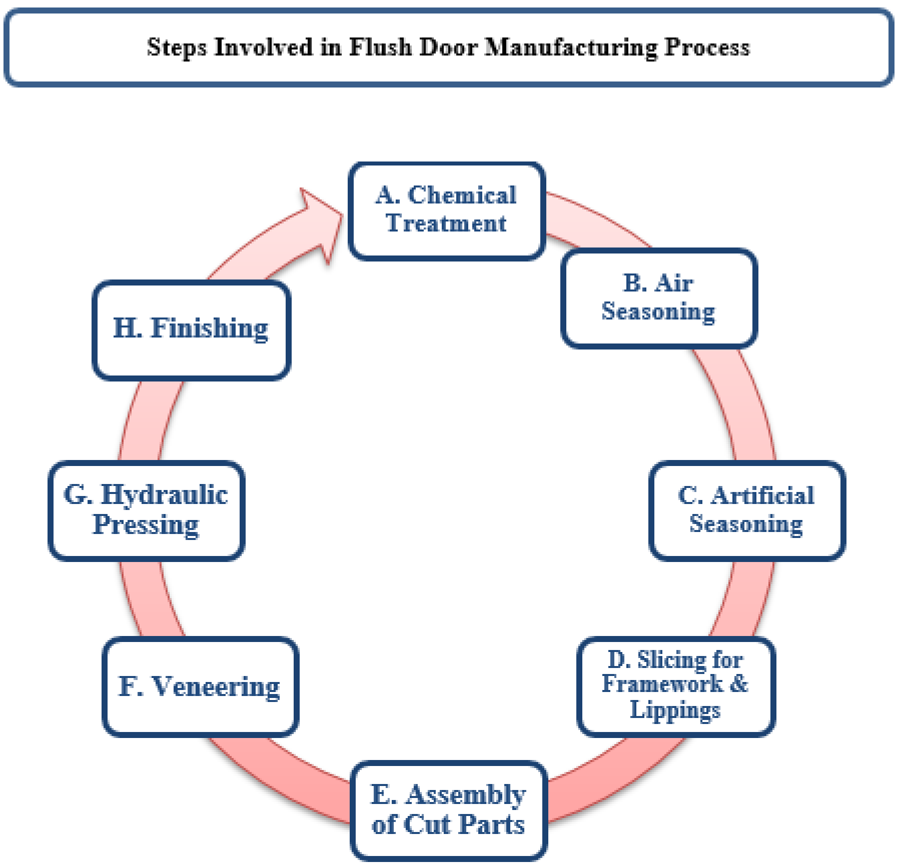


Figure 4. *Processes involved in manufacturing flush doors*

The flush door manufacturing industry was visited and critical observations of the processes happening in the industry were made. As a result of which the areas of major concern were chosen. They were chosen based on the failure classifiers for which we calculated the Risk priority number RPN and the obtained results were very high for the 8 processes in the flush door manufacturing production process as in fig 6 and explanation about this is as shown in table 1.

All these problems resulted in obstruction to smooth flow of the production process and the industry was not able to work to their full capacity and due to this more than 40-45% of raw materials were getting wasted. Hence, we focused on improvising the processes by the application of DMAIC technique in-order to reduce the RPN value and increase the product throughput at the production plant. The following table 1 shows the calculation related to the actual and reduced RPN value for the 8 production processes involved in producing a flush door [4].

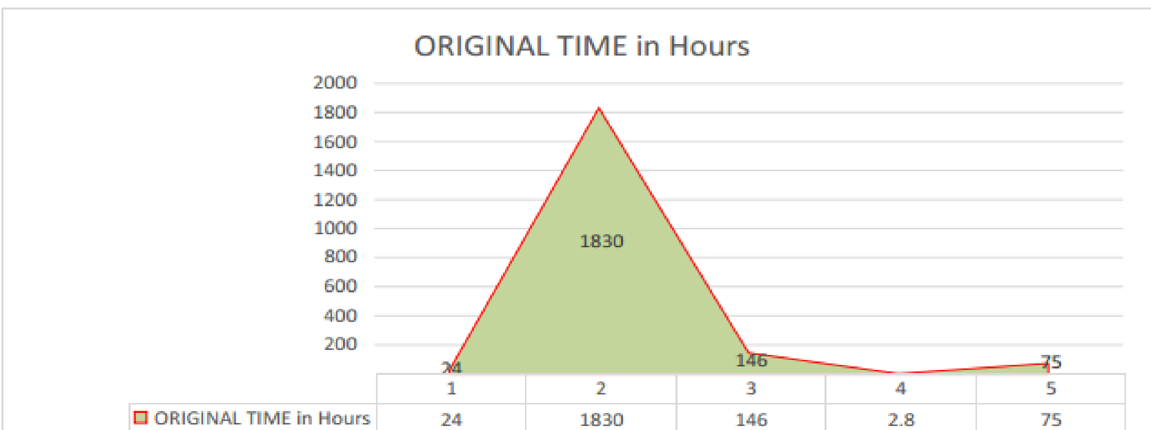


Figure 5. *Calculated Actual Time for each workstation*

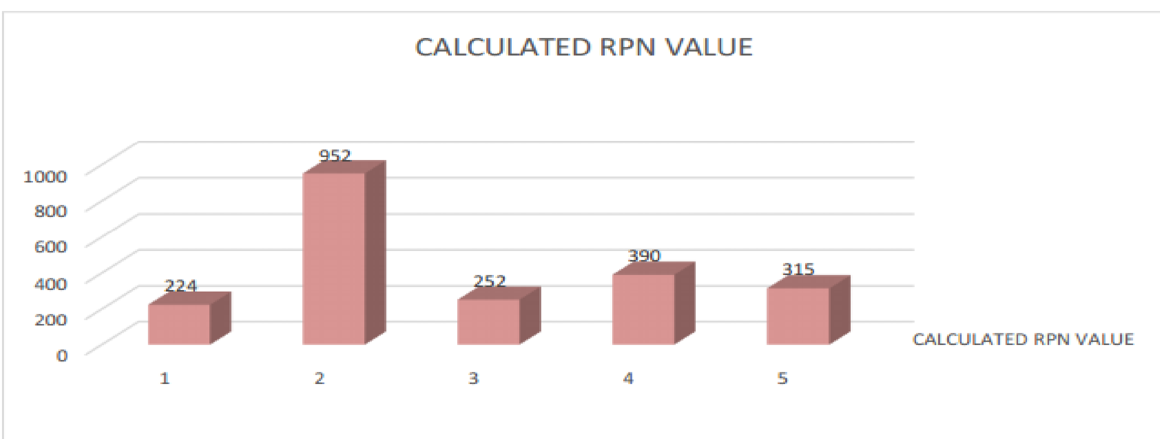


Figure 6. *Calculated RPN values for each workstation*

3.1 Swim line Process

Table 2 shows the modified swim-line diagram having 5 work-stations and the reduced manufacturing lead time. The lead time is reduced based on the formula:

Initial RPN = Initial Lead Time

Reduced RPN = Reduced Lead time (x); where x- lead time to be calculated.

i.e.

$$Reduced\ Lead\ Time = \frac{Reduced\ RPN\ \times\ Initial\ Lead\ Time}{Initial\ RPN} \quad \ldots (2)$$

Example: For the first work station, reduced lead time is calculated based on the above formula.

$$Reduced\ Lead\ Time = \frac{126\ \times 24}{224} = 13.5\ Hours$$

By using the same formula, reduced lead time is calculated for remaining 4 workstations.

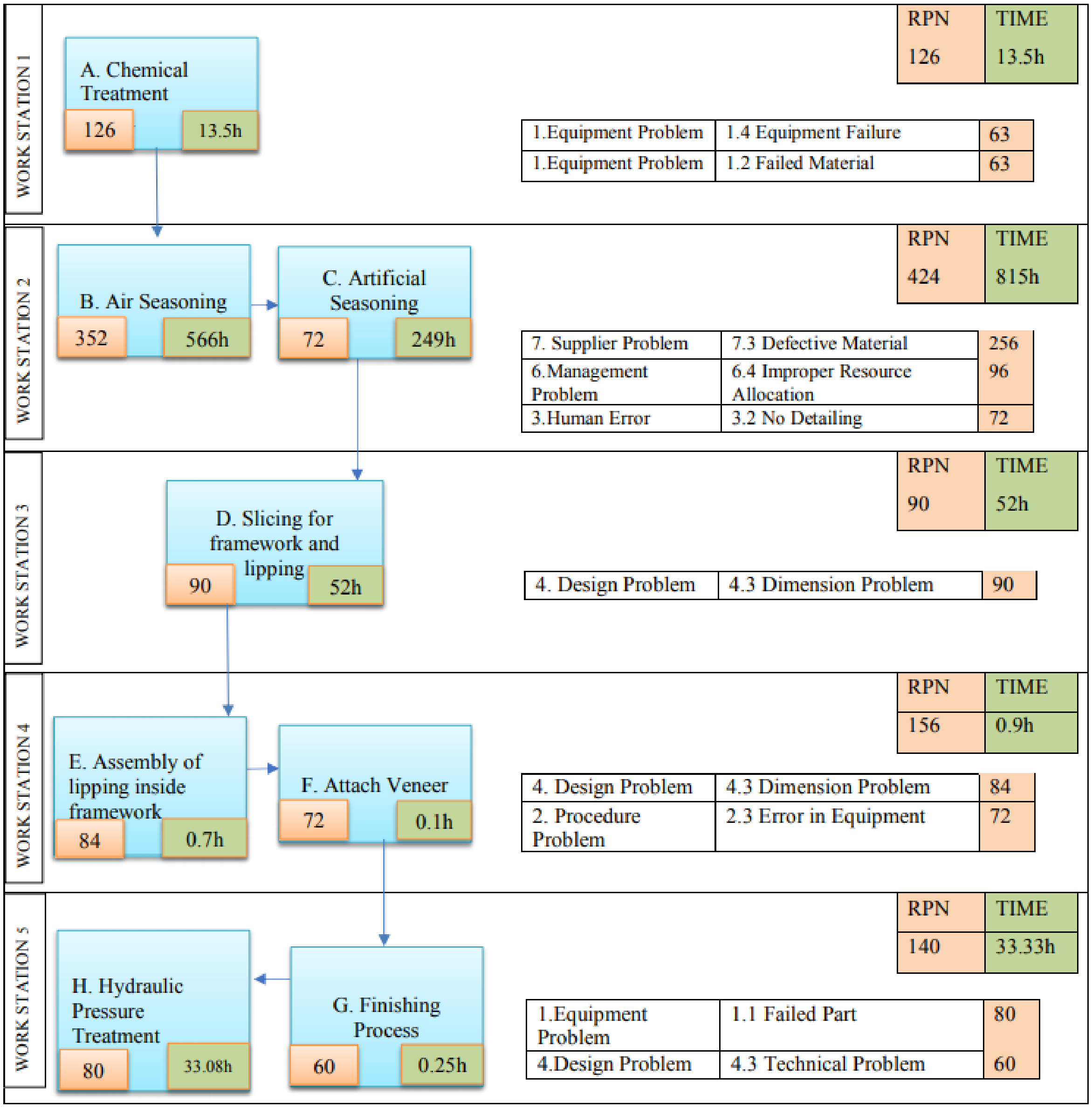
Table 1. *Calculation and Reduction of RPN values.*

Product/ Process Function Require-ment	Potential Failure Mode	Potential Effect of Failure	SEVERITY	Potential Causes Mechanism of failure	OCCURENCE	Current Control	DETECTION	RPN	Recommen--ded Action	Reconcilable Target Compilation Date	Action Results				
											Action Taken	S	O	D	RPN
A. Chemical Treatment	Uneven Distribution of Chemical to the wood inside the chemical treatment tank	- More time consumed and reduction in quality of wood	7	Uneven Pressure Supply	4	Same Pressure for all loads	4	7*4*4 = 112	Set Pressure through manual control as per load requirement	Responsibility assigned to the respective department with target completion date	Chemical and pressure supply is inspected every hour by the operator	7	3	3	63
				Effectiveness of Chemical Used	4	Same quantity of chemical supplied for all loads	4	7*4*4 =112	Manually set chemical supply as per requirement			7	3	3	63

B. Air Seasoning	Improper Seasoning of chemical treated wood	Consumes enormous amount of time and results in wastage if not seasoned properly	8	Problem in wood obtained through supplier as bending of wood takes place	6	No Control measures	9	8*6*9 = 432	Obtain wood from suppliers known for good quality	Tender given to good quality suppliers. Responsibili -ty assigned to supervisor	Suitable material handling equipment used to reduce the time consumed and defective wood is filtered out in the initial stage	8	4	8	256
				Imprope r material handling	5	Manual Arrangemen t through unskilled labour	7	8*5*7 = 280	Use suitable material handling equipment and supervise laborer			8	3	4	96
C. Artificial Seasoning	Improper and over Seasoning of chemical treated wood	Consumes enormous amount of time which results in more inventory and leads to wastage of wood if not seasoned properly	8	Improper temperature maintained reduces efficiency of artificial seasoning	6	No current control measures	5	8*6*5 =240	Manual Assessment of temperature in artificial seasoning room by using suitable electronic device	Responsibi -lity assigned to respective seasoning department to maintain suitable temperatur e in artificial seasoning room	Tempera-ture maintained by respective labour in-charge	8	3	3	72
D. Slicing for Frame--work and Lipping	Dimension based wood slicing	Wastage of wood due to slicing process	9	Wastage due to cutting and slicing based on required dimensions	7	Wood is sliced based on manual calculations and experience of workers	4	9*7*4 =252	Use cutting software instead to calculate the precise dimensions to be cut so as to reduce wastage and save time	Awareness about the importance of using wood cutting software should be created	By using wood cutting software the worker knows exactly how much to slice and wastage is reduced	9	5	2	90

											reduced				
E. Assembly of Lipping into Frame-work	Lipping and framework should fit precisely with each other for making the flush door	Uneven size of lipping and framework will lead to wastage	7	Improper assembly of lipping into framework	6	Visual inspection	5	7*6*5 =210	Obtain precise sizes of lipping during lipping cutting as mentioned in cutting process	Respective departments are assigned responsibility	Using accurate dimensio-ned lipping has reduced wastage	7	4	3	84
F. Attach Veneer	Improper application of glue on to veneer	Veneer doesn't stick properly on the wood, causes problem during finishing process	6	Machine work is ignored and gluing is done manually. This consumes more time.	6	No action taken to repair machinery and work done manually	5	6*6*5 =180	Repair machinery and use it for application of glue and for pressing	Assign responsibility to respective department to get machinery repaired	Machinery repaired is used. Less time is consumed and glue is effectively applied and sticks wood and veneer strongly	6	4	3	72
G. Hydraulic Pressure Treatment	Uneven temperature and pressure maintained.	Improper sticking of veneer on to flush door due low temperature and pressure	5	Low temperature and pressure reduce the efficiency of making good quality flush doors	5	Temperature and Pressure are manually set	7	5*5*7 =175	Pressure and temperature should be maintained as per requirement	Responsibility assigned to supervisor	Temperature and pressure are maintained according to the requirement in the hydraulic pressure	5	4	5	80
H. Finishing Process	Time consumed based on design and rework of damage if noticed	Complex design consumes more time and requires skilled labour	4	Attachment of accessories and carpenter work will consume more time and increases cost to the consumer	7	Manual work done by simple tools by skilled carpenter	5	4*7*5 =140	Provide training to workers on handling complex designs	Ensure work is done with lot of care and detailing. Satisfy or exceed customer requirements	Trained workers produce good quality products	4	5	3	60

Table 2. *Swim-line process after reducing RPN value*



4. Results

By making use of FMEA template, the RPN value was calculated by the analysis of severity, occurrence and detection. Further, the RPN value along with manufacturing lead time and eliminating non-value-added activities which yielded smooth flow of production process, improved product throughput and reduction in trim loss problem which was major cause of waste. The comparison between reduced RPN value and calculated RPN value and also reduction in time consumed and actual time is shown in fig 7 and fig 8 respectively.

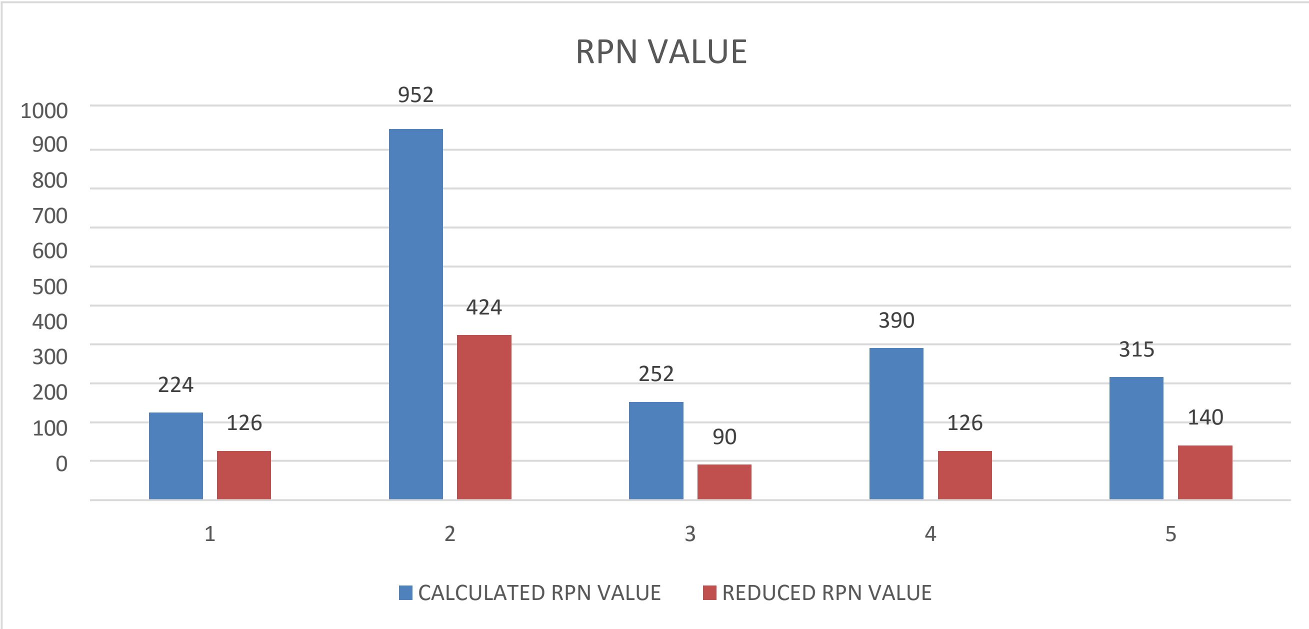


Figure 7. Comparison between Initial RPN value and Reduced RPN value

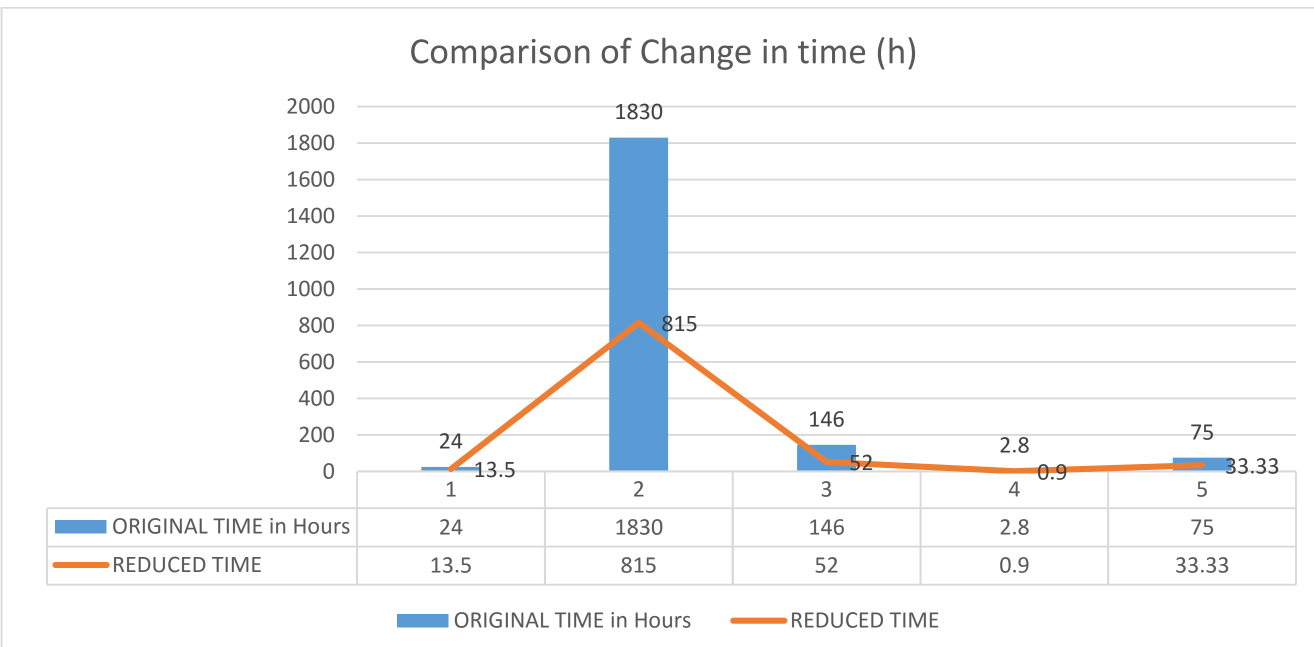


Figure 8. *Comparison between actual time and reduced time*

5. Conclusion

The RPN value was effectively reduced by making use of the defined methodology. Failure classifier, FMEA and swim line diagram have contributed positively to enhance the process by reduction of RPN value which resulted in smooth flow of production process in the flush door manufacturing industry. It has also helped in eliminating non-value-added activities by focusing on minimum material wastage and manufacturing lead time reduction. Hence, the six sigma DMAIC methodology was successfully implemented for improvising the process at flush door manufacturing industry which yielded in reduction of RPN value and simultaneously increased the productivity by decreasing the manufacturing lead time. Therefore, industry could deliver the products to the customers within the expected duration of time along with high quality.

6. References

[1] Six Sigma for Managers, Greg Brue by McGraw-Hill companies, Inc. 2002

[2] Sahn o Jevgeni, Shevtshenko Eduard, Zahharov Roman, “Framework for Continuous Improvement of Production Processes and Product Throughput”, 25th DAAAM International Symposium on Intelligent Manufacturing and Automation, 2014.

[3] Maze Arafeh, "Combining Lean Concepts & Tools with the DMAIC Framework to Improve Processes and Reduce Waste", American Journal of Operations Research, Scientific Research Publishing Inc, 2015.

[4] N. Sellapan, K. Palanikumar, “Modified Prioritization Methodology for Risk Priority Number in Failure Mode and Effects Analysis”, International Journal of Applied Science and Technology, Vol. 3 No. 4, April 2013.

[5] Lubica Simanova, “Specific Proposal of the Application and Implementation Six Sigma in Selected Processes of the Furniture Manufacturing”, Published by Elsevier B.V, Business Economics and Management 2015 Conference, BEM 2015.

[6] Monika Smetkowska, Beata Mrugalska, “Using Six Sigma DMAIC to Improve the Quality of the Production Process: A Case Study”, Published by Elsevier Ltd, 14th International Symposium in Management, SIM 2017.

[7] Lubica Simanova, Pavol Gejdos, "The Use of Statistical Quality Control Tools to Quality Improving in the Furniture Business", Published by Elsevier B.V, Business Economics and Management 2015 Conference, BEM 2015.

[8] Taufik Djatna, Imam Muharram Alitu, "An Application of Association Rule Mining in Total Productive Maintenance Strategy: An Analysis and Modelling in Wooden Door Manufacturing Industry", Published by Elsevier B.V, Industrial Engineering and Service Science 2015, IESS 2015.

[9] Gulshan Chauhan, S. K. Sharma, T. P. Singh, "Sustainability of Plywood and Block Board Industry in India", Proceedings of the National Conference on Trends and Advances in Mechanical Engineering, 2006.

[10] Rajesh Kumar Mishra, "Significance of Wood Seasoning", Published by Tropical Forest Research Institute, Vol. 4, No. 11, 2017.

[11] Stanislaw Borkowski, Piotr Sygut, Dorota Klimecka-Tatar, "Analysis of the Production Process of Wood Products used in Households", Chapter 11.