Abstract
In this article, design of failure mode and effect analysis (DFMEA) is a structured qualities analysis of the system, subsystem and components/functions that highlights impending failures modes of which their cause and effects of a failure on system operation. Few years ago, many industries are forced to use design of failure modes and effect analysis (DFMEA) technique to physically powerful their product design and manufacturing process due to the global competitive market. DFMEA is agreed out systematically by brainstorming. The aim of this paper is to in attendance a new approach for evaluation of RPN and failure modes to augment the utility of the traditional DFMEA technique. At the closing stages, the statistical method of the factor analysis was used to confirm the effectiveness.

Keywords: DFMEA; Failure modes and Factor Analysis; Risk Priority Number (RPN)

Cite this article as: Prabir Namhata, Amit Rakshit, Sukanta Kumar Naskar, et al. 2021. Risk Priority Number (RPN) assessment in design failure modes and effective analysis for the Automobile Plant using factor analysis. I J Mech Eng. 3: 20-24.

Copyright: This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. Copyright © 2021; Prabir Namhata

Introduction
This method is widely used during the process of design analyze of engineering system from their reliability aspect. It was described as an effective approach to analyze of each potential mode in the system to examine the failure mode effects on the system. D FMEA also can be applied to various conducting engineering systems safety analysis. The history of DFMEA may be traced flipside to the early years of the
1950s with the development of flight control systems, when U.S Navy’s Bureau of Aeronautics, in order to widen a procedure for reliability control over the detailed design effort to develop a requirement known as Failures Analysis. There are so many factors that must be explored earlier than the implementation of DFMEA. Some of this factor which includes

(i) Examination of each and every conceivable failure mode by the involved professionals.
(ii) Measuring FMEA cost benefits.
(iii) Obtaining engineer’s approval and support.
(iv) Making decisions based on the risk priority number (RPN).

Design Failure Modes and Effect Analysis was an analytical technique old to design phase of a product development. It was a proactive technique worn to identify the weak points of a product design in early stage. Design Failure Modes and Effect Analysis was a specific tool used during product design phase to develop robust and more reliable product. Its aim to recognize and alleviate or eradicate the product failures earlier than releasing the production drawing for the manufacture.

RPN technique was commonly used in the automation industry, based on the risk priority number for an item failure mode based on three factors-

(i). probability of occurrence,
(ii). the severity of the failures effect, and
(iii). probability of failure detection.

The probability of occurrence is the likelihood of failure, or relative number of failures, expected during the item’s useful life.

$$RPN = \text{Occurrence} \times \text{Severity} \times \text{Detection}$$

Failure modes with a high RPN are more critical and given a higher priority than ones with a lower RPN.

When the scales used range from 1 to 10, the value of an RPN will be between 1 and 1000. The scales and categories used.

| Table 1: Severity (S), Occurrence (O) and Detection (D) guidelines for design DFMEA. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Rank | Effect | Severity (S) | Occurrence (O) | Detection (D) |
| 10  | Hazardous | Hazardous effect | Almost certain | Failure almost certain | Almost impossible | No known technique available |
| 9   | Serious  | Potential hazardous effect | Very high | Likely very high number of failures | Remote | Only unproven technique available |
| 8   | Extreme | Customer very dissatisfied | High | Likely high number of failures | Very slight | Providing durability test |
| 7   | Major    | Customer dissatisfied | Moderate | Likely moderate high number of failures | Slight | Test on products with prototypes |
| 6   | Significant | Customer experiences discomfort | Medium | Likely medium number of failures | Low | Test on similar system |
| 5   | Moderate | Customer experiences some dissatisfaction | Low | Likely occasional number of failures | Medium | Test on preproduction system |
| 4   | Minor    | Customer experiences minor nuisance | Slight | Likely few failures | Moderately high | Test on early prototypes |
Risk Priority Number (RPN) assessment in design failure modes and effective analysis for the Automobile Plant using factor analysis

DOI: https://doi.org/10.36811/ijme.2021.110006

This paper presents a novel approach for prioritization of RPN S with case study analysis.

Novel loom for Evaluation of RPN

Case Study-DFMEA for Buffering Machine (Tire Retarding plant).

The proposed methodology for evaluation of RPN was able to deals with the situation when:

(i). The FMEA team has a divergence in the rating scale S, O and D indexes, the RPN means are indistinguishable for more than one failure mode and the three failure indexes S, O and D are equally important.

(ii). The potential failure modes of a Buffering Machine are listed in Table-2. It shows that there is a incongruity in rating scale for S, O and D indexes. We calculated RPNs and their mean for all possible combinations of severity, occurrence and detection ratings. Various combination of S, O and D values are producing an identical value of RPN means 225. First priority should be given to the failure mode which has similar RPN range.

| Product Name | Failure Mode | Potential Effect of Failure | Potential cause of Failure | Severity (S) | Occurrence (O) | Detection n (D) | RPNs | RPN |
|--------------|--------------|-----------------------------|---------------------------|--------------|---------------|----------------|------|-----|
| Buffering Machine | Inspection Difficult to use the function | Low skilled engineer | 1 | 7 | 5 | 225 | **196** |
| | Cutting | Not able to take cutting in tire | Probably damage Rubber | 6 | 9 | 3 | 144, 72, 36 | **432** |
| | Brushing Brushing is not properly | Brushing not working | 8 | 2 | 5 | 360, 120, 720, 240 | **690** |
| | Repairing Needs frequent repair | Poor quality materials | 8 | 4 | 2 | 112, 128, 448, 512 | **456** |
Risk Priority Number (RPN) assessment in design failure modes and effective analysis for the Automobile Plant using factor analysis

DOI: [https://doi.org/10.36811/ijme.2021.110006](https://doi.org/10.36811/ijme.2021.110006)

The planned methodology for the prioritization of the failure modes for the above case study is given as follows:

(i). The failure mode with higher RPN is more severe and
(ii). The failure mode with smaller RPN range is more severe if the RPNs means are same.

| Build Mode | Hardware corrupted connecting | 7 | 9 | 56 |
|------------|-------------------------------|---|---|----|
| (5)        |                               | 5 | 9 | 6  |
|            |                               | 63,42,56 | 2 | 537 |
|            |                               | 378,45,30 | 2 | 537 |
|            |                               | 405,270  | 2 |    |

Statically Psychiatry and Argument

In this paper statistically tools have been used to assess the proposed RPN prioritization methodology. The results shown of each analysis provide sufficient evidence for the usefulness of the proposed method.

Descriptive Statistics

Buffering Machine shows that the means of the RPNs are indistinguishable. Standard deviation of the modes of failure are 65.273, 140.347, 226.779, 173.090 and 208.723. It shows that the most critical failure modes need to be addressed first. Similarly, it is one of the vital roles to be adapted the rank of the failure modes of a Buffering Machine.

Correlation Matrix

From the Table 3 it reveals that the correlation coefficient between a single variable and every other variable in the investigation.

| Table 3: Correlation Matrix for S, O and D. |
| Coefficient of Correlation | S | O | D |
|----------------------------|---|---|---|
| Correlation                |   | 1.000 | -.590 | .175 |
| O                          | -.590 | 1.000 | -.590 |   |
| D                          | .175 | -.590 | 1.000 |   |

The Eigen value for the above correlation matrix is 0.2486, 0.8255, and 1.9260. A measure of the multicollinearity among three independent variables is computed from the correlation matrix using the following computation:

\[ C = \sqrt{\frac{\text{Maximum Eigen value}}{\text{Minimum Eigen Value}}} \]

\[ C = \sqrt{\frac{1.92596}{0.24857}} \]

\[ C = 2.7834 \]

The computed value is ≤ 4, thus it provides strong evidence for there is no multicollinearity among these three independents.
Conclusion

In this paper, we had projected a new methodology for the evaluation of RPNs and the failure modes. Results of statistical analysis are hold up the utility of the proposed methodology. Thus, we conclude that the proposed methodology can successfully prioritize the prioritization of failure modes. Some results of this study are important.

➢ The D FMEA team has a disc agreement into the rating scale for S, O and D indexes.
➢ The RPN means are identical for more than one failure mode.
➢ Three failure indexes S, O and D are equally important.

References

1. Kumar R, Mondloi KR. 2018. Failure Mode and Effect Analysis of Petrol Engine of Car. In International Journal of Science and Research. 7: 180-183.

2. Dahooie HJ, Vanaki SA, Firoozfar RH, et al. 2020. An Extension of the Failure Mode and Effect Analysis with Hesitant Fuzzy Sets to Assess the Occupational Hazards in the Construction Industry. In MDPI, International Journal of Environmental Research and Public Health. 02-22. Ref.: https://pubmed.ncbi.nlm.nih.gov/32102295/ DOI: https://doi.org/10.3390/ijerph17041442

3. Zuniga AA, Baleia A, Fernandes J, et al. 2020. Classical Failure Modes and Effects Analysis in the Context of Smart Grid Cyber-Physical Systems. In MDPI, energies. 01-26.

4. Carson C. 2014. Understanding and applying the fundamentals of FMEAs. Annual Reliability and Maintainability Symposium. 01-32.

5. Boldrin M, Lorenzi AD, Fiorentin A, et al. 2009. Potential Failure Mode and Effects Analysis for the ITER NB Injector. Fusion Engineering and Design. 84: 466-469.

6. Brakeman JJA, Masters JA, Klingender W et al. 2012. A Quantitative Method for Failure Mode and Effects Analysis. in International Journal of Production Research. 50: 6904-6917.

7. Vencheh H, Hejaz S, Eslaminasab Z. 2013. A Fuzzy Linear Programming Model for Risk Evaluation in Failure Mode and Effects Analysis. In Neural Computing and Applications. 22:1105-1113.

8. Sadat AH, Jean DY, Patrick M. 2008. Conceptual Processes Planning -An Improvement Approach Using QFD, FMEA, and ABC Methods. Robotics and Computer- Integrated Manufacturing. 26: 392-401.

9. Hsieh LK, Tong IL, Wang CM. The Application of Control Chart for Defects Clustering in IC Manufacturing based on Fuzzy Theory. Expert Systems with applications. 765-776.

10. Hsu MC. 2008. Solving Multi-response Problems through Neural Networks and Principal Component Analyze. Journal of the Chinese Institute of Industrial Engineers. 18: 47-54.

11. Kang YH. 2011. A Multi-criteria Decision-Making Approach for Capacity Allocation Problem in Semiconductor Fabrication. International Journal of Production Research. 49: 5893-5916.

12. Kilt G, Folgers AT. Fuzzy Sets, Uncertainty, and Information, New York-Prentice-Hall.

13. Kuok HJ, Shea DD. 2006. A Forecasting Model for Semiconductor Equipment Preventive Maintenance. Journal of Occupational Safety and Health. 14: 124-132.

14. Slapping N, Nagarajan D, Palani Kumar K. 2014. RPN in Failure Mode and Effect Analysis. International Journal of Applied Engineering Research. 07-15.