China Petroleum Processing and Petrochemical Technology

Catalyst Research Volume 23, Issue 2, November 2023 Pp. 3993-3999

IMPLEMENTATION ISSUES OF PROCESS FAILURE MODE AND EFFECT ANALYSIS IN THE AUTOMOTIVE INDUSTRY OF TAMILNADU

Dr.T.Umapathy

S/ C.Thulasidass Assitant professor, Post Graduate & Research Department of Economics, Dwaraka Doss Goverdhan Doss Vaishnav College (Autonomous), Arumbakkam, Chennai-600 106.

Abstract

Since the competitive era began, the realm of total quality management (TQM) has been undergoing rapid expansion. This progression has been characterized by the emergence of various potent methodologies. One such methodology is Failure Mode and Effect Analysis (FMEA), which originated from NASA's space programs and was later adopted by the automotive industry to bolster quality and prevent mishaps. Initially, FMEA was divided into design and process FMEAs. PFMEA primarily entails the identification of manufacturing failures and their quantification using a metric referred to as Risk Priority Number (RPN). PFMEA then concentrates on taking measures to reduce the RPN value, thus mitigating the consequences of failures. As a result, PFMEA plays a pivotal role in achieving ongoing quality enhancement by reducing the likelihood of recurrent manufacturing process failures. This study aims to scrutinize the benefits and effectiveness of PFMEA, as well as the obstacles encountered during its implementation.

Key words: Total Quality Management, Process Failure Mode and Effect Analysis, Quality Improvement and Failure Prevention.

Introduction and Problem Discussion

As the Indian economy has embraced globalization, it transitioned from a heavily protected market to a competitive free market, introducing international manufacturers into the mix. The Indian car market has emerged as one of the world's fastest-growing markets. Subsequently, different modern areas have uplifted their emphasis based on item quality in conditions of usefulness, unwavering quality, steadfastness, and cost. The disappointment pace of many efficiently manufactured items and parts has been essentially decreased to only a couple of parts for each million. The tolerance for defective products is no longer acceptable, necessitating the adoption of tools and techniques aimed at getting things right on the first attempt.

In pursuit of this objective, industries have embraced concepts such as Total Quality Management (TQM), Six Sigma, Total Productive Maintenance (TPM), Just in Time (JIT), Lean Manufacturing, and Agile Manufacturing. A multitude of tools have been developed and continue to evolve to implement these concepts in daily industrial operations, and one such critical tool is Process Failure Mode and Effect Analysis (PFMEA).

Catalyst Research Volume 23, Issue 2, November 2023 Pp. 3993-3999

Albeit the foundations of the PFMEA procedure date back to the 1920s, its significant documentation and application just started in the mid 1960s, especially by NASA. It tracked down broad use in the car business since the mid 1970s and picked up speed during the 1990s as a reaction to huge quality and dependability challenges presented by significant vehicle producers. Moreover, changes in corporate obligation regulation have provoked organizations to utilize PFMEA to improve item well being.

PFMEA, alongside other quality apparatuses, lines up with the standards of disappointment avoidance and constant improvement, which are crucial components of any Complete Quality Administration framework. PFMEA explicitly resolves issues emerging from assembling processes. It includes recognizing potential disappointment modes and their causes at each cycle step, assessing existing controls, and surveying the effect of disappointments on assembling line administrators and end-clients. A cross-practical group including specialists from different divisions commonly does PFMEA, frequently shaped during the arranging phase of another item's turn of events. The group examines the disappointment methods of every part and subsystem, recognizes likely circumstances and end results, and surveys the dangers related with these impacts.

The expansion of the automotive industry in developing countries like India, with several global automotive manufacturers establishing manufacturing hubs, has had a significant impact. This research primarily focuses on PFMEA within the Indian automotive industry, where most automotive suppliers conduct PFMEAs to meet the requirements of automotive manufacturers. However, some suppliers perceive PFMEAs as mere paperwork, missing the opportunity to derive benefits from them. This perception contrasts with that of automotive manufacturers, who view PFMEA as a crucial tool for preventing problems and supporting their continuous improvement efforts, integral to their Total Quality Program. Some suppliers currently undertake PFMEAs to secure or retain quality awards, indicating a lack of comprehensive understanding of the technique. To investigate this situation, this research has been initiated to examine how automotive suppliers in India approach and utilize PFMEA.

Reviews

In 2003, Devadasan et al. underlined the critical importance of identifying the challenges associated with implementing PFMEA in the Indian manufacturing sector. They emphasized the necessity for these industries to cultivate expertise in effectively implementing PFMEA.

Around the same time, Johnson and Khan (2003) conducted a study in the UK's automotive sector and found that the majority of suppliers were conducting PFMEA primarily due to contractual obligations.

Catalyst Research Volume 23, Issue 2, November 2023 Pp. 3993-3999

Pantazopoulos and Tsinopoulos (2005) took on the task of implementing PFMEA for quality improvement in the metal forming industry. They underscored the significance of creating robust supporting documents and records to collect data on failure control and monitor preventive action plans, essential for the successful implementation of PFMEA.

In 2007, Senol made an effort to refine the occurrence scale used in Risk Priority Number (RPN) calculations within PFMEA applications. They employed a Poisson process approach and integrated Pareto analysis for risk prioritization. However, this effort was more focused on refining the analysis aspect and did not address broader issues related to PFMEA implementation.

Returning to the work of Johnson and Khan (2003), they noted that major automotive component suppliers to Ford Motor Company in the UK regarded PFMEAs more as a regulatory obligation rather than a tool for preventing problems and driving continuous improvement, cost reduction, and quality enhancement. Their investigation led to the creation of a comprehensive questionnaire covering essential aspects related to PFMEA implementation in the automotive industry.

Objectives

The study has been made;

1. To analyse the benefits and effectiveness of PFMEA in automotive industry
2. To examine the difficulties in implementation of PFMEA in automotive industry

Research Methodology

A total of 50 questionnaires were sent to major automotive suppliers in Tamilnadu and 36 responses were received. The response rate achieved in this survey is 72%, which is deemed to be accepted to carry forward in the research.

Analysis on Measure of Benefits and Effectiveness of PFMEA

It is observed from the table that nearly 86% of the companies are measuring the benefits and effectives on PFMEA implementation and the remaining 14% are not measuring the benefits and effectiveness of PFMEA implementation.

Measurement of Benefits and Effectiveness

Table 1 Measure of Dimension of Benefits and Effectiveness

Benefits and effectiveness		Y		N		Tot.	
		No(s).	%	No(s).	%	No(s).	%
1	Improved First Run Capability	24	67	12	33	36	100.0

Catalyst Research Volume 23, Issue 2, November 2023 Pp. 3993-3999

2	Increase in process potential capability	28	78	08	22	36	100.0
3	Increase in process efficiency	23	64	13	36	36	100.0
4	Reduction in internal scrap/reject areas	22	61	14	39	36	100.0
5	Reduction in parts per million (ppm)	31	86	05	14	36	100.0
6	Reduction in Customer returns	27	75	09	25	36	100.0
7	Reduction in warranty	30	83	06	17	36	100.0
8	Improvement in maintenance frequency	28	78	08	22	36	100.0
9	Improvement in Reliability	29	81	07	19	36	100.0

Source: Compiled and calculated using primary data

The above table depicts the statements that measure the benefits and effectiveness of PFMEA and the respective frequencies recorded through the data collection.

H01: There is no significant difference among the factors of benefits and effectiveness towards PFMEA implementation

Table 2- One-Sample t-Test

One-Sample t-Test						
Qt.No	t	df	S – 2 T	MD	95%	
					Low	Up
BE1	24.26	35	.000	1.22	1.18	1.28
BE2	25.92	35	.000	1.34	1.21	1.39

Catalyst Research Volume 23, Issue 2, November 2023 Pp. 3993-3999

BE3	23.18	35	.000	1.19	1.12	1.24
BE4	19.15	35	.002	1.11	1.06	1.15
BE5	27.33	35	.000	1.22	1.14	1.28
BE6	22.52	35	.000	1.51	1.31	1.61
BE7	18.19	35	.000	1.44	1.26	1.51
BE8	20.11	35	.000	1.11	1.01	1.19
BE9	24.68	35	.000	1.30	1.17	1.43

Source: Compiled and calculated using primary data

The table above denotes the t test to identify the difference among the factors of benefits and effectiveness towards PFMEA implementation. Since p value is less than 0.01, the null hypothesis is rejected and concluded that there is a significant relationship between the factors of benefits and effectiveness towards PFMEA implementation.

H02: There is no significant difference between mean rank values between frequency of review of PFMEA with respect to overall benefits and effectiveness in PFMEA implementation

Table 3 - Kruskal – Wallis Test

Stat	Fre	MR	x^2	Sg. (p)
Not at all	5	25.11	129.121	0.003**
Less than 3 months	12	28.15		
4 – 6 months	11	32.63		
7– 12 months	08	41.20		

Source: Compiled and calculated using primary data

The above table denotes the Kruskal – Wallis test and in which the p value is less than 0.01. Hence, the null hypothesis is rejected and there is a significant difference between mean rank values between frequency of review of PFMEA with respect to overall benefits and effectiveness in PFMEA implementation.

Analysis on Challenges and Difficulties in Completing PFMEA

H03: There exists no significant difference between factors of challenges and difficulties in PFMEA implementation

Catalyst Research Volume 23, Issue 2, November 2023 Pp. 3993-3999

Table 4 One-Sample Kolmogorov-Smirnov Test on Challenges and Difficulties in PFMEA Implementation

One-Sample Kolmogorov-Smirnov Test															
		Challenges and Difficulties in PFMEA Implementation													
		CDI1	CDI2	CDI3	CDI4	CDI5	CDI6	CDI7	CDI8	CDI9	CDI10	CDI11	CDI12	CDI13	CDI14
Normal Parameters (a,b)	M	8.95	7.82	8.62	8.28	8.13	4.66	7.63	4.33	6.18	5.39	5.98	4.1	3.32	3.17
	SD	3.11	4.1	3.21	2.62	1.92	2.12	3.2	2.81	1.88	2.11	3.89	2.47	3.08	2.16
Most Extreme Differences	Absolute	0.281	0.412	0.238	0.521	0.333	0.413	284	0.223	0.296	0.205	0.198	0.241	0.267	0.236
	Positive	0.172	0.145	0.115	0.127	0.119	0.23	0.217	0.158	0.241	0.266	0.145	0.236	0.25	0.208
	Negative	-0.182	-0.251	-0.238	-0.274	-0.283	-0.271	-0.256	-0.183	-0.14	-0.166	-0.127	-0.133	-0.14	-0.156
Kolmogorov-Smirnov Z		3.521	3.336	2.812	3.005	2.82	3.541	2.642	2.428	2.161	2.184	1.462	2.321	2.711	2.412
Asymp. Sig. (2-t)		0.001	0	0	0.002	0.003	0	0	0	0	0.001	0.005	0	0.005	0.007

As the p value is less than 0.01, there is a significant difference between factors of challenges and difficulties in PFMEA implementation It is conferred that Involvement and commitment of managers at different levels are vital for implementing TQM tools and practices.

Conclusion

Many automotive suppliers conduct PFMEAs primarily to meet the requirements of their automotive manufacturers, viewing them as mere paperwork with no expected benefits. This perspective contrasts with that of automotive manufacturers, who see PFMEA as a proactive tool for preventing problems, supporting continuous improvement, and integral to their Total Quality Program. In the present day, suppliers engage in PFMEAs to secure or maintain specific quality awards. However, it is believed that suppliers may not have a comprehensive understanding of this technique. To delve deeper into this situation, this research aims to explore how automotive suppliers approach and utilize PFMEA.

The research methodology provides a structured and organized framework to guide researchers in achieving the research objectives. This study identifies that the most significant difficulty and challenge in PFMEA implementation is the commitment of management.

References

1. Andia L.M. (1998), 'How to Train with a Partner (and not come to blows)', Training and Development, Vol. 52, No. 5, pp. 14-15.
2. Atkinson R.M., Montakhab M.R., Pillay K.D.A., Woollons D.J., Hogan P.A., Burrows C.R. and Edge K.A. (1992), 'Automated Fault Analysis for Hydraulic Systems Part 1-fundamentals', Proceedings of the Institution of Mechanical Engineers, Part 1, Journal of System Control Engineering, Vol. 206, No. 14, pp. 207-214.
3. Devadasan S.R., Muthu S., Neil Samson R. and Sankaran R.A. (2003), 'Design of Total Failure Mode and Effects Analysis Programme', International Journal of Quality & Reliability

Management, Vol. 20, No.5, pp. 551-568.

4. Johnson K.G. and Khan M.K. (2003), 'A Study into the use of the Process Failure Mode and Effects Analysis (PFMEA) in the Automotive Industry in the UK', Journal of Materials Processing Technology, Vol. 139, pp. 348-356.
5. Pantazopoulos G. and Tsinopoulos G. (2005), 'Process Failure Mode and Effect Analysis (PFMEA): A Structured Approach for Quality Improvement in the Metal Forming Industry', Journal of Failure Analysis and Prevention, Vol.5, No.2, pp.5-10.
6. Senol S. (2007), 'Poisson Process Approach to Determine the Occurrence Degree in Failure Mode and Effect Reliability Analysis', The Quality Management Journal, Vol.14, No.12, pp.29-40.
7. Sexton R.D. (1991), 'An Alternative Method for Preparing FMECA's', Proceedings of Annual Reliability and Maintainability Symposium.
8. Teng S.G. and Ho S.M. (1996), 'Failure Mode and Effects Analysis - An Integrated Approach for Product Design and Process Control', International Journal of Quality and Reliability Management, Vol. 13, No. 5, pp. 8-26.
9. Teoh P.C. and Case K. (2004), 'Failure Modes and Effects Analysis Through knowledge Modeling', Journal of Materials Processing Technology.
10. Wirth R., Berthold B., Krämer A. and Peter G. (1996), 'Knowledge- Based Support of System Analysis for the Analysis of Failure Modes and Effects', Engineering Application - Artificial Intelligence, Vol. 9, No. 3 pp. 219-229.
11. Xu K., Tang L.C., Xie M., Ho S.L and Zhu M.L. (2003), 'Fuzzy Assessment of FMEA for Engine Systems' Reliability Engineering and System Safety, Vol. 75, pp 17-29.
12. Yang C. C, Wen-Tsaan Lin, Ming-Yi Lin and Jui-Tang Huang. (2006), 'A Study on Applying FMEA to Improving ERP Introduction, An Example of Semiconductor Related Industries in Taiwan', International Journal of Quality and Reliability Management, Vol. 23, No.3, pp. 298-322.