CHAPTER 6

FINDINGS

6.1 INTRODUCTION

This Chapter summarizes the findings from all the statistical analysis and test carried out on all the factors and dimensions of PFMEA. The findings identify the priority issues of each dimension towards effective PFMEA implementation.

6.2 GENERAL

1. It is observed from the survey results that 65% of automotive companies had TS 16949:2002 and Q1 registrations. Around 30% of the companies had ISO 9001:2000 certifications. Among other certification level companies had ISO 14000 certification in addition to above certifications.

2. The t-test applied to investigate if there exists a significant difference between Q1 registered companies with respect to dimensions of PFMEA towards implementation, reveals that there is a significant difference among them.

3. The t-test applied to find the existence of a significant difference between TS registered companies with respect to the dimensions of PFMEA towards implementation, reveals that there is a significant difference among them.
6.3 OVERALL MEAN OF DIMENSIONS OF PFMEA

1. It is observed that team characteristics are found to be the most important aspect in the successful implementation of PFMEA in the Automotive Industry. The cross-functional team that carries out PFMEA should have balanced representation from all departments, and should consist of experts with very high commitment towards the goal of PFMEA implementation. The next most important aspect in PFMEA implementation is revealed to be the technical characteristics. Technical issues are really crucial in PFMEA implementation with twenty-two factors identified has most relevant in this section. Managing the process of PFMEA is selected as next important factor in PFMEA implementation, followed by organizational characteristics and Motivation in going for PFMEA implementation. The training process for all the team members and management people constitute next overall level of importance, and finally the external influences towards PFMEA implementation.

2. The Friedman Test applied to investigate the significant difference between mean rank values among different dimensions of PFMEA towards its Implementation reveals that there is a significant difference among them.

6.4 MOTIVATION FOR PFMEA IMPLEMENTATION

1. The primary objective or motivation for PFMEA implementation in automotive industry is observed to be part of company’s total quality effort towards continuous improvement of its processes. Increasing the commitment of line management to quality, avoid making mistakes, and to meet customers requirements, are observed to be other important motives behind PFMEA implementation.
2. The One-Sample Kolmogorov-Smirnov test applied to investigate the significant difference between mean rank values among the factors of motivation towards PFMEA implementation reveals that there is a significant difference among them.

6.5 ORGANIZATIONAL CHARACTERISTICS

1. It is observed that management commitment is the primary concern among organizational characteristics towards PFMEA implementation. Management understanding of the PFMEA technique, provision to involve all relevant managers from design to service, usage of PFMEA by the organization as the upfront quality planning tool, constitutes important concerns for successful implementation of PFMEA in industry. The management should appreciate the fact that PFMEA contributes to the continuous improvement of the organization. Management’s recognition of the need to allocate resources, management review of the PFMEA process against implementation program is the other critical issues of the organizational characteristics towards PFMEA implementation.

2. The Friedman Test applied to investigate the significant difference between mean rank values among factors of organizational characteristics towards PFMEA implementation reveals that there is a significant difference among these factors.

3. The Chi-square test applied to find the significant relationship between Percentages of managers participating in PFMEA and TS Registered Companies reveals that there is a significant relationship.

4. The Chi-square test applied to find the relationship between percentages of managers participating in PFMEA and Q1 Registered Companies reveals that there is a significant relationship.
5. Manager’s participation in PFMEA implementation reveals that 50% of managers are taking part in PFMEA on an average frequency and 32% of managers are participating on a high frequency and 19% of the managers are participating on a low frequency. It is observed that 95% of the managers are reviewing the progress of the PFMEA periodically towards PFMEA implementation.

6.6 MANAGING THE PFMEA PROCESS

1. Follow up of the recommended actions in eliminating high risk failures is reported to be the main concern among the factors of PFMEA managing the process in PFMEA implementation. Regular review and updating of PFMEA, prioritizing the failure modes for preventive actions, using standard formats, clear definition of roles and responsibilities for the CFT, effective management of time and use of realistic value of Severity, Occurrence and Detection are the other important factors considered in the managing process of PFMEA implementation.

2. The Friedman test applied to find the significant difference between mean rank values among the factors of managing the PFMEA process towards implementation reveals that there is a significant difference.

3. It is observed that 80.65% of sub-suppliers are involved in the PFMEA implementation, 58.06% of the existing PFMEA processes are observed to be reviewed once in 7 months to 12 months period, 19.35% of PFMEA process are reviewed once in 4-6 months period, 17.74% of PFMEA process are reviewed once in three months and 4.84% PFMEA process are observed to be not reviewed

4. Kruskal – Wallis one-way ANOVA test applied to find the significant difference between frequency of review of PFMEA and the factors of managing the process reveals that there is a significant difference.
6.7 TEAM CHARACTERISTICS

1. Use of team approach in PFMEA implementation is observed to be the most important factor among the dimensions of team characteristics. This is followed by a good CFT, with good representation from all the departments. The understanding of the team objective and good all-round training of the team members is observed to be significant.

2. The Friedman test applied to find the significant difference between mean rank values among factors of Team aspects towards PFMEA implementation reveals that there is a significant difference.

3. Companies participating in team building program are observed to be 88.71%, and the remaining 11.29% of the companies are not involved in the team-building program.

4. Team building program is largely participated by engineers with 92.74%, followed by supervisors’ participation of 91.13%, managers’ participation of 86.29%, operators’ participation of 70.16% and Directors’ participation of 67.74% towards PFMEA implementation.

5. Team building program organized towards PFMEA implementation between 2-3 days is 67.74%, 16.94% for one-day programs, and 4.03% for over three days. The remaining 11.29% of companies are not organizing any team-building program.

6.8 TECHNICAL CHARACTERISTICS

1. The study reveals the following priority issues towards PFMEA implementation. (i) Clear definition of root causes, (ii) Clear definition of current controls, (iii) Clear understanding between cause and effect, (iv) All
failure modes are considered, (v) Availability of clear process flow chart and
description, (vi) Establishment of clear links between PFMEA control plan
and instruction. All other technical characteristics are observed to be highly
significant towards PFMEA implementation.

2. The Friedman test applied to find the significant difference
between mean rank values among Technical characteristics towards PFMEA
implementation reveals that there is a significant difference among the factors
of technical characteristics towards PFMEA implementation.

3. The proximity matrix for technical characteristics reveals
prominent relationship of Q6_15, Difficulty in determining Ratings of
severity, Occurrence and Detection, with the following thirteen technical
characteristics among the twenty-two characteristics that intends to measure
importance of technical characteristics towards the implementation of
PFMEA.

Q6_2 : Understanding the difference between a design and a
process FMEA
Q6_3 : Defining the scope of PFMEA
Q6_4 : Clear understanding of the process purpose
Q6_5 : Clear process flow chart and description
Q6_6 : Clear understanding of Fit and Function
Q6_7 : All failure modes being considered
Q6_8 : Clear definition of failure mode
Q6_9 : Clear understanding of effects on operator through to
customer and service
Q6_10 : Clear definition of Tool causes
Q6_11 : Use of Brainstorming to Identify root causes
Q6_13 : Clear understanding between cause and effect
Q6_14 : Clear Identification of Controls
Q6_17 : Understanding the ranking of CCs and SCs
4. The hierarchical cluster analysis applied to technical characteristics in the implementation of PFMEA reveals that ‘the design FMEA as the single most important attribute, which in turn is clustered with the attribute ‘difficulty in determining ratings of SOD’. This in turn is clustered with all other factors of technical characteristics.

5. The ANOVA test applied to find the significant difference between frequencies of review of PFMEA with respect to technical characteristics reveals that there is a significant difference between technical characteristics towards PFMEA implementation.

6. The Mann–Whitney U–Test applied to find the significant difference between mean rank values among technical characteristics of PFMEA and participation of sub-supplies in PFMEA reveals that there is a significant difference towards PFMEA implementation.

7. It is observed that all the practitioners of PFMEA use Brainstorming techniques and process flow charts towards PFMEA implementation. Use of fish bone diagram and other failure mode identification techniques are used in 91.13% of the organizations. Alternate techniques, such as why-why analysis and similar other techniques are used in 8.06% of the organizations only.

6.9 TRAINING

1. It is observed that PFMEA practitioners prefer to have third party training program for effective PFMEA implementation. Instead of one shot training programs, practitioners prefer regular ongoing training programs. Training requirement is emphasized for supervisors and managers.
2. The Friedman Test applied to find the significant difference between mean rank values among factors of Training aspects is found to be significantly different towards PFMEA implementation.

3. It is observed that nearly 70% of training programs are provided by customer training institutes, 27% of training is provided by training colleges, and the remaining 29% are provided through audio visual media.

4. It is observed that 70% of the companies have organized training programs to an extent of more than three days at a time towards PFMEA implementation, nearly 18% of the companies have organized between two to three days and nearly 13% organized one day programs.

5. It is observed that among the participation of team members in PFMEA training, middle level supervisors and supervisors have participated to an extent of 92%, senior managers in the order of 83%, operators nearly 24% and the directors nearly 11%.

6.10 RESOURCES

1. Amount of time spent in PFMEA implementation is the prime concern expressed by the PFMEA practitioners towards its implementation. Lack of process capability data and suitable software are expressed as other resources of concern in PFMEA implementation.

2. The Friedman Test applied to study the significant difference between mean rank values among factors of resources reveal that there is a significant difference among the factors of resources towards PFMEA implementation.
3. It is observed that over 60% of the companies spend 6 to 10 hours per week towards PFMEA implementation, over 16% between 1 to 5 hours per week, and the remaining 23% spend just one hour per week.

4. It is observed from the survey results that in 56% of the companies six persons are involved in CFT, in 18%, 4-6 persons, in 15%, 2-3 people, and in over 11%, only one person is involved to handle PFMEA implementation.

5. It is observed that 63% of the companies handle only one PFMEA at any given time, 30% 2-3 PFMEAs, and the remaining over 7% of the companies handle more than three PFMEAs simultaneously.

6. Over 59% of the companies use PFMEA software towards PFMEA implementation, and the remaining 41% of the companies still perform PFMEA using conventional methods.

7. The survey results on the software features reveal that over 59% of the softwares are user friendly and 41% of the users find the software they use are having specific feature requiring special training and know-how.

8. Cost measurement towards PFMEA implementation is an important factor to compare the benefits achieved through PFMEA practice. It is observed from the survey results that nearly 97% of the companies are not performing cost measurement towards PFMEA implementation.

6.11 MEASURE OF BENEFITS AND EFFECTIVENESS

1. It is observed from the survey as given in Table 3.35 that nearly 78% of the companies are measuring the benefits and effectiveness on PFMEA
implementation, and the remaining 28% of the companies are not measuring the benefits and effectiveness.

2. It is observed from the results that nearly 80-85% of the companies are measuring the benefits and effectiveness on PFMEA implementation in terms of the nine performance measures.

3. The One-Sample t-Test applied to test the significant difference among the factors of benefits and effectiveness reveals that there is a significant difference among the factors of benefits and effectiveness towards PFMEA implementation.

4. The Kruskal – Wallis Test applied to find the significant difference between mean rank values among frequency of review of PFMEA with respect to overall benefits and effectiveness reveal that there is a significant difference towards PFMEA implementation.

5. The Mann – Whitney U test applied to find the significant difference between mean rank values among participation of sub-suppliers in PFMEA and overall benefits and effectiveness reveal that there is a significant difference towards PFMEA implementation.

6.12 EXTERNAL FACTORS

1. External factors like late engineering changes and on-going changes in the product are observed to be affecting the PFMEA implementation.

2. The Friedman Test applied to find the significant difference between mean rank values among external factors reveal that there is a
significant difference among the external factors towards PFMEA implementation.

6.13 DIFFICULTY AND CHALLENGES TOWARDS PFMEA IMPLEMENTATION

1. It is observed that management commitment is the top most difficulty in meeting the challenges expressed in this study towards PFMEA implementation. Other priority issues observed in the study include understanding function, ranking severity, and availability of appropriate training, linking PFMEA to control plan and instruction, and allocation of resources among others.

2. The One-Sample Kolmogorov-Smirnov Test applied to find the significant difference between factors of challenges and difficulties reveal that there is a significant difference between these factors towards PFMEA implementation.

6.14 CORRELATION OF PFMEA DIMENSIONS

The following findings are observed from the Correlation analysis performed among the factors of the dimensions of PFMEA.

1. The correlation between team characteristics and technical characteristics is found to be significant at 0.921 (p<0.01).

2. The correlation between team characteristics and the managing process is found to be significant at 0.896 (p<0.01)
3. The correlation between technical characteristics and the managing process is found to be significant at 0.888 (p<0.01)

4. The correlation between technical characteristics and organizational characteristics is found to be significant at 0.886 (p<0.01)

5. The correlation between managing the process and organizational characteristics is found to be significant at 0.865(p<0.01)

6. The correlation between organizational characteristics and aspects of motivation is found to be significant at 0.802(p<0.01)

7. The correlation between team aspects and organizational characteristics is found to be significant at 0.800 (p<0.01)

8. The correlation between training and technical characteristics is found to be significant at 0.770 (p<0.01)

9. The correlation between resources and technical characteristics is found to be significant at 0.761 (p<0.01)

10. The correlation between training and team characteristics is found to be significant at 0.761 (p<0.01)

6.15 REGRESSION ANALYSIS

6.15.1 Multiple Regression of percentage of Managers actively Participating in PFMEA with six independent variables

Multiple Regression of percentage of managers actively participating in PFMEA with independent variables R square value for the
model is 0.557, which indicate that nearly 56% Variation due independent variables considered above towards percentage of managers participation in PFMEA. The regression model is significant (p<0.01).

Percentage of managers participating in PFMEA implementation is influenced by the management’s strong drive towards continuous improvement of its manufacturing processes, the total quality initiative of the company, initiatives to avoid mistakes in the manufacturing process, management commitment and involvement towards continuous improvement and clear understanding of PFMEA contribution towards continuous improvement of its manufacturing processes. Technical issues like prioritization of failure modes and implementation of remedial measures, follow up of recommended actions and regular review of PFMEA and updating need strong managers participation in PFMEA implementation. The extent of successful PFMEA observed through first run capability, increase in process efficiency, reduction in internal scrap, reduction of defects in terms of ppm are need to be thoroughly monitored and measured by the managers and their participation in PFMEA implementation. Training and team building is important for managers towards the realization of objectives in PFMEA implementation.

6.15.2 Multiple Regression of overall Team characteristics with Organizational characteristics and managing the process

R square value for this model is 0.805, which indicate that nearly 81% of variation due to independent variables organizational characteristic and managing the process of PFMEA towards team characteristics. The regression model is significant (p<0.01).

The organizational characteristics and aspects of managing the PFMEA process influence the overall team characteristics. Management
commitment and involvement and understanding of PFMEA implementation towards contribution to continuous improvement and management review of the PFMEA process against program all have direct influence on the team characteristics. In addition clear definition of roles and responsibilities, follow up of recommended actions. Regular review and updating, effective management of time further impact team characteristics.

6.15.3 Multiple Regression of Training process with organizational Characteristics and managing the process

R square value for this model is 0.664 which indicates that nearly 66% variation due to independent variables considered towards training process. Since P value is less than 0.01 the regression models is significant.

Technical issues in the use of various problem-solving tools like fish bone diagram, brain storming technique, process flow chart, root cause analysis all require rigorous training process. Classification of failure modes, prioritization of failure modes, understanding current controls and improvement measures are important issues influencing training process. Clear definition of roles and responsibilities, effective management of time, clear communication, developing detailed product requirement, involvement of all managers in PFMEA implementation need to be strengthened through effective training process.

6.15.4 Multiple Regression of External factors with Organizational Characteristics, Managing the Process and Technical Characteristics

R – Square value for this model is 0.468, which indicate that nearly 47% variation due to independent variables X₁, X₂, X₃ towards ext. factor. Since p value is less than 0.01, the regression model is significant.
Establishment of clear links between PFMEA control plan and instructions, clear understanding of Fit and function, preparation of flow chart and description and scope of PFMEA are having direct influence on external factors where late engineering changes and releases affects seriously the PFMEA implementation. The frequent changing of personnel in PFMEA implementation influences clear definition of roles and responsibilities.

6.15.5 Multiple Regressions of Resources with Organizational Characteristics, Managing the Process and Technical Characteristics

R – Square value for this model is 0.605, which indicate that nearly 61% variation due to independent variables $X_1$, $X_2$, $X_3$ towards resources. The regression model is significant ($p<0.01$).

Resources requirement in PFMEA implementation have a direct dependence on organizational characteristics where management needs to recognize the resource allocation for the implementation process. Time allocation with reference to PFMEA implementation is crucial in successful implementation of PFMEA. Requirement of useful customer guidelines, developing resources for clear understanding of the process are important factors of resource requirement from technical perspective of PFMEA application.

6.15.6 Multiple Regression of Technical Characteristics with Organizational characteristics and managing the process

R- Square value for this model is 0.844, which indicates that nearly 84% variation due to independent variables towards technical characteristics. The regression model is significant ($p<0.01$).
Management understanding of the PFMEA technique and its commitment and involvement are having a strong relationship with technical characteristics in PFMEA implementation. Managing the PFMEA process in terms of clear definition of roles and responsibilities, prioritizing actions, regular review and updating, use of standard proformas, tailoring rating values to specific product are having strong relationship with technical issues.

6.15.7 Multiple Regression of team characteristics with Technical Characteristics

R-Square value for this model is 0.952, which indicates that nearly 95% variation due to independent variables considered towards team characteristics. The regression model is significant (p<0.01).

The team characteristics and technical characteristics which are identified to be the topmost priority issues in PFMEA implementation is found to have nearly 95% association with each other. Clear understanding of the difference between Design FMEA and Process FMEA, clear understanding of the process purpose, ability to handle process flow chart and description, clear definition of failure modes, understanding the rankings of critical characteristics and significant characteristics are inevitably associated with a strong cross functional team responsible for handling technical issues in effective implementation of PFMEA. In addition defining the scope of PFMEA, use of brainstorming to identify root cause, establishment of clear links between PFMEA control plan and instruction need a vibrant CFT.