CHAPTER 7

CONCLUSIONS

This Chapter outlines the major suggestions based on the findings from the statistical analysis and tests on the survey data towards successful PFMEA implementation. Conclusions are drawn based on the research towards effective PFMEA implementation. It also briefs the scope of further research work.

This study makes a contribution to the understanding of the issues of PFMEA implementation practices in Indian automotive industry, a virtually unexplored area of research to date.

The overall mean score values of the different dimensions of PFMEA considered for its implementation were analyzed to identify the priority issues in the implementation. The following order of PFMEA dimensions with their mean rank values was obtained when measured on a six-point scale, where 5 stood for very important and 0 for not important:

Team characteristics (4.53), Technical Characteristics (4.41), Managing the process (4.23), Organizational characteristics (3.98), Motivation for implementing PFMEA (3.75), Training process (3.73), Resources required for implementing PFMEA (3.69) and external factors influencing the implementation of PFMEA (3.26).
The team characteristics are identified as the most important dimension for successful PFMEA implementation. Teamwork and team spirit among PFMEA team is vital for PFMEA implementation towards achieving total quality (Crosby, 1989; Kanji and Asher, 1993; Cebeci and Beskese, 2002; McAdam and Kelly, 2002; Mehra et al., 1998). Team evolution process having three phases, viz. team formation, development and renewal is recommended to demonstrate excellence and performance towards successful team building in the organization, Thompson et al. (2000). Belbin (1981) and Andia (1998) agree that team roles clarify the individual responsibilities of team members and highlight the collective goals and purpose of teamwork.

The fourteen major challenges and difficulties in PFMEA implementation (section 11 in the questionnaire) were ranked in the study, with rank 1 as the highest and rank 14 the lowest. The following major challenges and difficulties were identified in the order of importance, based on their mean rank values, towards PFMEA implementation:

Management commitment (3.56), Understanding function (3.96), Ranking severity (4.05), Availability of training (5.5), Linking control plan and instructions (5.54), Regular reviewing and updating (6.12), Allocating resources (6.42), Inadequate customer manual (7.35), Lack of suitable software (8.71), Lack of design FMEA (9.14), More paper work (9.19), Time (10.29), Document format (10.29), Cost (10.64).

It is observed in this study that management commitment is the top most difficulty and challenge towards PFMEA implementation. Other priority issues observed in the study include understanding of function, ranking severity, and availability of appropriate training, linking PFMEA to control plan and instruction, and allocation of resources among others. Involvement and commitment of managers at different levels are vital for implementing
TQM tools and practices (Deming, 1986; Dale and Lightburn, 1992; Juran, 1988; Crosby, 1992; Feigenbaum, 1993; Goffin and Szwejczewski, 1996; Ishikawa, 1985). It is also highlighted as a critical factor by several empirical studies (Ramirez and Loney, 1993; Zairi and Youssef, 1995; Ahire et al., 1996; Dayton, 2001; Saraph et al., 1989; Flyn et al., 1994; Thiagarajan and Zairi, 1997; Rao et al., 1999; Zhang et al., 2000; Pun, 2001; Lau and Idris, 2001; Palo and Padhi, 2006; Rad, 2006). The finding, which indicates that there is a significant relation between the PFMEA implementation success and senior management commitment and involvement, is consistent with the findings of previous studies.

The impact of PFMEA technical characteristics towards successful PFMEA implementation were measured on a six point scale, where 5 stood for very important and 0 for not important. The six important technical characteristics identified towards successful PFMEA implementation include the following. Clear definition of root causes (4.63), Clear definition of current controls (4.57), Clear understanding between cause and effect (4.54), All failure modes are to be considered (4.53), Availability of clear process flow chart and description (4.53), Establishment of clear links between PFMEA control plan and instruction (4.53).

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 (p<0.01).

The proximity matrix for technical characteristics reveals prominent relationship of the technical characteristic, 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.

1. Understanding the difference between a design and a process FMEA
2. Defining the scope of PFMEA
3. Clear understanding of the process purpose
4. Clear process flow chart and description
5. Clear understanding of Fit and Function
6. All failure modes being considered
7. Clear definition of failure mode
8. Clear understanding of effects on operator through to customer and service
9. Clear definition of Tool causes
10. Use of Brainstorming to Identify root causes
11. Clear understanding between cause and effect
12. Clear Identification of Controls
13. Understanding the ranking of CCs and SCs

The following three hypothesis tests establish that there is a significant relationship between frequency of review of PFMEA with managing of the PFMEA process, technical characteristics and benefits and effectiveness of PFMEA.

1. 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.
2. 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.
3. 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.

The impact of the characteristics of managing the process of PFMEA towards successful PFMEA implementation were measured on a six point scale, where 5 stood for very important and 0 for not important. The three important aspects of managing the process identified towards successful PFMEA implementation include the following, follow-up of recommended actions (4.48), prioritizing actions (4.42), regular review and update (4.4). All other aspects of managing the process are significantly different towards PFMEA implementation. 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 (p<0.01).

The impact of training process characteristics of PFMEA towards successful PFMEA implementation were measured on a six point scale, where 5 stood for very important and 0 for not important. The two important training characteristics identified towards successful PFMEA implementation include the following, training by third party (4.55), Ongoing training programme (4.18). All other aspects of managing the process are significantly different towards PFMEA implementation. The Friedman Test applied to find the significant difference between mean rank values among factors of Training process is found to be significantly different towards PFMEA implementation.

The impact of the characteristics of Motivation towards successful PFMEA implementation were measured on a six-point scale, where 5 stood for very important and 0 for not important. The three important characteristics
of motivation identified towards successful PFMEA implementation include the following; provide a driver for continuous improvement (4.6), part of total quality effort (4.6), increase in commitment of line management to quality, (4.55). All other characteristics of motivation are significantly different towards PFMEA implementation. The One-Sample Kolmogorov-Smirnov test applied to investigate the significant difference between mean rank values among the characteristics of motivation towards PFMEA implementation reveals that there is a significant difference among them (p<0.01).

The impact of PFMEA organizational characteristics towards successful PFMEA implementation were measured on a six point scale, where 5 stood for very important and 0 for not important The six important organizational characteristics identified towards successful PFMEA implementation include the following, management commitment (4.67), management understanding of the PFMEA technique (4.56), appreciation of PFMEA as an up-front planning tool (4.49), understanding of PFMEA contribution to continuous improvement (4.48), management involvement (4.42), management’s recognition of need to allocate resources (4.37). All other aspects of managing the process are significantly different towards PFMEA implementation. 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 (p<0.01).

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.
Correlation analysis has been performed among the dimensions of PFMEA, and the following major correlations are established based on the study, which are having positive impact towards PFMEA implementation.

1. Team characteristics and technical characteristics \((r=0.921)\),
2. Team characteristics and the managing process \((r=0.896)\),
3. Technical characteristics and the managing process \((r=0.888)\),
4. Technical characteristics and organizational characteristics \((r=0.886)\),
5. Managing the process and organizational characteristics \((r=0.865)\),
6. Organizational characteristics and aspects of motivation \((r=0.802)\),
7. Team characteristics and organizational characteristics \((r=0.800)\),
8. Training aspects and technical characteristics \((r=0.770)\),
9. Resources and technical characteristics \((r=0.761)\),
10. Training and team characteristics \((r=0.761)\)

The relationships were statistically significant in all cases \((p<0.01)\)

The following measures of associations are established using multiple regression analysis. The multiple regression analyses were statistically significant in all cases \((p<0.01)\).

Team characteristics explain 95.2 percent variation with technical characteristics towards PFMEA implementation. The team characteristics and technical characteristics which are identified to be the topmost priority issues in PFMEA implementation is found to have nearly 95 percent 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.

Technical characteristics explain 84.4 percent variation with organizational characteristics and managing the process towards PFMEA implementation. Team characteristics explain 80.5 percent variation with organizational characteristics and managing the process towards PFMEA implementation. Training process explain 66.4 percent variation with organizational characteristics and managing the process towards PFMEA implementation. Managers active participation in PFMEA explain 55.7 percent variation with the dimensions of team, training, motivation, managing the process, benefits and effectiveness towards PFMEA implementation.

Some of the major suggestions by the practitioners of PFMEA (Section 12: suggestions in the questionnaire) towards successful PFMEA implementation include the following. Appointing champions (experts) in the cross-functional team and making them responsible for PFMEA. Clear targets to be set for the CFT and the team should be allowed to work dedicatedly. DFMEA to be made available before starting of PFMEA. Thorough root cause analysis is to be made. The process of identifying cause and effect is to be made systematic. The PFMEA format should be a simple excel based document.

Management to be committed to PFMEA implementation and review the process regularly assessing cost and benefits. Follow up of recommended action through on-line system should be implemented for periodic review and updating. Operators must be encouraged to handle minor correction of PFMEA, this will bring out all the small process defects and the engineer can authorize the changes.
Proper understanding of the customer delight is very important and PFMEA should be customer driven. Customer complaints should be linked to PFMEA. Certifying bodies should ensure strict compliance of the guidelines. All concerned people should be thoroughly trained before starting the work.

A knowledge bank should be developed for the easy understanding of products and processes. A special software directory of failure modes linked to a process should be developed with corrective actions taken earlier for a quick reference. Involvement of sub-suppliers and customer participation in PFMEA implementation is vital.

A web-based software model, PFMEA – Online, has been developed to foster effective PFMEA implementation. With the implementation of the PFMEA-Online knowledge-based system for PFMEA generation, the concurrent team involved in the PFMEA generation can access the Online PFMEA from their service location worldwide and update the PFMEA with respect to failure modes, causes, prevention and detection techniques and can simultaneously view similar data available in the knowledge base for other failure modes as well. The time required in the generation of PFMEA is much reduced, and the knowledge base acts as an expert support in generation of new PFMEAs. The online access fosters a concurrent approach. The user friendliness of the PFMEA online system reduces the documentation effort coupled with worldwide network for excellent reuse of PFMEA report for other diagnostic and maintenance purposes. The PFMEA online system realizes the need for supporting the PFMEA generation with process information and exhaustive failure history available in the knowledge base. The PFMEA online system acts as an excellent tool for Supplier Technical Assistance Team involved in multinational operations.
In conclusion this study identifies several critical issues of PFMEA towards its successful implementation in the Indian automotive industry.

Management Commitment is found to be the important challenge experienced during the PFMEA implementation. Hence, Management Commitment should be translated in terms of time, effort and enthusiasm invested by the management, developing clear goals and organizational structure to facilitate effective PFMEA implementation. The management should develop a passion for optimization of production processes and focus on staff training and team development.

Team and Teamwork emerged as the most important concern in terms of successful implementation of PFMEA. Best team building practices at all levels, and strong cross-functional teams constitute the successful implementation of PFMEA.

Cost measurement towards PFMEA implementation is not carried out in almost all the organizations. Cost measurement could positively help them to expect rewarding results and maximize the effectiveness towards PFMEA implementation and accountability of the cross-functional team responsible for PFMEA implementation.

It is observed in the survey that practitioners at present are given only customer training on PFMEA. The survey result reveals that third party training is more preferred for effective implementation. Hence, companies are suggested to identify appropriate third party trainers and employ them for effective implementation.

From the analysis it is interesting to find that strong relationship is established between key technical characteristics and team characteristics, which call for a robust team to handle effectively technical issues associated with PFMEA.

Next the PFMEA process management and organizational characteristics were found to be important and need constant improvement and focus. Among the organizational characteristics the percentage of
managers actively participating in PFMEA process is having a direct effect on motivation, team aspects, training aspects, benefits and effectiveness, among other aspects of PFMEA. In the overall PFMEA implementation challenges “the management understanding of PFMEA and its commitment to implement the same” is found to be the prime concern.

Technical issues such as ranking severity, linking control plan and instruction, availability of training, resources, customer manual software and regular reviewing are the other challenges in PFMEA implementation.

The Correlation coefficient at significant level of 0.01 (2 – tailed) reveals the following relationships existing between different PFMEA characteristics. Team Characteristics are highly correlated with technical characteristics ($r=0.921$), Managing the process is highly correlated with team characteristics ($r=0.896$), Organizational characteristics are highly correlated with technical characteristics ($r=0.886$) and training process is highly correlated with technical characteristics ($r=0.770$).

The study identified the need to develop a failure mode directory connected to problem directory coupled with a knowledge base for easy understanding of product and process in the implementation of PFMEA. Hence, a web based software model, PFMEA-online, has been developed to facilitate easy implementation of PFMEA, and supported by a knowledge base using the spot welding process of car front body pillar sub assembly as a case study.

With the implementation of the PFMEA Online knowledge based system for PFMEA generation, the concurrent team involved in the PFMEA generation can accesses the Online PFMEA from their service locations world wide and update the PFMEA with respect to failure modes, causes, prevention and detection techniques and can simultaneously view similar data available in the knowledge base for other failure modes as well. The time required in the generation of PFMEA is much reduced when the knowledge base acts as an expert support in generation of new PFMEAs. The online access fosters a
concurrent approach. The user friendliness of the PFMEA online system reduces the documentation effort coupled with worldwide network for excellent reuse of PFMEA report for other diagnostic and maintenance purposes as well. The PFMEA online system realizes the need for supporting the PFMEA generation with process information and exhaustive failure history available in the knowledge base and acts as an excellent tool for Supplier Technical Assistance team involved in multinational operations.

7.4 SCOPE FOR FURTHER RESEARCH

1. Although this study is conducted in India, it is anticipated that the findings may well have relevance on a broader scale. This study may serve as a foundation for future studies in different countries. So, it is recommended that this study may be repeated in different countries and contexts.

2. The study can be extended to other sectors as well.

3. Cost – benefit analysis should be carried to bring out the hidden cost associated with PFMEA implementation and to exactly measure the outcome of the process.

4. A standardized checklist should be developed to monitor the progress of PFMEA implementation.

5. Integration of PFMEA and other quality tools may be explored.