CHAPTER 5
Decision Support System for Innovation integrated TFMEA Programme

5.0 Introduction

One of the ways of effecting continuous quality improvement in TQM projects is by preventing the recurrence of failures. Theorists and practitioners have been propagating the application of the technique called FMEA to prevent the recurrence of failures in companies. As FMEA suffers from certain deficiencies, currently researchers work towards improving its working (Sankar and Prabhu, 2001; Daya and Raouf, 1996; Chang et.al., 1999; Braglia, 2001). At the same time, it is found that no researcher has evinced the methodology of bringing out innovation through FMEA technique. In this context, a module of this doctoral work was carried out with the main objective of infusing IM principles with an advanced technique called Total Failure Mode and Effects Analysis (TFMEA). TFMEA integrates all the functions starting from design to service and it is based on the proactive approach. IM principles are aiming to create innovative features in the product (Adam et.al., 1998). The new system of integrating TFMEA and IM will be able to supply the products with innovative features and avoid the potential problems arising during its product life cycle. The author borrowed the help from an postgraduate engineering student to introduce the above new concept in an automobile horn manufacturing company by name ‘Roots Industries Limited’ (hereafter referred to as Roots). Due to the lack of knowledge on IM among the quality engineering professionals of Roots, this innovation integrated TFMEA programme could not be implemented. However this attempt hinted that, because of the requirement of voluminous documentation work and continuous decision support, companies would hesitate to implement IM integrated TFMEA programme. Hence, in order to shrink the manual
documentation work and provide continuous decision support, a DSS for the application of 1M integrated TFMEA model has been developed during this module of doctoral work. This DSS helps to evolve innovation through TFMEA technique.

5.1 Fundamentals of FMEA

FMEA is a systematic and analytical tool for quality planning. It is an effective method of establishing the formal and documented procedures for manufacturers to anticipate and eliminate defects in their products. It is a technique for identifying at the product and process design stages, what potentially could go wrong with a product during its manufacture or end use by the customer. The FMEA suggests the recording of failures with causes, modes and effects. Provision is also made to rank the failures, estimate the risk and recommend action. The format of FMEA table is shown in Table 5.1. As shown, the recording of failures and their analyses are carried out by assessing their major occurrence, severity and detection and estimation of risk by “Risk Priority Number (RPN)”. After this process, the effect of the failure and the action to be taken are denoted. Aldridge et.al., (1991) pointed out the need of forming teams to develop FMEA tables. They also identified two types of FMEA namely Design FMEA and Process FMEA. Though FMEA technique is very powerful in bringing down failures and effecting continuous quality improvement, it is not finding its authentic place in TQM projects. In fact, in comparison to other major TQM enablers such as quality circle programme, ISO 9000 series quality system models etc., the theoretical and practical works exercised on FMEA by both academicians and practitioners have been very minimum.
A thorough study reveals the following deficiencies of the existing FMEA technique:

- TQM envisages the integration of all functions, that is, from design to service. Hence, failure occurrence, detection and prevention should be applicable to all functions of the organisations. However, conventional FMEA applies only to design and production processes, which makes the TQM process incomplete.

- The success of FMEA lies on the effective retrieval of the tables and subsequent actions to prevent further occurrence of the failures. However, the traditional FMEA approach does not effectively support this process because of the absence of simple representative system.

- FMEA insists on calculating an index called RPN. This is slightly complex task given the tight working situation that prevails in an active organisation. Also,
indexing by RPN itself suffers from certain drawbacks (Daya & Raouf, 1996; Chang et al., 1999; Braglia, 2001; Sankar & Prabhu, 2001).

Considering the above weak spots and with the objective of removing them, a refined technique named as TFMEA (Devadasan, 1996) was adopted to accomplish this module of the doctoral work.

5.3 Conceptual features of TFMEA

The conceptual features of TFMEA technique are depicted in Figure 5.1. As shown, the entire TFMEA process involves the development of TFMEA tables pertaining to all the associated functions. Table 5.2 shows the format of TFMEA table to be developed by design department. The column for entering RPN value has been replaced by a column titled as rating. In this column, ratings are to be entered using a Likert's scale of range 0 to 10. Another important feature is that, a column titled as 'Interactive functions' is added. In this, the functions (or department) associated with each failure should be listed. The entry in this column indicates that the concerned failure has got its impact on the functions listed and TFMEA tables have to be developed pertaining to those functions also. In essence, this approach of developing TFMEA tables infuses totality in identifying, recording and analyzing the failures. This is possible only if team approach is adopted. In other words TFMEA tables pertaining to a particular failure of a product or component cannot be developed without the endorsement of team members representing the functions which are associated with the failure concerned. In order to ensure that the entire process of TFMEA is monitored and managed from a centralized source, it is suggested to have TFMEA cards or drawings or both. In the case of TFMEA cards, against each component and assembled product, a card containing all the failures with all the departments shall be developed. A TFMEA card may contain the collective information received from the TFMEA tables developed by all the departments concerned. Alternatively, like production
drawings that are in vogue in manufacturing enterprises, drawings containing TFMEA denotations may be developed. Thus the features of conventional FMEA are suitably modified and improved and are addressed under the title TFMEA so that failure prevention is carried out holistically.

![TFMEA Conceptual Features Diagram](image)

Figure 5.1 Conceptual Features of TFMEA

TFMEA-DESIGN

<table>
<thead>
<tr>
<th>Members present</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components name</td>
<td>Last date:</td>
</tr>
<tr>
<td>Part name</td>
<td>Update by:</td>
</tr>
<tr>
<td>TFMEA No</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Cause of Failure</th>
<th>Effects of Failure</th>
<th>Present Control</th>
<th>Rating 0 to 10</th>
<th>Interactive Functions</th>
<th>Remarks</th>
<th>Taken By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Prepared by:

Table 5.2 TFMEA Table.
5.4 Modules of TFMEA

The failures occurring in a product may have origin in any function of the manufacturing enterprise. These failures may in turn have impact on other functions. Hence, while designing TFMEA forms, provision is made for interactions with other functions.

5.4.1 TFMEA - Design

The quality failures related to design are realized in manufacturing environment. In fact the awareness of design failures is found to be very feeble in manufacturing environments. TFMEA tables designed exclusively for design function constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.2 TFMEA - Production

Frequently the production failures are easily identified in manufacturing environments. However, very rarely systematic efforts to prevent their recurrence are undertaken. Generally the failures may be attributed to mainly causes like machine tool variations, operator mistakes, applying improper methods used etc. TFMEA tables for production functions constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.3 TFMEA - Inspection

In many instances the failure may be attributed to inspection function. The reasons for the failures may be attributed to operator mistake, inaccurate inspection equipment, non-availability of equipment for inspection of certain parameters etc. TFMEA tables for inspection function constitutes one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.
5.4.4 TFMEA - Materials Management

The quality failures attributed to the materials management functions are very rarely sensed. The failures may be due to lack of control of material consumption, delay in supply of materials, improper inventory system and policy etc. TFMEA tables for materials management function constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.5 TFMEA - Process Planning and Development

Quality failures related to process planning function are found to have key effects. These failures may be excessive scrap and rework, long process lead-time, failures to incorporate changes, frequent failure of tools etc. TFMEA tables for process planning function constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.6 TFMEA - Sales and Service

Many times the failures originate from sales and service function too. These failures may be increased transportation cost, damage to product during transit, failure to receive customer complaints, long service lead-time etc. TFMEA tables for sales and service constitutes one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.7 TFMEA - Operation and Installation

There are certain times, failures originate from operation and installation functions. TFMEA tables designed to take care of the failures in operation and installation functions constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.
5.4.8 TFMEA - Technical Assistance and Maintenance

In many instances, failures originate from the technical assistance and maintenance functions. These failures may be due to improper maintenance, inadequate technical assistance etc. TFMEA forms for technical assistance and maintenance functions constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.9 TFMEA - Marketing

At times, failures may also originate from marketing function. Failure to recognize market trend, failure to recognize potential geographical areas of market, failure to record customers' reaction, insufficient and improper advertising etc. are some of the failure that originate from marketing function. TFMEA tables for marketing constitute one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.10 TFMEA - Finance

Many failures originate from finance function also. The possible failures may be inadequate budget allotment for new design and product development, improper release of funds, failure to meet customer demand etc. TFMEA tables for finance function constitutes one of the modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.4.11 TFMEA - Training

Training is an important function in any manufacturing enterprise. Each function requires training for their effectiveness and efficiency. Hence training is considered as a separate module. The failures that originate from this function are reflected in failures in other functions. The main failure occurring in training function may be improper training management. TFMEA forms for training constitute one of the
modules of TFMEA process for the purpose of recording and analyzing those kind of failures.

5.5 Implementation of TFMEA

Practical implementation of FMEA has not been effective in companies right from the time it was introduced to the practitioners. Hence, TFMEA being a new and refined technique, it shall be implemented with undue care so that it fits suitably in a practical environment. For this purpose, procedures shown in Figures 5.2 and 5.3 have been designed for implementing TFMEA. As shown, implementation is required to be undertaken in two phases. The first phase is devoted for estimating the preparedness of the company to accept and implement TFMEA. After creating the sound foundation, the second phase of implementation is to be carried out for implementing TFMEA with sustainability.

5.6 Integration of IM and TFMEA

TFMEA facilitates in recording and analyzing failures and preventing their recurrence in all functions. However, it is not aiding in bringing out innovations. In fact, historically, failures have resulted in evolving innovation. As this phenomenon is not infused in TFMEA, it was decided to develop a model for bringing out innovation through the usage of TFMEA. To begin with, TFMEA table format was redesigned by infusing the salient features of IM principles. Such table has been named as innovative TFMEA Table. The format of the innovative TFMEA table is shown in Table 5.3. As shown, two new columns have been added to TFMEA table format to facilitate idea generation and innovative idea selection. The companies, which have undergone successfully the two phases of TFMEA implementation (shown in Figures 5.2 and 5.3), shall proceed to implement innovative TFMEA technique. Implementation of innovative TFMEA in an organization must have to be done as a programme. The beginning of this
programme starts with a preliminary meeting with the top management. (Smith and Ainsworth, 1993). Implementation of innovative TFMEA principles requires team effort.

Innovative TFMEA-DESIGN

| Members present : | Date : |
| Components name : | Last date : |
| Part name : | Update by : |
| TFMEA No : | |

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Cause of Failure</th>
<th>Effects of Failure</th>
<th>Likert's Rating</th>
<th>Interactive functions</th>
<th>Idea generation</th>
<th>Innovative idea</th>
<th>Date</th>
</tr>
</thead>
</table>

Table 5.3 Innovative TFMEA - Design Table

So the top management is required to play its role as a member of a team to share the innovative intent. While identifying critical failures, the top management shall discuss the same with the employees of the concerned department. The beginning of the programme is marked by the formation of a core innovative TFMEA team, which will later assume leadership. The core team will have members from upper and middle managerial levels. Training shall be imparted to all the employees on idea generating techniques. For the core innovative TFMEA team, training is to be imparted on the criteria setting, idea evaluation, idea protection, and idea improvement. The responsibility assigned to the core team are, understanding of overall process and building of personnel competence in generation, evaluation, protection and improvement of ideas. Against each failure identified, the innovation integrated TFMEA team shall have to complete innovative
TFMEA tables. The core innovative TFMEA team is required to check the practical viability of the innovative ideas generated through the conduct of innovative TFMEA programme.

5.7 Practicality

In order to test the practicality of the framework of innovative TFMEA programme, Roots was approached. As mentioned under introduction section, for this purpose, the author availed the service of a post graduate industrial engineering student by name R.A.Sankaran. In Roots, FMEA has been implemented for meeting QS 9000 requirements. Roots is situated in Coimbatore city of India and was started about 25 years back as a small size automobile repair shop. Today, Roots, is a multifaceted corporate entity with interests in manufacturing of automobile accessories, cleaning equipment, casting, precision tools, hi-tech engineering services, healthcare and education. Roots is a leading original equipment supplier to major vehicle manufactures like Mercedez Benz, Mitsubishi, Mahindra, Toyato, Fiat, Telco, TVS Suzuki, Kinetic etc. The technical collaboration with Robert Bosch S.A of spain starting form 1995 has strengthened the research and development activities and increased Roots' technical competence to international standards. Roots products have successfully made their presence felt in the market. Horns manufactured in Roots are exported to over 15 countries worldwide. A major share of the exports goes to USA, Japan, Middle East and South America. It is the largest exporter of automobile horns in India. Roots has full-fledged design, development and test center.

FMEA in Roots has been carried out in the design and process departments. This has been undertaken not only to deliver quality products but also as a prerequisite for obtaining QS 9000 certification. The working structure of FMEA
Figure 5.2 Implementation Phase 1

1. Study the TQM trend in the company
2. Expose the effect of failure prevention in TQM
3. Study the awareness of FMEA

- FMEA is being practiced
  - Check the areas of application
  - Identify the success factors
  - Identify the weak spots

- FMEA has never been practiced
  - Create awareness
  - Study the feasibility for exposure
  - Demonstrate the sample application
  - Assess the interest among all levels

- FMEA has been practiced once or twice
  - Evaluate the past performance of FMEA
  - Identify the loopholes and weaknesses to be prevented in future applications

- Assess the feasibility of implementing TFMEA

- Formulate management's vision and policy towards TFMEA
Figure 5.3 Implementation phase II
followed in Roots Industries is shown in Figure 5.4. With a view to implementing innovation integrated TFMEA technique, the management was approached to obtain their consent. The management personnel who have got commitment and zeal towards achieving total quality, was gracious enough to allow the testing of practicality of innovative TFMEA in Roots.

To begin with, the external guide in Roots was appraised about TFMEA concepts. He nourished the concept of TFMEA to some extent and maintained that the data related to FMEA were confidential and only sample data could be taken for analysis. As TFMEA concept requires the linking of departments, he made arrangement to visit

![Diagram of FMEA process]

**Figure 5.4 Working structure of FMEA in Roots Industries**

all the departments in the company. This process consumed around two weeks. Due to heavy workload of the personnel in all departments, many difficulties were faced while interviewing the competent personnel. During this stage, the competent personnel in each department was approached and enquired about the FMEA implementation. The casual
interviews indicated that, in Roots the scope of FMEA implementation has been limited to design, process and inspection departments. So the necessity of implementing TFMEA was recognized.

5.7.1 Phase I

Since TFMEA is a refined form of FMEA and FMEA was carried out in the design department of Roots, the work was started in the design department. The work progressed by interviewing the personnel working in design department. According to the literature, FMEA applies only to design and production processes, but the competent personnel in Roots declined to endorse this statement. These personnel claimed that, FMEA has been carried out in Roots as a team comprising members from all the departments. However the records indicated that, FMEA was carried out, as design FMEA, Process FMEA, and Inspection FMEA. Moreover, the departments were not linked. This situation indicated that in Roots personnel suffer from mental blocks and their views are not widely brought out and disseminated. After thorough discussions and arguments, FMEA personnel in Roots accepted to help to test the practicality of innovative TFMEA technique.

5.7.2 Phase II

FMEA personnel working in the design department agreed to support the work and made arrangements to interact with other department personnel to gather failure modes. As mentioned earlier due to confidentiality restrictions, the competent personnel declined to provide failure mode data recorded in the FMEA tables. Instead the failure mode data were collected from the customer returned product test/analysis report. This report has been prepared by the quality assurance department personnel. The personnel working in the quality assurance department, accepted to show records related to failure mode for only one component. Accordingly, against the component by name ‘Smart

...
around seven failure modes were identified and TFMEA design forms were
developed. For these seven failure modes, around five departments were linked and the
respective department personnel were approached to find the effects, causes, action taken
and the rating for each failure mode. Due to unavoidable reasons, particularly due to the
tight schedule of working personnel, the competent personnel in each department were
not able to sit together to derive the solutions. The competent personnel in design
department was appraised about this situation. Due to his busy schedule, he responded
only to a small extent.

Also a contradiction was noticed. Earlier, personnel in design department
and other related department said that team efforts were exercised to carry out FMEA
activities. But no personnel other than personnel in design department were aware of
solutions brought out by implementing FMEA. This kind of situation prevailing in Roots
indicated that FMEA has only been initiated and its authentic benefits are yet to be
nourished by implementing it along the breath and length of the Roots. At one point of
time it was clearly discernable that personal associated with FMEA found it difficult to
nourish the concepts of innovation integrated TFMEA. Hence, it was not possible to
deduce the opinions, suggestions and feedback on innovative TFMEA technique from the
competent personnel. This condition was somewhat disappointing and considering the
fact that the current competitive era demands phenomenal innovations from
organizations. Thus the testing of practicality of innovation integrated TFMEA could not
be carried out with complete success. However, the experiences of this effort were used to
develop innovation integrated TFMEA tables. Also this experience indicated that for
ensuring sustained and successful implementation of innovation integrated TFMEA
programme, the core team requires decision support on continual basis. In order to fulfill
this requirement, a DSS was developed.
5.8 DSS

The DSS for implementing innovation integrated TFMEA programme has been developed using Visual Basic (version 6.0) programming language as front end and Microsoft Access database software as back end. The DSS supports the following operations:

- Input and storage of company names
- Input and storage of product names
- Creation, deletions, and modification of the departments
- Viewing the existing failures of a product for a specific department
- Entering data for a new product or failure
- Giving the idea to solve the problem with help of IM principles.
- To input the idea generated with interactive functions
- To select the best innovative idea.

The DSS also provides the option of modifying the data, if necessary. This feature is important in the sense that if the data were to be modified in the documented records, it would involve the re-writing of the record itself. This is avoided if the developed DSS is used.

5.8.1 Operational features

The DSS for Innovation integrated TFMEA is available in the CD attached at the end of this thesis under the name “TFMEA”. On loading and execution, the DSS screen will display user name as ‘TFMEA’. The word ‘dt’ to be entered against the pass word and the DSS begins to work by displaying the author’s name and guide’s name. By pressing the ‘package’ option, menu driven screen shown in Figure 5.5 will be displayed. On pressing TFMEA and choosing “Feed”, the screen shown in Figure 5.6 will appear. As shown, the names of the company, product and company shall be fed. The screens to
follow will enable the entry of names of the departments, employees, products and the corresponding components. After completing these entries, on choosing "Department Form", the screen shown in Figure 5.7 will appear. As shown, in this screen, the names of the departments are listed. On pressing the department of the User's choice, the form containing the features of Innovative TFMEA table would be displayed. Figure 5.8 shows a sample information entry screen to develop TFMEA-Design Table. The Innovation integrated TFMEA table pertaining to interactive functions can be accessed from this screen itself. While using the menu driven screen, the user, who shall be necessarily a member of innovation integrated TFMEA core team, can enter the appropriate information. These screens will instigate the user to form team and generate ideas and innovations. One such screen facilitating the team formation is shown in Figure 5.9. After that, the details can be viewed using various options. Those screens are shown in Figures 5.10-5.11. Finally reports can be generated by using the menu titled reports.

Conclusion

This chapter reported a module of this doctoral work in which a model for infusing the principle of IM with that of the failure analysis technique called TFMEA was developed. It has been identified from the literature that conventional FMEA does not aim to attain totality characteristics, which is one of the primary requirements of TQM. Hence, a refined technique called TFMEA has been adopted during this module of doctoral work. This technique integrates all the functions starting from design to maintenance. Adoption of TFMEA aids in identifying critical failures in all the departments. Meanwhile, it was noted that the world had been looking for innovations to
Figure 5.5 Main Menu screen

Figure 5.6 Data Feed Entry Screen
Figure 5.7 Department listing
Figure 5.8 Sample Information Entry Screen
Figure 5.9 Innovation integrated TFMEA Team formation

<table>
<thead>
<tr>
<th>SELECT PRODUCT</th>
<th>SELECT COMPONENT</th>
<th>SELECT DEPARTMENT</th>
<th>FAILURE MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hom</td>
<td>Smart tone</td>
<td>DESIGN [D]</td>
<td>1 No continuity in hom</td>
</tr>
<tr>
<td>Smart tone</td>
<td></td>
<td>INSPECTION [I]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MARKETING [M]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OPERATION [O]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MATERIALS [F]</td>
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</tr>
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<td></td>
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<td>SALES [S]</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TEAM FORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRODUCT</td>
</tr>
<tr>
<td>Hom</td>
</tr>
<tr>
<td>COMPONENT</td>
</tr>
<tr>
<td>Smart tone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EMPLOYEES</th>
<th>DEPARTMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>tankar</td>
<td>Design</td>
</tr>
<tr>
<td>sabir</td>
<td>Design</td>
</tr>
<tr>
<td>baskar</td>
<td>Finance</td>
</tr>
<tr>
<td>baku</td>
<td>Finance</td>
</tr>
<tr>
<td>babu</td>
<td>Inspection</td>
</tr>
<tr>
<td>indran</td>
<td>Inspection</td>
</tr>
<tr>
<td>nayaraja</td>
<td>Inspection</td>
</tr>
</tbody>
</table>

Selected

Product  Component  Failure Mode  Personnel  Innovative ideas
Hom       Smart tone  1 No continuity in hom  tankar

108
Figure 5.10 Product wise Information Provider
Figure 5.11 Department wise Information Provider
Figure 5.12 Idea Detailing Screen
Figure 5.13 Innovative Ideas

compete in tough market condition. Hence, it was anticipated that, along with failure analysis, application of IM would offer fruitful contribution. Hence, by integrating, TFMEA with IM solves not only critical failures of a product but also make a product to compete in the world market. For this purpose a model called 'Innovation integrated TFMEA' was designed. While attempting to check the practicality of this model, it was found out that the core team members require continuous decision support to successfully implement it. In order to fulfill this requirement, a DSS has been developed. Critical failures and other relevant factors were gathered from Roots were fed into the DSS and its working has been checked. With the aid of this DSS, at any point of time, it is possible to evolve innovations and retrieve the innovative solutions required to solve the failures.