CHAPTER 5

KNOWLEDGE BASED PFMEA

5.1 INTRODUCTION

This chapter describes the salient features of PFMEA – Online, the knowledge based software tool developed for the effective implementation of PFMEA in automotive industry. The advantages of using database management system (DBMS) towards PFMEA implementation with KBPFMEA are clearly outlined.

5.2 KNOWLEDGE BASED PFMEA (KBPFMEA)

In conventional PFMEA, the diversity and ability of the teams are the most important considerations, Instruction Manual, Ford Motor Company (1988), followed by training for the team members. This leads to a high cost, Aldridge et al (1991). Furthermore, other industrial practitioners usually find it hard to share their experience. This indeed prohibits application of PFMEA in a broader scope, Wirth et al (1996). Hence, developing a system in which expert’s experiences can be incorporated for effective automation of the PFMEA assessment on computer will be very beneficial, Liu and Yang (1999). It is established that a knowledge-based approach to PFMEA can form a more comprehensive preventive quality assurance method in the concurrent engineering design process, Hsiao (2002). This knowledge based PFMEA is illustrated with a case study carried out in an automobile manufacturing spot welding process.
KBPFMEA attempts to improve the completeness, comprehensibility and consistency of a PFMEA, and thus to improve its maintainability and reusability, Hecht et al (2004). Another goal is to improve the communication between departments, with in companies and between companies (e.g.: manufacturer and supplier), with respect to the exchange of PFMEA relevant information, Yang et al (2006). KBPFMEA aims at reducing the effort needed for conducting PFMEAs in the long term. In addition, a PFMEA can be conducted faster by mainly re-using case-based information from existing PFMEA’s, Kraniak et al (2001). It can be compared with analysis of similar systems conducted earlier. Thus it is possible to concentrate on new parts, and yet stay in the context of known parts, Wang et al (2005).

Achieving these goals will lead to a higher acceptance of PFMEA. A positive impact on the motivation can be expected if PFMEAs can be re-used, not only for conducting other PFMEAs but also for other tasks, such as design or diagnosis, Goble and Brombacher (1999). Computer Assistance enables a quick and intelligent re-use of the knowledge expression in previous examinations, and it facilities the import of data from external sources directly into the knowledge. The knowledge based system acts as an expert assistance to the user, Kimura et al (2004). In knowledge based systems the four main components are usually distinguished as: a knowledge base, an inference engine, a knowledge engineering tool, and a specific user interface, Dhaliwal and Benbasat (1996). On the other hand, the term KBS includes all the organizational information technology applications that may prove helpful to manage the knowledge assets of an organisation, such as expert systems, rule based systems, groupware, and database management systems (DBMS), Laudon and Laudon (2002). In this research DBMS methodology is used.
5.3 ADVANTAGES OF USING A DATABASE FOR PFMEA

5.3.1 Scalability and Performance

Enterprises continue to demand more physical storage for both structured relational data and unstructured data (documents, spreadsheets, etc). Hardware vendors continue to expand the per-disk capacity to meet these demands; however, the performance of disks has not improved at this same pace. With multi-terabyte databases becoming commonplace, database technologies provide rich enhancements that empower IT organizations to cost-effectively scale their storage infrastructure, while continuing to meet performance requirements.

5.3.2 Backup and recovery

With the size of enterprise databases continuing to grow – it has become more advantageous to take advantage of Bigfile Tablespaces. Database features an enhanced Recovery Manager (RMAN) tool that can perform intra-file parallel backup and recovery operations.

5.3.3 High availability

Availability of applications and company information is vital to the success of the enterprise. As the importance of IT continues to grow – so too does the technology infrastructure. Therefore, IT organizations need to ensure that the technology driving their infrastructure is built with scalable High Availability (HA) features and tools.
5.3.4 Meaningful Division of Data

One major advantage of having a database for storing the PFMEA data is that the many types of data required to do the PFMEA analysis, as well as the enormous amount of data generated by it are stored in a well organized fashion. The data is not stored in a single file at one place - instead it is distributed in several files which can even reside on separate systems.

5.3.5 Faster Access

Huge amounts of data can be generated in a PFMEA. On a complex system such as an automobile, a complete PFMEA can be several hundred thousand pages in length. Operations like editing parts of that data or viewing a specific type of data are frequently required during the analysis. Using a conceptually correct database design ensures that all relevant data reside together in a table and so only the required table needs to be opened for specific operations.

5.3.6 More Specific Help Facilities

More on-line help and cross referencing capabilities can make the PFMEA less time consuming and help to integrate it with the overall design process. With information stored in separate tables according to its relevance, it is possible to access any combination of the data. A list of failure modes and their causes derived from other projects can be shown to help the analyst determine possible causes for a failure mode in the current project.

5.3.7 Consistency

A PFMEA is a lengthy and tedious engineering analysis, which requires inputs from engineers with expertise in design, manufacturing,
assembly, maintenance, safety and quality assurance. Usually a team of individuals with specialized knowledge in these fields is assembled to work on the PFMEA. The use of a database promotes the use of consistent terminology. Many failure modes can have the same failure effect description and this table removes the need for storing the same effect description for each mode separately.

5.3.8 Validity Checks

Multiple individuals working on the same PFMEA project can give rise to inconsistency and incompleteness problems in the analysis. Validity checks are required at different stages to ensure that these types of incompleteness do not exist in the finished PFMEA analysis.

5.3.9 Easy Maintenance

Different engineering organizations within a company will generally control different categories of data. Since this data is stored in different files, the division makes it possible for these groups to take responsibility for maintaining and updating the data they control.

5.3.10 More Configurable Capabilities for Reports

A PFMEA is essentially a reliability task but the data generated also provides valuable information to other engineering groups in a company. These engineers would prefer to view the PFMEA data in a way that makes their work easier and less time consuming and the results better. They also do not have to develop the reports themselves, only the data items to be placed in the report and the sort order needs to be specified - everything else can be
done using the report generator which is provided as a basic tool with most database packages.

5.3.11 Multi-user Capabilities

Data stored in the PFMEA files should be available to many departments within a company at all times. Also, it is desirable that a PFMEA for a large project, in which different subassemblies have been designed by different groups, be conducted by those groups. This calls for multi-user capabilities for handling the data. Using a database makes it easier to achieve these multi-user capabilities.

5.3.12 More Security

As multi-user capabilities for accessing the data are provided, security problems also arise. It is not desirable to allow unauthorized personnel access to the PFMEA data files, and different people may need different access capabilities. Password protection is a simple solution to such security problems. But simply placing data under password protection is not enough - different access levels may be needed for different types of users. Apart from providing password protection for database files, DBMS can provide the required access level permissions for different tables stored in the database.

5.3.13 Promotes Generation of Transportable

The data generated in a PFMEA analysis is put into various tables depending on the relevance a particular type of data has to other types of data. This means that specific portions of the data can be transported to other projects and used there.
5.3.14 Ease in Forming Custom Libraries

The user can form a custom library by selecting various component categories from these libraries and individual components and their failure mode data from other projects. Merging this data into a custom library is easy because the data already exists in the form of tables.

Once a project is completed, the library can be used for reference purposes in other projects. In fact, the analyst can easily tailor the failure mode distribution search by setting priorities on the data from the various libraries.

5.3.15 Fast, Easy and Specific Browsing of Similar

Maintaining the PFMEA data in a database makes browsing through the data from similar projects not only possible, but less time consuming and more specific. Depending on the type of data, which is needed for reference at a particular stage in the PFMEA, the related database files from other similar projects (specified by the analyst) can be opened, and the information presented in a form, which allows cutting and pasting of the data. A basic advantage of such a procedure is that all the projects in the system can be opened in parts, and the data presented as on-line help. This replaces the cumbersome activity of flipping through the numerous worksheets used in a manual PFMEA analysis. The activities of browsing and searching for the relevant data are integrated within the PFMEA system itself.

5.4 PFMEA – ONLINE

The knowledge based software system developed is named as “PFMEA Online”. The PFMEA online system is developed using Java Server
Page (JSP) as the front end and Oracle as the back end using Apache Tomcat as the web server.

5.4.1 Features of PFMEA-Online

1. Concurrent in Nature
2. Knowledge grows for future use
3. Graphical User Interface
4. Portable - Application suitable for all platforms
5. Secure by user authentication
6. Ease of installation
7. Can be used across Clint/Server architecture for LAN access in a company
8. Global access through internet
9. Easy to update/ modify

5.4.2 Advantages of using java server pages (JSP)

1. Concurrent programming
2. Platform independent
3. Robust and secure
4. Architecture neutral and portable
5. Dynamic programming
6. Simple coding
7. High performance
8. Secure because of JVM - Java Virtual Machine

5.4.3 Apache tomcat

Apache Tomcat is a Servlet container developed by the Apache Software Foundation (ASF). Tomcat implements the Java Servlet and the Java Server Pages (JSP) specifications from Sun Microsystems, and provides a "pure Java" HTTP web server environment for Java code to run.
5.4.4 **Oracle Database**

The Oracle Database (commonly referred to as Oracle RDBMS or simply Oracle) consists of a relational database management system (RDBMS) produced and marketed by Oracle Corporation. The Oracle RDBMS stores data logically in the form of table spaces and physically in the form of data files. Oracle database conventions refer to defined groups of ownership (generally associated with a "username") as schemas. Most Oracle database installations traditionally come with a default schema called SCOTT. The SCOTT schema has seen less use as it uses few of the features of the more recent releases of Oracle.

5.5 **PFMEA ONLINE MODEL USES SEVEN STEPS APPROACH AS GIVEN BELOW**

Step 1 : Selecting a process involved in the company

Step 2 : Selection of failure modes

Step 3 : Viewing causes and effects for the failure modes

Step 4 : Use of preventions / detection available in the knowledge base

Step 5 : Updating new prevention / detection technique

Step 6 : Updating the details about the person responsible for the new process control

Step 7 : Revising Risk Priority Numbers (RPN)
A case study of front body pillar sub-assembly spot welding process involving typical failure modes and effects, with consequent prevention and detection techniques are used to illustrate the software model. This knowledge base can be updated or modified according to any new material usage, design modification, process variation or for any other reasons.

In the front body pillar subassembly spot welding process, illustrated with the fault tree diagram, Figure 5.1, there are eight typical failure modes identified viz, less nugget diameter, low strength weldment, no nugget, missing spot, dislocation of parts, noisy clamping, assembly damage, and fume seal mislocation. The consequent causes for the failure modes are indicated in the fault tree. For example less nugget diameter is the result of improper setting of current, welding time, weld pressure, the chances of high current spot welded with low current program, weld current not available for full welding cycle, axial misalignment of weld gun and angular misalignment of weld gun etc. The data flow diagram, Figure 5.2, indicates the concurrent online user environment with access through knowledge base for selection of process and working for respective PFMEAs with areas of their domain. Constant up gradation of failure modes, causes and detection techniques are carried out in a concurrent mode. The data flow diagram gives a detailed flow of information during the generation of PFMEAs. The sequence of steps involved in PFMEA generation is presented in Figure 5.3.

The access to the PFMEA-Online system is through a user authentication and PFMEA is generated through the steps of process identification, selection failure modes, identification of causes and controls and installation of prevention / detection techniques. The knowledge base captures the information on processes, failure modes, effects, causes,
prevention and detection and makes it available for the user while generating a new PFMEA. The log register records employee information responsible for implementing corrective measures. The final PFMEA format can be viewed and reports generated using the report generation module. A set of sample snap shots of the software are shown in Figure 5.4 to Figure 5.13 indicating respectively PFMEA-Online home page, process features, failure features, view failures options, view effect options, view cause options, knowledge features, addition of prevention/detection, view knowledge base and PFMEA chart generation.
Figure 5.1 Fault Tree diagram for Spot-welding process
Figure 5.2  Data Flow Diagram
Figure 5.3  The flow diagram indicates a sequence of steps involved in PFMEA generation
Figure 5.4  Home Page

Figure 5.5  Process Features
Figure 5.6 Failure Features

Figure 5.7 View Failure options
Figure 5.8 View Effect options

Figure 5.9 View Cause options
Figure 5.10 Knowledge Features

Figure 5.11 Adding Prevention / Detection
Figure 5.12  View Knowledge Base

Figure 5.13  PFMEA Chart Generated
5.5 INFERENCE ON KBPFMEA IMPLEMENTATION

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 location 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 with the knowledge base acts as a 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 operation.