CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

During the recent years, foundries have been functioning under the globally competitive environment. Hence foundries are required to enhance their performance to offer world class quality products and services. In order to offer world class quality products and services, the managers and engineers working in different kinds of companies situated in various parts of the world adopt several strategies. One of those strategies is failure prevention (Ahmed 1996; Dowlatshahi 2001 and Lu 2002). According to this strategy, failures are identified and analyzed and then their causes are pinpointed so that failure recurrence is prevented in future. In order to carryout these tasks, researchers and practitioners deploy frequently the technique called Failure Mode and effects Analysis (FMEA) (Teoh and Case 2004 and Marriott et al 2013).

FMEA is defined as “an engineering technique used to identify, define and eliminate known and/or potential failures, problems, errors and so on from the system, design, process and/or service before they reach the customer” (Stamatis 1995 and Palady 1995). The pace of implementing FMEA has been gradually increasing since its inception in the aerospace industry in mid-1960s (Savick 1981 and Barnard 1996). FMEA was developed by National Aeronautics and Space Administration (NASA) in the year 1963 to minimize design failures. FMEA was applied in nuclear and electronics industries during 1970s (MIL – STD – 1629A, 1980; Norell 1993; Maier, 1995; Onodera, 1997 and, Rhee and Ishii, 2003) and in Automobile industries during 1970s (AIAG 1995 and Chang et al 2001). In recent years,
FMEA is widely applied in the medical field as well as in the design, development and manufacturing process of consumer and capital goods industries (Breiing and Kunz 2002).

FMEA has been adopted in several quality improvement models too. For example, the standards like QS 9000 (Lawrence et al 2002) and ISO 2002/TS 16949 as well as concept like six sigma (Park 2003) are incorporated with FMEA technique in them.

While the studies on FMEA progresses in different directions (Garcia et al 2005), the scope of FMEA has been extended from design and production (Ford manuals 1988a,b; Francesshini and Galetto 2001; Sellapan and Karuppusami 2009) to other functions like service, system and maintenance (Stamatis 1995; Rotondaro and Deoliveira 2001; Besterfield et al 2004). In another direction, FMEA procedures are modified to eliminate the pitfalls in the traditional FMEA using different approaches (Sankar and Prabhu 2001; Chang and Cheng 2010 and Zhang and Chu 2011).

After simultaneously observing the power and deficiencies of FMEA technique, researchers have been developing the modified version of FMEA. All these new versions are depending on experts’ opinions to enable the FMEA for aiding the organizations to meet world class quality requirements. As the experts’ opinions are subjective in nature, an approach is required to be adopted for reducing the fuzziness occurring in them. Hence it has become the need of the hour to incorporate fuzzy logic in this FMEA technique. In order to fulfill this need, a modified FMEA model named FEAROM (Failure Effects And Resolution Of Modes), was developed during the doctoral work reported in this thesis.

During this doctoral work, the practical implications of applying FEAROM model in three private steel foundries located at Coimbatore city of
India were investigated. In each foundry, FEAROM was applied on two components. The results of conducting these investigations indicated the superiority and usefulness of the FEAROM model in enabling the foundries to produce quality castings. The details of these practice oriented research investigations are presented in the following parts of this thesis.

1.2 PROBLEM DEFINITION

The challenge faced by the foundries today is the need to produce high quality cast components with reduced production costs and within shorter development times. In order to ensure the delivery at the desired time, at the required quality level and at a competitive price, the foundries have to implement a proper quality improvement technique, during the development stage of cast components. During the past five decades, among the various quality improvement techniques, FMEA has been used popularly in several areas. After a detailed literature survey, it has been realized that so far FMEA in any form has not been applied as the decision making technique to improve quality during the development stage of cast components. Also, it was inferred from the literature review that, using Fuzzy set in FMEA can resolve its pitfalls (Franceschini and Galetto 2001; Sellapan and Karuppusami 2009, Wang et al 2009). Hence, the absence of applying FMEA with decision making capabilities in foundries is recognized as the problem of this doctoral work.

1.3 OBJECTIVES OF THE DOCTORAL WORK

After identifying and defining the problem, the following were set as the objectives of the doctoral work being reported here.

- To study the various models of modified traditional FMEA developed by the earlier investigators
• To design and develop a FMEA model incorporated with fuzzy concept named FEAROM

• To validate using Modified Fuzzy Technique for Order Preference by Similarity to Ideal Solution (MFTOPSIS) method incorporated with Analytic Hierarchy Process (AHP) method

• To investigate the practicality and usefulness of the FEAROM in foundries

A careful study of the above objectives and problem definition would indicate that, the primary objective of this doctoral work was to devise and validate a modified FMEA encompassing fuzzy subset for application in foundries. The above objectives were attained during the doctoral work reported in this thesis by following the research methodology described in the next section.

1.4 RESEARCH METHODOLOGY

This doctoral work has been accomplished to fulfill its objectives by following the methodology depicted in Figure 1.1. As shown, this doctoral work was started by studying the various modified traditional FMEA models developed by earlier investigators by referring to the literature. After this, three different private steel foundries located in Coimbatore city of India were visited to study the foundry practices adopted in practice. By utilizing the theoretical and practical knowledge gained from literature and foundry arenas respectively, the FEAROM model incorporating fuzzy set was designed. Then, the FEAROM model was subjected to the application in three foundries. In one foundry investment casting method is adopted. In other two foundries, sand casting method is followed. Finally experiences of applying
FEAROM in the three steel foundries were analyzed and thus the practicality of the FEAROM model was investigated.

![Figure 1.1 Doctoral work Methodology](image)

1.5 ORGANIZATION OF THE THESIS

This thesis is compiled in eight chapters. The organization of these chapters is depicted in Figure 1.2. Chapter 1 introduces the doctoral work by defining the problem and enumerates the methodology of the doctoral work. The information and knowledge gathered by conducting literature survey have been presented in chapter 2. An overview on the conceptual features of the
FEAROM model is presented in chapter 3. The orientation on the application feasibilities of the FEAROM model in the foundries is also described in this chapter.

Figure 1.2 Organization of Thesis
The experiences of implementing FEAROM in the three different foundries have been presented in Chapters 4, 5 and 6. The results of conducting these investigations are discussed in chapter 7. Finally, the thesis is concluded in chapter 8. In this chapter, the limitations as well as avenues available for further extending this doctoral work are presented. Followed by these chapters, references, list of publications and curriculum vitae of the research scholar have been appended with this thesis.

1.6 CONCLUSION

This thesis presents the details of the doctoral work in which the ways of applying ‘failure prevention’ as an important strategy for enabling the foundries to produce world class quality castings was investigated. This doctoral work progressed systematically by developing a novel model which has been named as FEAROM. Further, the application of FEAROM in improving the quality of cast components was investigated. A literature survey conducted in this direction has indicated that, foundries are yet to use a failure prevention technique for achieving continuous improvement of quality during the development stage of cast components. On realizing this research and practice gap, the doctoral work being reported in this thesis was initiated. This gap has been filled in this doctoral work by contributing a procedure for implementing FEAROM in foundries. This thesis is written in such a way that the contributions of this doctoral work could be understood by both researchers and practitioners. The details of the efforts made in this direction are presented in the following chapters of this thesis.