Fault knowledge management based FMEA technology driven by functional model

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Keywords: FMEA; Definition of fault; Failure mechanism; Knowledge management

Abstract. FMEA is a qualitative fault analysis method. Fault mode and failure mechanism analysis is the most critical link in the process of FMEA implementation, and it is also the most difficult to grasp. From the use of the situation and the results of the analysis, due to the lack of strict definition on fault mode and failure mechanism, the fault mode is likely to cause confusion. The usability of the analysis result is lower, the definition of the fault is more difficult to understand and so on. And the results over reliance on the experience of technical personnel knowledge, resulting in FMEA is not always able to get the desired results. In order to solve the problem of the relative confusion of the fault knowledge, in this paper, the related fault knowledge is defined, based on the new FMEA technology driven by functional model. The failure mechanism and fault mode are strictly distinguished, and the relationship between them is established to avoid confusion.

1 Introduction

FMEA (Fault modes and effects analysis) popular to say that before the system is put into operation, discover known and potential problems, thereby maximizing a way to eliminate or reduce the loss of customers. It's a special method used to assess the fault in the system design, process or service where fault may occur. FMEA technology plays an important role in the quality management of product design. FMEA technology can be considered as a systematic approach for identifying systems, products and features of faults, and analyzing the impact and the severity of these fault modes [1]. Under usual circumstances, in the field of product development, FMEA can be divided into design FMEA (D-FMEA) and process FMEA (P-FMEA). Design phase mainly including product decomposition, the decomposition of products for the subsystem or component, and identify each subsystem or component of the potential failure, causes and effects and take preventive measures for every fault; and judge the faults of criticality use the prior knowledge and product information. Generally speaking, there are several problems in the process of D-FMEA, for example, the problem of fault identification [2].

Due to the confusion of the fault mode and failure mechanism, the results of FMEA analysis are lack of consistency, so it is very casual and easy to repeat or omit. This not only makes the analysis result is difficult to exchange and share among different personnel and departments in different stages of product development, but also bring chaos between other analysis results of prevention and control measures and other means of detection. In addition, due to the confusion of the fault mode and failure mechanism, often makes the FMEA analysis lose the real focus, making the analysis results of the credibility and value reduction. In this paper, based on the fault analysis and identification method of FMEA technology driven by functional model, the fault mode and failure mechanism are redefined to improve the effect of FMEA. For other issues, please refer to the relevant literature, this article no longer specific analysis.

2 Fault definition

In order to ensure the consistency and portability of the final fault identification results, we need to conduct unified management of the relevant information and concepts prior to the

identification of the fault, and form a standard in a certain range.

For the knowledge management of FMEA, many scholars have made a great contribution in this area, the definition of the fault is summarized in the present, and there are 3 main methods: (1) based on the experience data of components. (2) Functional loss based on the definition of functional units. (3) The parameter deviation or the abnormal state defined based on the behavior model.

The three methods have their advantages and disadvantages, in this paper, we use "fault is the loss of system function" this explanation, and the fault mode of the product is defined based on the functional unit. At the same time, to overcome the ambiguity caused by reverse the semantic of the functional units, we defined the functional failure of the way carefully use Blischke and Murthy [3] proposed fault classification method and Tumer [4] and others who carry out the expansion. Blischce, Murthy and Tumer [3, 4, 5] proposed fault classification (referred to as BMT fault classification) as shown in Fig.1.

The fault mode is defined, which is easy to be connected with the failure mechanism, and it is convenient to contact with the fault treatment measures.

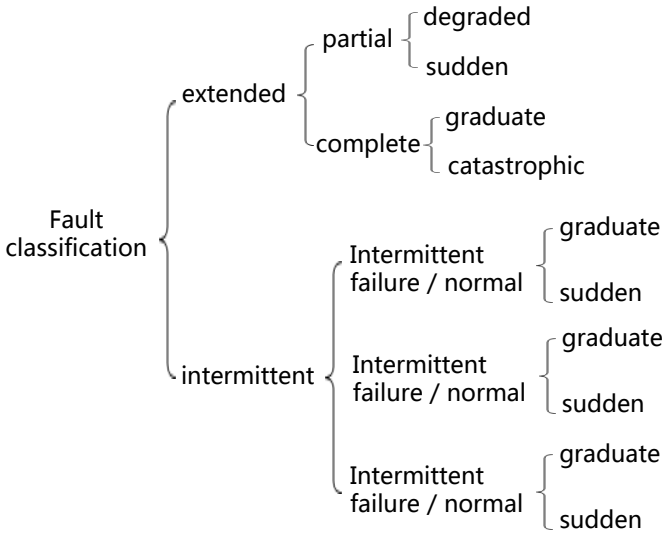

Fig.1 BMT fault classification method

3 Fault causes and failure mechanism

For each fault mode, determine the failure mechanism is the basis for the improvement of the design, detection or maintenance of preventive measures, this is one of the important and even fundamental purposes for implementation of the product FMEA. Relative to product fault mode, people's understanding of failure mechanism is relatively uniform, it is various physical and chemical processes that cause failure. This physical and chemical process, it cannot be divorced from the structure and components selection of the specific product and exist alone. In this sense, the product failure mechanism analysis is more suitable for the product scheme design in the late stage or the detailed design stage can be carried out. At this point, the product structure has been basically determined. It should be pointed out that according to the statistics of the actual development of the product, about 70 to 80% of the product is based on deformation design or adaptive design of the previous product. The basic structure of the product has been broadly defined in the early stages of development, therefore, the analysis of product failure mechanism can also be carried out in the early stage of product development.

According to IEC50 (191) standard, the causes of failure include 3 aspects: (1) Design factors. (2) Manufacturing factors. (3) The use of factors.

In the above factors, the manufacturing factors can be analyzed by the special process FMEA (P-FMEA); Wrong operation and maintenance of improper disposal often relate to maintainability design and human element Engineering. This does not belong to the research content of this project, so we focus on the design factors and the normal use of factors leading to the failure.

According to Pecht et al ' s point of view, whether it is design factors or the use of factors, the failure mechanism of the product is the physical process of the product material change due to various stress damage on the product. In the functional dependency relation, each input and output functions for flow elements will bring the corresponding stress environment, when the stress environment is abnormal, it will cause the fault of the product. The failure mechanism can be classified into 2 types according to the type of fault caused by stress. One is that the stress exceeds the intrinsic strength of the material, which can caused by the failure, be called over stress failure. Failure of the over stress failure often leads to catastrophic fault of the product, but it will also cause some local failure, intermittent failure. The second is the accumulation of material damage caused by normal stress, when the stress exceeds the durability of the material, it will be a failure, which is called wear failure. The failure mechanism of wear caused the product to appear functional degradation or gradual failure. The relationship between failure mechanism and fault mode is described in the following table.

Table 1 the relationship between failure mechanism and fault mode

Failure mechanism type	fault mode	example
Over stress failure	catastrophic	Material distortion; yield; capacitor breakdown
	sudden	Impact wear
	degraded	Abnormal elastic deformation induced by mechanical static load
	graduate	Contact surface detachment; Crack propagation fracture
	intermittent	Instantaneous anomalies of natural frequencies or damping caused by dynamic loads. Transient interference caused by excessive bending of flexible wire
Wear failure	degraded	fatigue
	graduate	Corrosion and crack growth fracture

Want a clear explanation of the failure mechanism of the product, only considering over stress and stress damage is not enough, consideration should also be given to the sources of stress and the nature of stress. From the source, we distinguish the stress as the following types.

Table 2 the sources of stress

Stress source	explain	Corresponding failure mechanism type
Sudden large stress event	Accidental violations, natural disasters, such as abnormal environmental stress events	Over stress failure
Insufficient design performance	Lack of mechanical, electrical and thermal design	Over stress failure
Operating condition damage	Product protection measures failure, fault caused by the functional mismatch and cause damage to normal stress conditions	Over stress failure, Wear failure
Potential path	Potential heat paths, vibration transfer paths, electrical pathways, etc.	Over stress failure, Wear failure
Normal use and environmental stress	Product scheduled working status	Wear failure

According to the physical mechanism of stress generation, the stress can be divided into mechanical, thermal, electrical / magnetic, chemical and radiation of several types, we call it the nature of stress.

Table 3 the nature of stress

Stress property	explain
Mechanical stress	The object is deformed by external factors, and the surface roughness is changed, and the internal force of the interaction between the object and the object is generated. Failure caused by mechanical stress mainly includes elastic or plastic deformation, distortion, brittle or (and) plastic fracture, interface separation, fatigue crack generation and diffusion, creep and creep rupture, etc.
Thermal stress	When the temperature changes, the object is due to the constraints of the external and internal parts, and the stress caused by the expansion and contraction cannot be completely free. Caused thermal overload failure reason is part temperature is higher than the critical temperature, the thermal wear failure including aging caused by depolymerization, metal between growth and mutual diffusion.
Electric / magnetic stress	Usually occurs in the electronic system, improper resistance, impedance
Chemical stress	The change of the object affected by the chemical reaction, such as corrosion, electrolysis.
Radiation stress	The performance of an object affected by radiation.

Through the definition of fault mode, failure mechanism, stress source and stress characteristics, the structural function of a product can be completely covered by all the faults that may occur. Next, according to the function of the product to identify the fault, judge and describe the fault, please refer to the relevant literature about the specific method.

4 Conclusions

In this paper, the failure mechanism and fault mode are strictly distinguished, and the relationship between them is established. The failure of the product is redefined from four aspects, fault mode, failure mechanism, stress source and the nature of stress, which makes the definition more comprehensive and accurate, and the standard is greatly improved, and is also conducive to improve the quality of FMEA.

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