DESIGN FAILURE MODE EFFECT ANALYSIS OF A CENTRIFUGAL OIL CLEANER AND PLAN FOR VALIDATION OF THE DFMEA

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Abstract

In present competitive environment owing to the globalization the customers are becoming very choosy and cautious about quality, cost, service and timely deliveries regarding their requirements. Quality and Reliability are the crucial factors in the satisfaction of Customers. Top managements now days are committed to the efforts required in achieving customer satisfaction. The paradigm is shifting from profit making to customer satisfaction. Today the word reliability has become a watch word in the fields of product design and manufacturing engineering. To achieve the quality and reliability at the satisfaction level of the Customer, FMEA is a significant tool.

Failure Mode Effect Analysis is an effective tool popularly utilized by the designers to average out the risks of failures in the product development. The FMEA is concerned with study of both Design failures and Process failures. Design Failure Mode Effective Analysis (DFMEA) and PFMEA(Process Failure Mode Effective Analysis) are meticulously carried out while carrying out the procedure of the FMEA .We have to calculate the Risk Priority Number(RPN).But it is necessary to validate the FMEA by using the experimentation methods. Because it can be possible that we have calculated Higher RPN for some cases, and in actual there may be no effect on actual performanance.

This paper discusses about the Failure Mode Effective Analysis applied to Design & Development of Centrifugal oil cleaner which is the crucial part used for filtration of oil in Diesel Generator sets. and validation plan of the DFMEA

Key words*:* Customer satisfaction, Reliability, APQP ,FMEA, DFMEA, Risk priority no.

Introduction

In present competitive environment owing to the globalization the customers are having wide choices for their requirements. They are becoming very choosy and cautious about quality, cost, service and timely deliveries regarding their requirements. Customers always want that the products they purchase must be reliable. Reliability from their point of view means that the products should meet their requirements for a considerable time.

Quality and Reliability are the crucial factors in the satisfaction of Customers. Hence the organizations throughout the world are striving for these contemporary measures of performance. It is now mandatory for the organization from survival point of view to fulfill the demands of Customers and to satisfy them.

Top managements now days are committed to the efforts required in achieving customer satisfaction. The paradigm is shifting from profit making to customer satisfaction.

It has now to be the desire as well as the prime duty of the manufacturers that whatever they produce should be reliable and fulfill the customer's expectations. For this purpose manufacturers continually redesign their

products and refine them to eliminate the defects and discrepancies related with their products.

Today the word reliability has acquired a highly specialized technical meaning in relation to the control of the quality of the manufacturer products. It has become a watch word in the fields of product design and manufacturing engineering.

To achieve the quality and reliability at the satisfaction level of the Customer, FMEA is a significant tool. FMEA can be defined as the step by step analysis for identifying all possible failures in design, manufacturing or assembly process or a product or service. It is a methodology to detect the potential reliability problems in early stage of development.

Failure modes and effects analysis (FMEA) is a thorough analysis of the malfunctions that can be produced in the components of an engineering system. The thrust is on how to redesign the components to improve system reliability.

Failure mode effect analysis (FMEA)

In today's competitive environment, it is necessary for the organization to fulfill the demands of Customers and to satisfy them. Quality and Reliability are the crucial factors in the satisfaction of Customers. To achieve the quality and reliability at the satisfaction level of the Customer, FMEA is a significant tool.

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process or a product or service. It is a methodology to detect the potential reliability problems in early stage of development. Failures are any errors or defects, especially ones that affect the customer and can be potential or actual. "Effects analysis" refers to studying the consequences of those failures.

The FMEA is typically being used;

i) For the development of a new product

ii) When the existing product or process is to be reengineered

Iii) Analyzing failures of an existing process, product or service.

Types of FMEA

Engineering risk can be considered the link between technological growth and social values as they are reflected in public policy. Risk assessment has become increasingly important in engineering design as the complexity of engineering systems has increased. The risks associated with engineering systems do not arise because risk avoidance was ignored in the design. One category of risks arises from external factors that were considered acceptable at the time of design. This calls for effective utilization of FMEA. FMEA should always be done whenever failure means potential harm or injury to the user. It can be used for figuring out the potential harm or injury to the user due to product/process/design.

The following are the different types of FMEA;

i) System FMEA:- It Concentrates on system functions . It is a thorough analysis of the malfunctions that can be produced in the components of an engineering system.

ii) Design FMEA:-Focuses on components and subsystems of a system/product and an exhaustive study of all possible failures in design is done.

iii) Process FMEA:-Focuses on manufacturing and assembly processes for identifying all possible failures in a manufacturing or assembly process of a product.

iv) Service FMEA:-Focuses on possible failures in a design and execution of service function.

v) Software FMEA:- It is a thorough analysis of the malfunctions in the software function.

Significance of FMEA

FMEA is a methodology for analyzing potential reliability problems in the product/process/service in the early development stages which makes it easier to take actions to overcome the related risks, thereby enhancing reliability through design. FM EA is used to identify potential malfunctions, determine their effects on the operation of the product and to identify remedial actions to extinguish the possible failures.

The purpose of the FMEA is to take action to eliminate or reduce failures, starting with the highest-priority ones.

Prioritization of failures is done according to their serious consequences, frequency of occur and ease in detection.

Use of FMEAs in the design process allows the designers to drive out probable failures and produce reliable, safe and customer delighting products. FMEAs allow to utilizes past experience and historical Information for use in future product improvement. It also documents current knowledge and actions about the risks of failures for use in continuous improvement

Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service, to

prevent failures and subsequently establish control, both before and during the ongoing operation of the process.

FMEA Methodology

- Select the product or process and describe the function.
- Draw the block diagram of product or process.
- Prepare the worksheet which includes name of the product, process, date, function etc.
- List the components, processes.
- Try to find out the potential failures.
- Write the failures in technical terms.
- Describe the effects and severity of each failure.
- Try to find out causes of potential failures.
- Find out the probability of occurrence of each failure mode cause.
- Describe the current prevention techniques if any.
- Find out the possibility of detection of failure mode.
- Calculate Risk Priority Number
- Suggest the preventive actions for the failures having high RPN
- Implement recommended actions.

Benefits of FMEA

1. Early identification and elimination of potential product/process failure modes.
2. Emphasizes problem prevention.
3. Documents risk and actions taken to reduce risk
4. Prioritize product/process deficiencies.
5. Improve product/process reliability and quality.
6. Provides focus for improved testing and development.
7. Increase customer satisfaction.
8. Capture engineering/organization knowledge.
9. Minimizes late changes and associated cost.
10. Promote for teamwork and inter-functional co-operation.

Case study

The Company and the product :-

M/S Bhagyashree Accessories Pvt. Ltd. Pune INDIA is an SME engaged in manufacturing of Automobile accessories. They are the manufacturers of Centrifugal oil cleaners and Automotive Filters. The main function of Centrifugal oil cleaner is to clean the used oil. Generally it is used on DG sets, which is a stationary application.

The Need of FMEA

The company is engaged in manufacturing of Centrifugal oil cleaner generally used on DG sets, which is a stationary application. However as per the requirement of Customer they have to design a new product of the said group for road transport application.

The Technical Director Mr. Satyajeet Chitale has supported the idea of new product development using APQP.

For the APQP methodology implementation ,FMEA , PPAP, and control plan are the essentials.Hence it becomes essential to prepare the DFMEA & PFMEA for the newly developing product.

The Procedure for DFMEA / PFMEA

FMEAs allow to utilizes past experience and historical Information for use in future product improvement. It also documents current knowledge and actions about the risks of failures for use in continuous improvement. Hence it was decided to utilize the available data for similar existing product to identify potential malfunctions, determine their effects on the operation of the product and to identify remedial actions to extinguish the possible failures.

For the preparation of DFMEA & PFMEA, The Customer complaints were analyzed. With the help of this repeatedly rejected components and their causes were identified. There are five components of the assembly, regarding which most of the complaints are registered. These components are specially considered while the preparation of DFMEA& PFMEA.

The sample FMEA of Assembly and shaft is attached in the annexure I & II . The risk priority numbers are calculated and prevention and detection stages are also mentioned

Plan for validation :

Despite of utmost care taken by the designers sometimes the FMEA shows higher side estimation of risks as it involves subjective treatment and human judgement based on personal experience and feelings, hence It is essential to validate the DFMEA/PFMEA outcomes. Some of the potential causes are,

I) Assignment of unnecessary higher risk leading to higher risk priority number for some function. But in actual practice it may not turn out.
II) Allocation of lower value of RPN to an entity which may lead to potential failure.

The controlling factors :-

For the validation the failure modes showing RPN above 70 were concentrated on and the associated controlling factors were listed down with their extreme levels as shown in **Table 1.**

The Design of Experiment :-

To understand the contribution of the controlling factors in the risk involved in operations it is necessary to design the experimentation of the products assembled from the components showing level 1 and level 2 of the controlling factors, and conducting actual performance trials.

To avoid unnecessary experimentation involving two factorial methods, dealing with two variations in one experiment and thereby calling for 128 trial runs it is decided to go for Taguchi method. Considering the seven controlling factors Considering these factors Taguchi Array for OA-8 is prepared as shown in **table.2**

Table no.1

CONTROLLING FACTORS

Sr.	Controlling Factor	Level 1	Level 2
A	Valve plunger diameter	Oversize	Undersize
B	Shaft diameter	Oversize	Undersize
C	Shaft drilling hole	Oversize	Undersize
D	Shaft Hardness	Excess	Less
E	Rotor diameter	Oversize	Undersize
F	Housing diameter	Oversize	Undersize
G	Housing threading	Tight	Loose

Table no.2

Taguchi's Orthogonal Array

Combination / Trial No.	A	B	C	D	E	F	G
1	1	1	1	1	1	1	1
2	1	1	1	2	2	2	2
3	1	2	2	1	1	2	2
4	1	2	2	2	2	1	1
5	2	1	2	1	2	1	2
6	2	1	2	2	1	2	1
7	2	2	1	1	2	2	1
8	2	2	1	2	1	1	2

The experiments were conducted accordingly. The results of experimentation were also showing interaction of controlling factors with each others.

Conclusion:- To achieve the quality and reliability at the satisfaction level of the Customer. Failure Mode Effect Analysis is an effective tool popularly utilized by the designers to average out the risks of failures in the product development. FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service, to prevent failures and subsequently establish control.

Despite of utmost care taken by the designers during FMEA, sometimes owing to subjective treatment and human judgement based on personal experience and feelings, there are chances for miss- allocation of risks leading to incorrect Risk Priority Nos.(RPN). Normally it tends to higher side leading to unnecessary fear and over cautious approach both from manufacturer's and consumer's point of view. Hence it is always desirable to validate the FMEA outcomes which are nothing but RPNs. And thereby reaching toward factual data reflecting the reliability of the product.

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.Annaxure-I

Sr.	Function	Potential Failure Mode	Potential Effects of Failure	Potential Causes of failure	Severity	Occurrence	Detection	Risk Priority Number
1	Removal of dirt from engine oil.	Oil interval is less than stated.	Centrifuge is not removing the dirt with its full efficiency.	i)Use of the different grade oil than specified ii)Servicing is not in regular manner.	6	4	5	120
2	The centrifuge	Centrifuge cover	Penetration of Filter cover and	Use of improper	5	3	3	45

	assembly should be aesthetic	coating is not as per specification	hence threat to entire assembly	coating material for filter cover				
3	The centrifuge assembly should be in enclosed position	Centrifuge position is not in enclosure.	i) Damage to assembly due to external objects.		5	5	5	125
4	Centrifuge operates at specified pressure.	i)Operates before specified pressure.	i)Engine starves of oil	i)Wrong valve setting.	4	4	4	64
		ii)Operates after specified pressure.	ii)No effect		5	4	5	100
		iii)Does not operate at all.	i)Valve plunger jamming due to oversize.		6	6	6	196

Annaxure-II
FMEA OF SHAFT

Sr.	Function	Potential Failure Mode	Potential Effects of Failure	Potential Causes of failure	Severity	Occurrence	Detection	Risk Priority Number
1	Tightening of shaft in housing.	Breaking of shaft while doing the assembly or sometimes while functioning.	i)Stops the operation of filter. ii)Damage of entire rotor assembly.	i)Threading is not maintained as per mentioned size. ii)Threading length is not maintained as per mentioned length.	4	4	3	48
2	Rotation of the	Sudden breaking of shaft	i)Stops the operation of filter.	i)Case hardening parameter are not followed.	3	6	6	108

	rotor assembly around the shaft.	without any indication.	ii)Damage of entire assembly.					
3	Tightening of shaft in cover nut.	Breaking of shaft while doing the assembly or while sometimes functioning	i)Stops the operation of the filter ii)Damage of entire rotor assembly	i)Threading is not maintained as per mentioned size. ii)Threading size is not maintained as per mentioned length.	5	3	3	45
4	Smooth rotation of rotor assembly	i)Noise & vibration during operation of rotor assembly	i)Stops the operation of filter, but there are warning signals ii)Damage of assembly with warning signals	i) Diameter of shaft is undersize.	6	4	4	96