UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYZING TRANSFORMER MANUFACTURING FAILURE BY USING FMEA APPROACH

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) with Honours.

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ABSTRACT

This report is focused on the failure analysis of the Tangent Delta failure in transformer manufacturing process. Failure Mode and Effect Analysis or FMEA is a one of the quality tools that able to guide the engineer or designer to overcome the failure which has occurred in the product or in the manufacturing process. FMEA helps managements to figure out the failures by determining potential of the failure mode, effect of each failure, occurrences of each failure and the current control process through Severity (S), Occurrences (O), and Detection (D) rankings. From the combination of those rankings by using Risk Priority Number (RPN) technique, the priority to reduce or eliminate (if possible) the failure can be executed by identifying the highest RPN. For the FMEA effectiveness, other tools such as fish bone diagram, Pareto chart and Why-Why Analysis will be used along with the FMEA experiment which serves as communication tool and documentation for the FMEA Team. Literature review provides the theories and facts which obtained from the journal and books. That information will become an important reference in order to guide the project achieves its main objective. Before executing this project, the methodology need to be constructed regarding to the objectives and the problem stated. The project flowchart indicates the process flow and serves as a guideline for the entire project course. As well for the preparation for the next PSM II, the technique, equipment and the required information also been defined to ensure the project is on course and achieves its main objective. The case study is been concluded with the study of the each process involved in the production line and also to strengthen the information in order to provide better understanding. The experiment of the FMEA analysis has reveals the possibilities from several factors which lead towards the Tangent Delta failure. With proposed countermeasure based on the FMEA analysis, the possibility to reducing the failure effect could be achieved if the correct actions have been taken seriously.

ABSTRAK

Laporan ini menjurus kepada analisa kegagalan terhadap kegagalan "Tangent Delta" di dalam proses pembuatan transformer. "Failure Mode and Effect Analysis" atau FMEA ialah salah satu kaedah kualiti yang mampu membimbing jurutera atau pereka untuk mengatasi masalah kegagalan yang dihadapi pada sesetengah produk atau proses pembuatan. FMEA membantu pengurusan untuk mengetahui kegagalan dengan mengenal pasti mod potensi kegagalan, kesan setiap kegagalan, kehadiran kegagalan dan proses kawalan melalui tahap "Severity (S)", "Occurence (O)" dan "Detection (D)". Daripada kombinasi tahap tadi melalui teknik "Risk Production Number" atau RPN, keutaamaan untuk megurangkan atau menghapuskan (barangkali) kegagalan boleh dilaksanakan dengan mengenal tahap RPN yang tertinggi. Untuk keberkesanan FMEA, kaedah yang lain turut digunakan seperti "Pareto chart", "Fishbone diagram" dan "Why-Why Analysis" bersama-sama analisa ini. Ulasan terdahulu menyediakan teori dan fakta dimana telah didapati daripada buku dan kertas kajian. Maklumat berkenaan akan menjadi rujukan penting dengan harapan dapat membimbing projek ini mencapai objektif utamanya. Sebelum melaksanakan projek ini, terdapat beberapa perkara perlu diambil kira. Carta alir menunjukan cara kerja dan menjadi rujukan untuk keseluruhan projek ini. Kajian kes telah dijalankan melalui kajian terhadap proses yang terlibat didalam barisan pengeluaran. Ia juga untuk menguatkan maklumat awal dengan tujuan member pengetahuan yang jelas. Eksperimen FMEA telah mendedahkan kebarangkalian kegagalan daripada beberapa faktor. Dengan mencadangkan beberapa langkah pembaikan berdasarkan analisa, kebarangkalian untuk mengurangkan kesan kegagalan boleh dicapai jika langkah diambil adalah betul dan tepat.

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LIST OF ABBREVIATIONS

FMEA	-	Failure Mode and Effect Analysis
EMF	-	Electro Magnetic Field
PSM I	-	Projek Sarjana Muda I
PSM II	-	Projek Sarjana Muda II
DOE	-	Design Of Experiment
KV	-	Kilovolt
ONAN	-	Oil Natural Air Natural
ONAF	-	Oil Natural Air Forced
TNB	-	Tenaga Nasional Berhad
MVA	-	Megavolt Ampere
Hz	-	Hertz
LV	-	Low Voltage
HV	-	High Voltage
FMEA	-	Failure Mode Effect Analysis
RPN	-	Risk Production Number
WIP	-	Work In Progress
OLTC	-	On Load Tap Changer

CHAPTER 1
INTRODUCTION

During this section, this chapter will explain about the background, problem statement, objective, scope and importance of study. Furthermore this chapter also briefly explains about the Failure Mode and Effect Analysis (FMEA) that will be applying at the manufacturing or assembly processes for this final year project.

The production output is the most vital elements in the manufacturing industries. This is why, the output or product reflects about the assembly operation and the design of the product itself. When talk about the quality and reliability, when a product or system fails to achieve its final objective (functionality), it will trigger a disaster to the manufacturer which produce it. Customer complaints, critics, and turnovers will be a price that had to pay with costly recall and rework from the manufacturer. Many manufacturers are empowered themselves to gain loyalty from their customers. Absolutely the quality, functionality and reliability will be the key for their core strategy. Ensuring to achieve the objective, the manufacturer needs to concern about the product design and also the manufacturing process operations which important to the output that will produce.

The defects or failure of the products or sometimes in the manufacturing operations can contribute product or system fail to achieve its main objective, to perform functionality exactly as the manufacturer expectation. The effects of the defects or failure of the product can contribute a huge significant in terms of quality, reliability, functionality and another important addition, safety. This is because, the failure, defects, and errors where occurred to the product or manufacturing assemblies operation (related to the product), can bring a problem to the manufacturer in terms

of losses, delays, increased manufacturing costs, or any drawbacks which can jeopardize their business.

Failure Mode Effect and Analysis or FMEA was becoming the powerful answer about the problems of reliability and failure analysis. FMEA is defined as "*a systematic group of activities to; (a) recognize and evaluate the potential failure of a product / process and the effects of that failure, (b) identify actions that could eliminate or reduce the chance of the occurrence of potential failure*". Failure modes can be described as the modes of failures of a part or sub-assembly while the effect indicates the effect of the failure of a part in any of the modes, on a system. FMEA is popular tool or technique to identify failures of parts or components, which have significant consequences on the system when it will use. Any failures related with the modes may affect the system performance and also the quality of the system itself.

FMEA is useful for studying the failure modes, failure causes and their effects on the system as well as taking appropriate preventive actions. It is a reliability evaluation / design technique where it provides basic information to reliability prediction and product & process design. The information was come from the examination or research of the potential failure mode and effects through a product or system. FMEA helps the engineers and designers to detect any potential problems which contributing to the failure in the product or system in the early stages such as design stage or simulation stage. From this stage it will ensure them to avoid any changes or reworks at later stage such like production / manufacturing stage or product warranty stage where it claims the higher price when performing it (Teng and Ho, 1996)

FMEA is becoming the selected method for this final year project, Analyzing transformer failure by using FMEA approach. This is because; the FMEA providing the detailed failure analysis and also detailed information and those data can be used as conclusion and solution for the particular failure. Another advantage is, the data itself could be used again if any improvement is been implemented.

1.1. Problem Statement

"Tangent Delta" (Tan δ) failure is a very common problem in the transformer manufacturing. "Tangent Delta" is a problem where the power factor value of a transformer unit exceeded the maximum specification value of 0.5% at temperature 20°C. Tan δ is also known the "loss angle" or "dissipation factor" which important for electrical properties especially in transformer technology. It been used as a diagnostic test to determine the level of degradation in insulation materials of electrical machines and power cables. This problem could delay the shipment to the customer due to intensive rework and also increasing the risk of another major electrical failure of the transformer unit itself.

Figure 1.1: Power Transformer

1.2. Objective

1. To determine the possible factors that lead "Tangent Delta" problem by applying with Fish Bone Diagram method.
2. To analyze the problem by using FMEA technique.
3. To analyze the identified possible factors by using Pareto chart and revise RPN technique.
4. To propose a countermeasure with a purpose solution.

1.3. Importance Of The Study

The importance of this study is to investigate and determine the possible factors of the problems which contribute to the failure of the transformer and to analyze the failure by using FMEA technique. From the data collected from the study can be use to propose the new solution or answer to countermeasure the particular problem and defects.

1.4. Scope Of The Study

The study and the observation will be conducted at the ABC Company plant at Ulu Kelang, Kuala Lumpur. ABC Company is one of the transformer manufacturers in the ASEAN region which been established in early 1980s. The scope of this final year project will be focus only at the entire manufacturing process of the electrical transformer.

The research of this final year project study is focus on the stated problem and analyzing it by using FMEA technique. To meet this proposed research, other method such as Cause-and-Effect diagram (fish bone diagrams), Pareto diagram, process flowchart and other necessary method will be use to support the FMEA technique.

The subject for this study is the power transformer unit (step down type). The general information of this power transformer unit is 30MVA (33/11 KV) and widely used in the country. This transformer type is among the highest production output in the ABC Company and also always obtaining "Tangent Delta" failure during manufacturing stage.

Figure 1.2: Power transformer 30 MVA (33/11 KV) in operation.

CHAPTER 2
LITERATURE REVIEW

This chapter provides a basic knowledge and information about the Failure Mode and Effect Analysis (FMEA) where it been selected as a primary study for this final year project. The FMEA will be described with the necessary element required, benefit & limitation, and other relevant knowledge related to the FMEA and also to the project. This chapter also will describe another relevant topic in order to provide a deep understanding about the study in order to strengthen the purposed project. Without the guidelines from it, it will impossible to conduct the particular study and if so, the project will result the meaningless outcomes.

2.1. Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effects Analysis or FMEA is a common methodology used by engineer or designer for analyzing the potential reliability problems in early development stage where it were easier to take appropriate actions to overcome these selective issues, thereby enhancing the reliability. FMEA is a proactive tool developed to identify, evaluate and prevent product and/or process failures (Bluvband and Grabov, 2009)

FMEA also is a decision making tool for prioritizing corrective action to enhance product or system performance by eliminating or reducing failure rate (Chang and Sun, 2009). Until now, FMEA has been recognized as a powerful tool used to identify critical components / parts / functions whose failure will lead to undesirable outcomes such as production loss, production rework, injury or even an accident (Sharma *et al*. 2007). Previously, this tool was first proposed by NASA in 1963 for their obvious reliability requirements. Since then, it has been intensively used as a powerful technique for system safety and reliability analysis of product and processes in a wide range of industries such as aerospace, nuclear, automotive and medical (Ebeling, 2001)

2.1.1. Purpose of FMEA

The main purposed of FMEA is to identify the possible failure modes that could occur in the design or manufacturing of a product and determining the impact of those failures. (Bluvband and Grabov, 2009). Thus the corrective action can be taken in order to reduce or eliminate the potential for failures to occur. An effective FMEA identifies corrective actions required to prevent failures from reaching the customer and to assure the highest possible yield, quality and reliability.

There are several types of FMEA that has been implemented in the industries. Although the process steps is relatively same but they are some differences regarding to its subject that been research. The types of FMEA are:

a) System - focus on global system functions
b) Design - focuses on components and subsystems
c) Process - focuses on manufacturing and assembly processes
d) Service - focuses on service functions
e) Software - focuses on software functions

FMEA also documents current knowledge and actions about the risks of failures, for use in continuous improvement. FMEA is used during design to prevent failures. Later it's used for control, before and during ongoing operation of the process. The information used in the FMEA process should come from the company's own production lines, the customers, and the field data of similar products (Teng and Ho, 1996). Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service.

2.1.2. Benefits of FMEA

The FMEA programme offers a wide range of benefit for the organization which implemented it. Main benefits of implementing FMEA are improving the product or process quality and reliability and satisfying the customers (Teng and Ho, 1996). The several benefits that can be described are:

a) Minimizes late changes and associated cost since FMEA is been carried out during design stage.
b) Identifies failure modes which will have significant impact
c) Identifies the causes of failures and minimizes them
d) Helps in redesigning to reduce the effect of failures
e) Improve product reliability, maintainability and availability of the system
f) Increases customer satisfaction
g) Prioritize product / process deficiencies for improvement
h) Emphasizes problem prevention
i) Providing information of:
    i. Maintainability analysis

ii. Safety analysis
iii. Survivability
iv. Vulnerability
v. Logistic support analysis
vi. Maintenance plan analysis
vii. Risk analysis
viii. Failure detection
ix. Failure isolation

2.1.3. Part of a Comprehensive Quality System

A formal FMEA process should be a part of comprehensive quality system. This is why, a standalone FMEA process could be effective but the company will not get a maximum benefit without other system to support conducting FMEAs and implementing improvements that are result of the FMEAs. The example of from this statement such as one element of comprehensive quality system is effective use of data and information. Without reliable product or process data, the FMEA becomes a guessing game based on opinions rather than actual facts. This factor could lead the FMEA team focused on the wrong failure modes, thus missing significant opportunities to improve the failure modes that are the biggest problems.

2.1.4. FMEA Standards

For the stand alone FMEAs, the primary standards were been used are the "military standard" (Mil-Std 1629A) and the "Society of Automotive Engineers standard" (SAE J1739). These standards are only limited for the design and process FMEAs. These standards provide general FMEA forms and documents, identify criteria for the quantification of risk associated with potential failures, and provide very general guidelines on the mechanic of completing FMEAs.

Since the FMEA can be used as a part of the comprehensive quality system, it is been subjected under the quality standards of ISO/TS 16949. This standard is created for the automotive industry and based on ISO 9000 and builds on QS 9000, which was originally developed by the Chrysler, Ford, and General Motors (GM) Supplier Quality Requirement Task Force. The objective was to develop a fundamental quality system that provides for continuous improvement, emphasizing defect prevention and the reduction of waste in the supply chain. Furthermore ISO/TS 16949 incorporates the process approach to the quality system requirements originally presented in QS 9000

2.1.5. FMEA Planning

Before planning the FMEA steps on process, there are several series of considerations that have to be view. The following statement below will be regards as a minimum consideration.

2.1.5.1 Selecting appropriate applications for the analysis

The FMEA may be authorized by individuals at various levels in the organization or may be required by ISO 9000, QS 9000, Six Sigma methodologies, internal quality programs or customer requirements. However, the FMEA is expensive to complete and should be completed only in those instances where the benefit outweigh the cost.

2.1.5.2 Identifying and allocating resources

The resources will includes FMEA team members and reporting structure, physical space to conduct the analysis and store to documentation, time, and clerical or communications support.