IMPLEMENTATION OF FMEA AND WASTE ELIMINATION IN COMPANY MUEHLBAUER (ASSEMBLY COMPANY)

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

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the Degree in Bachelor of Manufacturing Engineering (Manufacturing Management). The member of the supervisory committee is as follow:

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ABSTRAK

FMEA telah digunakan secara meluas dalam industri untuk mencari dan menghitung kegagalan yang mungkin berlaku dalam sesuatu proses atau reka bentuk sebelum mereka berlaku dalam sistem yang diuji tersebut, dan mengambil tindakan yang sesuai untuk mencegah atau menghilangkan kegagalan tersebut. Dalam projek ini, subjek yang dikaji adalah mesin (DS10K) yang dipasang di Syarikat Muehlbauer dan fokus projek ini adalah kegagalan yang mungkin akan berlaku semasa proses pemasangan mesin. Kaedah-kaedah untuk menggunakan FMEA pada mesin tersebut telah diintegrasikan dengan kaedah-kaedah dalam pengurusan projek. Peta proses aliran, Bill of Material (BOM), dan Butiran Pekerjaan Struktur (WBS) digunakan untuk mengenalpasti komponen-komponen mesin, fungsinya dan bagaimana mereka berkaitan satu sama lain. Setelah FMEA ditabulasikan, Pareto chart digunakan untuk mengesankan beberapa komponen yang harus ditekankan dan diuruskan dengan teliti pada pemasangan proses pada masa depan. Hasil dari langkah-langkah pelaksanaan selanjutnya dinilai dengan menggunakan Value Stream Mapping (VSM) untuk menguji masa pemasangan mesin selepas perlaksana FMEA. Keputusan kajian menunjukkan bahawa waktu pemasangan mesin yang berkurang adalah 70 minit dan masa pembaziran yang dikurangkan adalah 98 minit, iaitu 14,83% dan 59,89% masing-masing. Pada akhir projek, alat dan cara yang digunakan dalam standardisasi FMEA dirangkul. Hasil pengajian projek ini dapat digunakan selanjutnya sebagai pembangunan perisian yang sesuai untuk langkah-langkah yang dapat memperolehi hasil perlaksanaan FMEA yang tepat dengan lebih cepat pada masa depan.
ABSTRACT

FMEA is used widely in the industry to search and quantify the potential design and process failure before they occur on the system observed, and take corresponding action to prevent or eliminate the potential failures observed. In this project, the subject of study is a machine (DS10K) assembled in Company Muehlbauer and the concern is the potential failure modes occur during the assembly process of the machine. The implementation steps of FMEA on the machine studied have been developed through its integration with other lean tools and project management tools. Process stream map, Bill of Material (BOM), and Work Breakdown Structure (WBS) are used to identify the components of the machine, their functions and how they relate to each other. After the FMEA is tabulated, Pareto chart is used to track out the significant few to be emphasized and the components are taken care during assembly process. The results of implementation steps are then evaluated using Value Stream Mapping (VSM), which is another lean tool, to examine if the assembly lead time of FMEA has been reduced through the implementation of FMEA. The result shows that the assembly time of the machine reduced is 70 minutes and the wasted non-value added time reduced is 98 minutes, which are 14.83% and 59.89% respectively. In the end of the project, the tools and ways used in standardizing the FMEA are summarized. Further study of the project would be the development of corresponding software of the standardized steps to get a faster and accurate result in the future.
I would like to thank Company Muehlbauer and the manager, Mr. Sekar, for the acceptance as an industrial part-timer. The opportunity provided enables author to gain knowledge beyond the book in university, and a chance to apply knowledge learned into the real working environment in manufacturing industry. The experience gained during the training is the valuable asset to be well prepared for engineering life in the future.

Besides that, I would like to thank the engineers from quality team developed. The engineers said had given useful guidance during the FMEA implementation, and been helpful especially during brainstorming and Q&A sessions in providing useful information during scheduled meeting. Without the help from the quality team, the implementation of the FMEA wouldn’t be finished successfully.

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CHAPTER 1
INTRODUCTION

This chapter is first of all starting from the background of company and the project to be conducted in the company. They are then followed by the problem statement of the company which necessitates the solution (project) in the company. After that would be the objectives, scope and finally the expected finding of the project that provide a main direction for the project to be moving forward.

1.1 Background

Company Muehlbauer selected as the subject to be studied in this project is located at Melaka and serves as the first production branch outside its main company headquartered in Germany. It is an independent consultant and manufacturer of innovative security solutions for market. Products of the company can be said as solutions for the Smart Card industry which is manufacturing any card type including ID cards, e-Passports, e-Visa, contact and contactless cards and many others. Besides that, it also is responsible for the development and enhancement of special machines for semiconductor industries. The machine is set up and adjusted according to customer requirement in new environment before being shipped to customer sites.

The project conducted in the company stated above is basically covering the
implementation of failure modes and effect analysis (FMEA) in eliminating waste in assembly process. FMEA is applied in the assembly process of a particular machine, so that key improvement opportunities for the process can be identified. This can be done by quantifying the potential errors and weak points in process, and trying to avoid them via development of adequate counter measures.

In addition of that, the effectiveness of the FMEA is also included into this project. Simulation tool is used to examine how efficient is the FMEA implementation in eliminating possible wastes in assembly process. This could be done, for example, by simulating the assembly time before and after the implementation of FMEA. Other measures such as assembling cost or amount of scrap parts or trial run could be used to quantify/illustrate the efficient of assembly too.

1.2 Problem Statement

The company Muehlbauer, as the subject to be studied, is an expanding branched company newly opened at Melaka. Regardless of 10 years history in Malaysia, the company’s production facilities are still in the developing and initial stage. Based on this reason, there are many wastes to be eliminated within the company.

One of the wastes stated includes the slow assembly time as well as high scrap rate. This would somehow reduce the efficiency of the material usage and time utilization. The main reason of the slow assembly process for some machines is due to the lack of a guide to be referred once there is any abnormality or machinery part which is not functioning as expected. Besides that, small details of components that might be affecting the overall performance
haven’t been emphasized and fixed at early stage. This would contribute to high scrap rate.

1.3 Objectives

The objectives of the projects are as below:

a) To quantify the key process input variables (KPIVs) of an assembly process

b) To evaluate the effectiveness of FMEA implementation.

c) To develop a standard work procedure for FMEA implementation using several lean tools and project management tools.

1.4 Scope

The study conducted in the Company Muehlbauer is primarily focusing on the implementation of Failure Modes and Effects Analysis (FMEA). Its implementation covers the observation of the overall assembly process on the particular machine after the understanding of each machinery part’s function. The scope of the project also covers the investigation of the causes that would stimulate the potential failure modes stated, as well as the suggestion of the corresponding prevention and correction action. The last part included in the project would be the measurement of how effective is the implementation of FMEA in helping the elimination of waste in the company, as the other lean tools are doing in other companies. The project does not cover the design of experiment (DOE) in running the particular machine to the failure so that to observe the possibility of the failure to happen and the technical skills to be used in assembly process.
CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION:

This chapter is primarily covering the general information and historical data or projects which have been done previously, either the research by gurus or educational institutes, or the similar implementation of FMEA in corresponding industries. All of the information and data included in this chapter serve as the guideline in designing and planning of the project completion. Besides that, all of these are used to support the result and discussion obtained in the PSM 2.

2.2 BACKGROUND OF INDUSTRY:

Today, effectively managing risk is an essential element of successful project management. Proper risk management can assist the project manager to militate against both known and unanticipated risks on projects of all kinds. Failure to perform effective risk management can cause projects to exceed budget, fall behind schedule, miss critical performance targets, or exhibit any combination of these troubles (Donald D. Tippett, 2004).

Among numerous types of development projects, only about one-fourth of all projects entering development become a market success (Adams, 2004). Datta and
Mukerjee (2001) stated that “successful project completion depends to a great extent
on the early identification of immediate risks.” Another example showing the
importance of project risk management, (Jiang et al., 2002) factor analysis has been
used to confirm the hypothesis that adversely impacts project success for software
development.

There are a number of factors that determine whether a project is a success, but it
seems likely that failing to perform adequate risk management will increase the
possibility of failure. It is hence very critical to have an effective method to plan for
and manage project risks so that the project team will understand, use, and apply. As
projects increase in complexity and size, taking a multidisciplinary approach to
project management requires giving proper attention to risk management. It is
apparent that there are many ways to capture the effect of project risks. The method
of an organization chooses is depending on the situation. (Thomas A. Carbone,
2004).

Risk analysis techniques include expert interviews, expected monetary value,
and response matrices, along with more advanced risk techniques such as the
Monte-Carlo method. Pritchard (2001) and Raz and Michael (1999) provide
comprehensive reference to and information about risk analysis techniques for
various applications and requirements. One of the risk management techniques
multiplies probability of the risk occurring with the expected impact of the risk, as an
evaluation for each risk. In this work, the method of multiplying three values of
likelihood of occurrence (or probability), severity (or impact), and detection is the
familiar format of the failure mode and effects analysis (FMEA) used for process,
design, and service planning.
2.3 FMEA:

Failure Mode and Effects Analysis (FMEA) is commonly defined as “a systematic process for identifying potential design and process failures before they occur, with the intent to eliminate them or minimize the risk associated with them”. (Sellappan Narayanagounder and Karuppusami Gurusami, 2009). It is arguably the fundamental technique to identify and manage single point failure modes, applied traditionally to piece-part and functional descriptions (“Procedures for Performing a Failure Mode, Effects and Criticality Analysis”, 1984).

2.3.1 Purpose of FMEA:

FMEA provides a systematic method of resolving the questions: “How can a process or product fail? What is the effect on the rest of the system if such failure occurs? What action is necessary to prevent the failure?” It is hence can be said that FMEA is a skeptical assessment of all design descriptions available by forming a search for potential (or actual) departures from design intent. FMEA is treated as a key element in design validation at each assembly level. The basic approach is to link FMEA application as closely as possible with design methods and data. (J. Murdoch, 2002).

The purpose of performing an FMEA is to analyze the product's design characteristics relative to the planned manufacturing process and experiment design, to ensure that the resultant product meets customer needs and expectations. When potential failure modes are identified, corrective action can be taken to eliminate them or to continually reduce a potential occurrence. (Mario Villacourt, 1993).
2.3.2 History of FMEA:

The FMEA technique was first reported in the 1920s but its use has only been significantly documented since the early 1960s. It was developed in the USA in the 1960s by National Aeronautics Space Agency (NASA) as a means of addressing a way to improve the reliability of military equipment. It has been used in the automotive industry since the early 1970s and its use has been accelerated in the 1990s to address the major quality and reliability challenges caused by the Far Eastern car manufacturers. (K. G. Johnson and M. K. Khan, 2003).

Besides that, the emphasis on FMEA is cited in much of the literature of Japanese system development (Ciraolo, Michael, 1991) In the late 1980s, the Japanese semiconductor manufacturing equipment industry had began experimenting with FMEA as a technique to predict and improve reliability. The FMEA approach also documents the rationale for a particular manufacturing process.

At Nippon Electronics Corporation (NEC), the FMEA process became the most important factor for improving equipment reliability during the design of new systems. In 1990, FMEA became part of NEC's standard equipment design document. The FMEA allowed NEC's equipment engineering group to accumulate design knowledge and information for preventing failures that were fed back to design engineering for new equipment (Matzumura, K., 1991)

Besides that, Ford Motor Company requires their suppliers to perform detailed FMEAs on all designs and processes (B.G. Dale and P. Shaw, 1990). As a result of that, the suppliers to Ford Motor Company, Texas Instruments and Intel Corporation, have implemented extensive training on FMEA as part of their total quality educational programs ("FMEA Process," June 1991). All of these are the examples of FMEA success story in industries as reference for other companies.
2.3.3 General application of FMEA:

The character of the FMEA technique varies according to the nature of the design description to which it is applied. Hardware systems are the traditional application domain; electronic hardware approaches, because of the distributed circuit nature of the designs, emphasize functional paths and failure paths (“Design Assurance Guidance for Airborne Electronic Hardware”, April 2000)

The FMEA can be performed as hardware or functional analysis. The hardware approach requires parts identification from engineering drawings (schematics, bill of materials) and reliability performance data, for example mean time between failures (MTBF), and is generally performed in a part-level fashion (bottom-up). However, it can be initiated at any level (component/assembly/subsystem) and progress in either direction (up or down). One the other hand, the functional approach is used when hardware items have not been uniquely identified or when system complexity requires analysis from the system level downward (top-down). This normally occurs during the design development stages of the equipment life cycle; however, any subsystem FMEA can be performed at any time. (Mario Villacourt, 1993)

Although FMEA analyses vary from hardware to software, and from components (i.e., integrated circuits, bearings) to system (i.e., stepper, furnace), the goal is always the same: to design reliability into the equipment. Thus, a functional analysis to FMEA on a subassembly is appropriate to use as a case study for the purposes of this guideline. Besides that, FMEA could also be used in reviewing product design safety through the evaluation of system behavior, for every potential failure mode of every system component. (Sellappan Narayanagounder et al, 2009)
2.3.4 Modifications allowed on FMEA:

Regardless the general implementation of FMEA as stated above, there are several modifications on FMEA from some particular aspects before, depending on the purpose of implementation. Pritchard (2000) first identified the FMEA technique as an advanced format capable of capturing project risks. The use of the FMEA technique is developed here with terminology, along with a detailed methodology. In addition, the method of using the simple graphical analysis techniques is introduced for risk priority planning.

One of the reasons for different version of FMEA implementation might be due to the concept of risk priority numbers used in the FMEA. As Bongiorno (2001) points out for the typical FMEA, a standard RPN threshold value across a project is not used or recommended in the FMEA of other project. A certain RPN value on one project may be deemed moderate, whereas on another project it may be a crucial risk to manage. As each project is unique, so are the risks and the corresponding RPN values.

In addition of that, timely performed FMEA is risk management instead of crisis management (Mäckel, O., 2001). In the early phases of software development where the costs for changes are small (Figure 2.1) and willingness to change is high, it makes sense to identify and avoid failures in a preventive way. By evaluating the individual risks a differentiation between high risk and low risk components, modules and functions can be achieved. This makes a risk-oriented development of software-intensive systems possible.
Figure 2.1: Fault occurrence, fault elimination and fault correction costs in software development

(Software-FMEA im Entwicklungsprozess softwareintensiver technischer Systeme: Qualität und Zuverlässigkeit, Vol. 46, 2001)

According to Oliver Mäckel (2001, p.2) SW-FMEA is the consistent continuation of the FMEA of the system (system FMEA: SFMEA) for analyzing software-intensive components of the considered system. Their results find their way back to the FMEA of the system. However, the FMEA technique is not yet widely used for software-intensive systems. General use of these analyses in the development of technical systems is more important than the requirements for time-to-market and cost-to-market increase.

The SW-FMEA is a systematic, structured technique for the review of the software architecture or the software design with respect to technical risks (e.g. safety, reliability or availability). The SW-FMEA is used for knowledge transfer. The knowledge of different departments, likes for example system development, software
development, test and service, is brought together and used during the FMEA in the team. So the number of views on or into a system and a system's software increases itself. (Oliver Mäckel, 2001)

2.3.5 Considerations of FMEA implementation:

One of the considerations to obey for FMEA implementation is the timing of performing FMEA, which is dictated by equipment life cycle. The early stages of the equipment life cycle represent the region where the greatest impact on equipment reliability can be made. Once the design matures, it becomes more difficult to alter. Unfortunately, the time, cost, and resources required to correct a problem increase as well. Toward the end of the design/development life cycle, only 15% of the life cycle costs are consumed, but approximately 95% of the total life cycle costs have already been locked-in. (“Guidelines for Equipment Reliability”, 1992)

In addition of the consideration of performing timing, FMEA is recommended along with Process Analysis Technique, Design of Experiments and Fault Tree Analysis, as a part of quality assurance that a company should use systematically for total quality control (“Partnering for Total Quality: A Total Quality Tool Kit”, 1990). All indicators from the total quality management perspective and from examination of the equipment life cycle tell us that the FMEA works best when conducted early in the planning stages of the design. However, the FMEA is an iterative process that should be updated continually as the program develops.