UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSING A SYSTEM RELIABILITY: A CASE STUDY IN ARM REAR AXLE ASSEMBLY

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

by

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I hereby, declared this report entitled "Assessing A System Reliability: A Case Study in Arm Rear Axle Assembly" is the results of my own research as cited in references.

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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 of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons.). The member of the supervisory committee is as follow:

……..

(Professor Madya Dr. Lukman Sukarma)

ABSTRACT

This study aims at assessing System Reliability in manufacturing industry. This takes place in the arm rear axle assembly of factory A. The problems arise when the workers need to do other works while waiting the robot to function again. The problem occurs when one of the robot frequently abruptly terminates during the process. Thus, the research was conducted to improve poor reliability of robots as well as the reliability of system.

Times to failure were recorded based on historical data. The life data analysis was conducted based on the survival data. The objective is to assess the reliability of robots in the assembly system. In contrast, the series configuration is identified in order to assess reliability of the system. The prediction based on statistical method analysis was applied by analyzing the result of the life data analysis and identifying the causes of failures. The application in Minitab was used as a tool to predict the lifetime of the robot instead to measure the survival probabilities of the individual failure mode that give effect to the performance of reliability system. In conclusion, the improvement was made by analyzing the failure mode and made suggestion regarding on conducting and maintaining the robot in the system.

ABSTRAK

Kajian ini bertujuan untuk menilai Sistem Kebolehpercayaan dalam industri pembuatan. Ini berlaku di lengan pemasangan gandar belakang kilang A. Masalah timbul apabila pekerja perlu melakukan kerja-kerja lain sementara menunggu robot berfungsi semula. Masalah ini berlaku apabila salah satu robot yang sering tiba-tiba menamatkan semasa proses tersebut. Oleh itu, kajian ini dijalankan untuk meningkatkan kelemahan dari segi kebolehpercayaan robot dan kebolehpercayaan sistem.

Kali kegagalan direkodkan berdasarkan data terdahulu. Analisis data hidup telah dijalankan berdasarkan data jangka hayat. Objektifnya adalah untuk menilai kebolehpercayaan robot dalam sistem pemasangan. Sebaliknya, konfigurasi siri tersebut dikenalpasti untuk menilai kebolehpercayaan sistem. Ramalan berdasarkan analisis kaedah statistik telah digunakan dengan menganalisis hasil daripada analisis data hidup dan mengenal pasti punca-punca kegagalan. Aplikasi dalam Minitab telah digunakan sebagai alat untuk meramalkan jangka hayat robot selain adalah untuk mengukur kebarangkalian jangka hayat bagi mod kegagalan secara individu yang memberi kesan kepada prestasi sistem kebolehpercayaan. Kesimpulannya, peningkatan itu dibuat dengan menganalisis mod kegagalan dan membuat cadangan mengenai mengendalikan dan mengekalkan robot dalam sistem.

DEDICATION

I dedicated this research to my beloved family, lecturers and friends whose have encouraged and inspired me in complete this project.

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In the name of Allah, the most gracious, the most merciful, I would like to express my gratitude to the people who directly or indirectly involved during the preparation and after I successfully manage to complete this PSM project.

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LIST OF ABBREVIATIONS

CMS	-	Continuous Manufacturing System
CMS	-	Cellular Manufacturing System
WIP	-	Work-In-Progress
PDF	-	Probability Density Function
CDF	-	Cumulative Distribution Function
MTTR	-	Mean Time To Failure
MRL	-	Mean Residual Life
FMEA	-	Failure Modes and Effects Analysis
FTA	-	Fault Tree Analysis
MTBF	-	Mean Time Between Failures
PSM	-	Projek Sarjana Muda
ID	-	Individual Identification
ADJ	-	Anderson – Darling statistic value
ML	-	Maximum Likelihood
CI	-	Confidence Interval
IQR	-	Interquartile Range
Q1	-	First Quartile
Q3	-	Third Quartile
TIG	-	Tungsten Inert Gas

CHAPTER 1
INTRODUCTION

This chapter provides a review about the project entitled "Assessing a System Reliability: A Case Study in the Arm Rear Axle Assembly". These include an overview of the concept and importance of a system reliability focusing in the system of arm rear axle assembly process. Background study, problem statements, objectives and scopes of this study are discussed in the following segments.

1.1 Background of the Study

Generally, manufacturing industry refer to sector areas which involve in the processing of raw materials, commodities, components, or parts into finished goods for sale to fullfill the market demand or as intermediate goods used in the production process. Manufacturing commonly employs human labour, machines, and tools on a large scale. The continuous flow of machine run is important to produce products or outputs to meet customers expectation. Any interruptions due to breakdown and stoppage machine will effect the flow of the production process. Each machine is characterized by three parameters which are: a) the processing time, b) time between failures and c) time to repair (Tezcan, 2001). Thats mean, the ability of machine to perform its function went smoothly without interruption due to fail and takes time to repair in shorter processing time. The great quality of the products will be produced as the performance of machines run efficiently. Thus, the manufacturers will gain higher profit from the sale of quality products produce.

Derivation the product probability law of series component was initiated during the analysis of the missile system by Robert Lusser. The theorem concerns about the overall systems functioning only if all the components are functioning and is valid under special assumptions. To make up the system, it reviews that the reliability of such system is equivalent to the product of the reliability of the individual components (Rausand and Hoyland, 2004a). From this situation, it explains that the production of the product in the system will stop and influence the quality of product as well due to the poor reliability of the machine. The reliability is measured by analyse the failure rate of machine and on how often does it fail during a certain amount of time.

The purpose of system reliability is to prevent failures that affect the operational capability of the system. According Jolly and Wadhwa (2004a), the consequences of the failure of a system were always considered in the term of 'reliability'. Thus, the rate of failure or failure probability of machine in the system need to be measured during the data collection under specified time for customer requirements compliance. The system reliability is important to ensure that the failure probabilities are reduced and failure detection capability needs to be increased.

According to the research made by Coolen (2008a), stated that the purpose and the reliability theory had been practiced in statistics as it most commonly used as a parametric probability distribution. By using a statistical method, basic probability concepts such as random variable and distribution need to define based on the failure rate data of the machine and measurement will emerge with lifetime distribution. Thus, operational of the machine during production process in the entire system needs to be observed. The measurement of machine configuration in the system need to relate with the concept reliability model.

To assess a system reliability of this study, one entire process system in manufacturing plant of Factory A has been chosen. Factory A is a manufacturing industry that provides robotic and machinery to join and assembled metal automotive component. One process of the assembly system in factory A will be selected and the mapping of the welding robots in the system will be observed and measured. The assembly process of arm rear axle is chosen since the one of the welding robot in the system is frequently abruptly stop. This stoppage of the robot is due to unreliable robot being used in the entire process. Thus, the aim of this study is to assess the reliability of the system by applying statistical method. Based on the results of this assessment, this study will emerge with suggestions to improve the reliability of the system.

1.2 Problem statement

The main problem of this research study is the poor reliability of the robots in a system of the production process in Factory A. In the arm rear axle assembly process, it found that one of the robotic welding is frequently abruptly stop as shown in the Figure 1.1. This event occurs for six months which is caused by the high failure probabilities of the welding robots in assembly system. The inability of the welding robot to perform its function during assembly process causes the performance of the system to be low and the workers need to do other works while waiting the robot to function again.

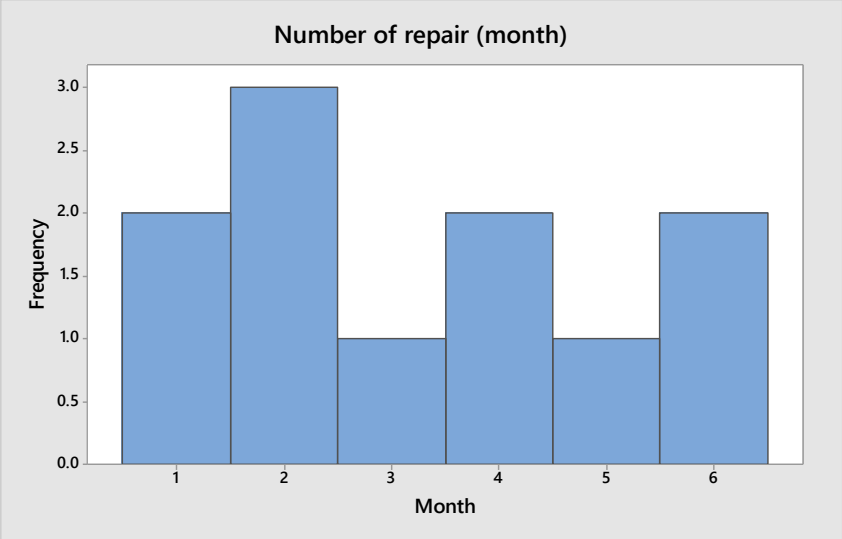

Figure 1.1: Frequency number of repairs for six month (Month)

This will effect the efficiency of the operation process and consequently reduce the overall performance of the system to assemble the arm rear axle. Thus, the series configuration of welding robots is identified through the flow of assembly process in the entire system. The two types of welding robots are conducted to assemble the metal automotive components which is the arm rear axle. Factory A has to maintain their robotic welding in highly reliable conditions in order to be able to struggle in a highly competitive global.

1.3 Objectives

a) To measure and assess the reliability of each machine as well as the reliability of the system under study.

b) To identify the causes of failures of the machine in a system that prevent a system from perform a required function.

c) To give suggestion for improvement of system reliability based on the identification of failure.

1.4 Scope of the study

This research is limited to one assembly system in the manufacturing plant of Factory A. Only the flow of the component assembly through the mapping of welding robots in that process system will be studied. The process of arm rear axle assembly is selected in this study which involve between two welding robots in series configuration. The life data analysis of each welding robot in the system is obtained. The lifetime distribution will be measured by using failure data in that process. The distribution will be studied using reliability prediction and modelling. Thus, the reliability of each robot needs to be improved to enhance the system's safety, quality and operational availability.

1.5 Structure of Project

The organization for this thesis according to the format in Projek Sarjana Muda 1 and 2 stated as below:

Chapter 1: Introduction

This chapter includes the background of relevant topic, problem statement, objectives, scope and limitation.

Chapter 2: Literature review

This chapter begins with a review of machine configuration and its capability in manufacturing system. Concepts, definition, purposes of a system reliability assessment in manufacturing industry focusing in the production line and followed by the application of lifetime distribution based on statistical method are explained in this chapter.

Chapter 3: Methodology

This chapter states the flow chart that carried out for the whole process of the methodology. Next, the data collection that includes the primary resources and second resources that obtained from production department of factory A is shown to aid in the problem analysis. The analysis techniques and tools are also summarized in this chapter.

Chapter 4: Result and Discussion

This chapter covers the reliability system and each welding robot based on the chosen life data distribution. The statistical method and parameter estimation are applied to get the result. The system data are collected and analyzed to obtain the connection between quantified failure modes that affect the system reliability.

Chapter 5: Conclusion

This chapter will conclude the research findings. The manufacturer can predict the lifetime of each machine based on the statistical method approach. The corrective planning and continuous improvement will be highlighted to improve the efficiency of the welding robot processing.

CHAPTER 2
LITERATURE REVIEW

This chapter provides a review of the concepts machine configuration that related to the concept, definition, purposes of a system reliability assessment in manufacturing industry focusing in the production line. Besides, this chapter also defines and explains the failure and lifetime term of the component, machine and equipment in the system that tend to relate with the research study using statistical methods regarding to exponential, normal distribution and so on. The failure analysis also is explained in order to define the reliability prediction of the system as well.

2.1 Manufacturing system

Machineries is a very common word in manufacturing process, especially for higher rate of production output (Subramaniam et al., 2009). The machine capabilities are needed to produce products during production runs. Machinery investments are high and costly, therefore industries try to exploit their usage to maximize profit.

Reliability plays a major role within the overall performance of a producing system. The reliability is especially related to the machines in production system as its capability to produce product in large quantities in manufacturing. Thus, reliability of of machines tools influences the whole manufacturing effectiveness and stability of equipment in the production system (Liu et al., 2014). The study on the reliability life data analysis in a manufacturing system at the time of machine operated

successfully or before it failed showed that the key factor in most of the performance systems is that reliability of machine (Sun et al., 2007a).

Li and Meerkov (2000) stated that the problem of production variability in manufacturing system is related to unreliable machine. Based on the Bernoulli statistics of machine reliability are assumed, unreliable production line also generate three problems which are the production variance, the constant demand satisfaction and the random demand satisfaction problems. These problems also are caused as the long lines smooth out of production and reduce its variability. Based on their study, the number of parts are produced by the system is a random variable due to machine breakdown during a fixed interval of time. This shows that its expected value and variances characterize the production volume and variability respectively. In general, the production variances only gives theoretical characterization of the production variability.

2.2 Machine configuration

The system-level reliability of a manufacturing system affected by the machine configuration selection as it gives a great impact on it. (Sun et al., 2007b). System-level reliability also is resulted from the unpredictable machine breakdown and improper maintenance decisions that affect the products quality and tools degradation.

The reliability of the system needs to be determined either the components in the systems are series, parallel or mixed systems in series and parallel. The system in series is the weakest linking or connectivity in the system. The interconnection of the equipment is in terms of the contribution of component failure gives effect to the system. This is define that if one of the component fails, the overall system fails. In contrast, the system in parallel is refer to as a redundant system.