RELIABILITY STUDY OF CONE LAYING AND PICKING MACHINE DURING FIELD TEST

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A report submitted

In fulfilment of the requirement for the degree of

Bachelor of Mechanical Engineering

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DECLARATION

I declare this project entitled " Reliability Study of Cone Laying and Picking Machine during Field Test" is the result of my own work except as cited in the references.

Signature :.....

Name : Izzat Najmi bin Ibrahim

Date : 20th June 2021

APPROVAL

I hereby declare that I have read this project and and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature :.....

Name : Dr. Nor Azmmi bin Masripan

Date :.....

DEDICATION

To my beloved family for the endless support that they had given, especially to my beloved father and mother, Ibrahim bin Sudin and Norelizah Binti Ismail.

Supervisor Dr.Nor Azmmi bin Masripan

&

Fellow friends

ABSTRACT

In effort to reduce the road accident that happens to the Plus Malaysia Berhad (PMB) workers, PMB collaborates with Universiti Teknikal Malaysia Melaka (UTeM) to find new and better ways of picking and laying cones for road maintenance and emergency purposes. Cone laying and picking machine can be installed to various size of lorry without modification to the existing vehicle. It possesses the ability to lay cones either in a straight or curve pattern by sliding the machine along the tailgate of the lorry. This project aims to study the reliability properties of cone laying and picking machine during field test. The process to get the reliability data will be done repeatedly with the specific methods, rules, guidelines, template and checklist to build an easily manageable quality system. The method that used for this project is using the reliability calculation to get a lifespan for every component on the cone laying and picking machine. This study aims to detect and reduce the failure that occurs on cone laying and picking machine components.

ABSTRAK

Dalam usaha mengurangkan kemalangan jalan raya yang menimpa pekerja Plus Malaysia Berhad (PMB), PMB bekerjasama dengan Universiti Teknikal Malaysia Melaka (UTeM) untuk mencari cara baru dan cara yang lebih baik untuk tujuan penyelenggaraan jalan dan tujuan kecemasan. Mesin meletak dan mengambil kon dapat dipasang pada pelbagai jenis lori tanpa memerlukan modifikasi pada kenderaan yang ada. Ia memiliki kemampuan untuk meletakkan kon sama ada dalam bentuk lurus atau lengkung dengan meletakkan mesin di sepanjang pintu belakang lori. Tujuan projek ini adalah untuk mengkaji sifat kebolehpercayaan mesin meletak dan mengambil kon semasa ujian lapangan. Proses untuk mendapatkan data kebolehpercayaan akan dilakukan berulang kali dengan kaedah, peraturan, garis panduan, templat dan senarai semak khusus untuk membina sistem kualiti yang mudah dikendalikan. Kaedah yang digunakan untuk projek ini adalah menggunakan pengiraan kebolehpercayaan untuk mendapatkan jangka hayat bagi setiap komponen pada mesin meletak dan mengambil kon. Tujuan kajian ini adalah untuk mengesan dan mengurangkan kegagalan yang berlaku pada komponen mesin meletak dan mengambil kon.

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LIST OF ABBREVIATIONS

MTTR	Mean Time to Repair
MTBR	Mean Time Between Repair
MTTF	Mean Time to Failure
MTBF	Mean Time Between Failure
OEE	Overall Equipment Effectiveness

LIST OF SYMBOLS

hh:mm	Hour: minute
Pcs	Pieces

CHAPTER 1

INTRODUCTION

1.1 Background

Plus Malaysia Berhad (PMB) was incorporated on 29 November 2010 and is involved in investment holding. PMB is the largest toll expressway operator in Malaysia and one of the largest in South East Asia. However, there is the problem that PMB had been facing which is the road accidents often happen when the workers are doing picking and laying cones for road maintenance and emergency purposes.

In the mid-1990s, one of the first automatic cone positionings was created and tested by researchers at CalTrans Advanced Highway Maintenance and Construction Technology Center (AHMCT). Its laying shape can set cones in the forward or straight travel direction by sliding the cone on the side of a lorry. AHMCT is also a fully automated machine and also can operate by one worker only (Theiss, 2017). The price is also quite expensive, which is RM323,560 each (Ferreira, 2019).

Moreover, the Centreville AutoCone machine is designed and marketed by Centreville Trailer as a fully automatic cone positioning and retrieval system. It also came as the CalTrans Advanced Highway Maintenance and Construction Technology Center (AHMCT) because it can set cones in the forward or straight travel direction by sliding the cone on the side of a lorry. The estimated price for this machine is RM320,840.00 each and expensive to buy (Theiss, 2017).

In effort to reduce the road accident which happen to the workers, PMB have a collaboration with Universiti Teknikal Malaysia Melaka (UTeM) to finding new and

better ways of picking and laying cones for road maintenance and emergency purposes. Cone laying and picking machine can be installed to various size of lorry without the needs of modification to the existing vehicle. It possesses the ability to lay cones either in straight or curve pattern by sliding the machine along the tailgate of the lorry. It is powered by 24V lead iron battery or can be directly connected to the power source of vehicle. No other types of power source are permitted.

The cone laying and picking machine is built with 3 main systems, which are the test bed, cone machine and the guiding post. Test bed is attached at the rear end of the lorry tailgate and becomes the hooking point of the cone machine. Cone machine is equipped with the mechanism to pick up and lay down the cone. It is the brain of this machine system. Guiding post is used to realign the position and orientation of the cone before being picked up by machine.

1.2 Problem statement

Cone is a guide for the drivers to slow down their car and be informed if there are maintenance or construction works. Picking and laying cones is risky work because it needs to be performed by workers manually. The number of road maintenance worker death during work on the highway is increasing day by day. This problem can be solved by stopping all vehicles when the operation or maintenance are running but it will cause a traffic jam. So, Universiti Teknikal Malaysia Melaka (UTeM) has proposed the Cone laying and picking machine to Plus Highway Berhad (PBM) to solve the problem. The reliability test also needs to be done to test the reliability of a cone laying and picking machine. The cone laying and picking machine will be testing on the road inside UTeM.

1.3 Objectives

The objectives of this project are as follows:

1. To study the reliability properties of cone laying and picking machine during field test.
2. To analyze the failure on cone laying and picking machine during field test.

1.4 Scope project

The scopes of this project are:

1. The method of reliability calculation for cone laying and picking machine is presented in this report.
2. Data will be collected based on the field test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss the background of the cone laying and picking machine and reliability calculation. The starting point will be discussing the cone laying and picking machine and comparing the other type of cone laying and picking machine available in the market. The components, design, and operation of the cone laying and picking machine will be discussed in this chapter. The pro and cons between cone laying and picking machine and cone laying and picking machine in the market also will be discussed. Next, the details about a reliability calculation also will be discussed in this chapter such as mean time to repair (MTTR), mean time to failure (MTTF), mean time between failure (MTBF), mean time between repair (MTBR) and overall equipment effectiveness (OEE) for every component on this machine during field test.

2.2 Cone laying and picking machine

Cone laying and picking machine is a portable cone laying and picking system. It is an innovative and ergonomic product design that can potentially improve the efficiency of road closure operations. It can be installed in various sizes of a lorry without the need for modification to the existing vehicle. It possesses the ability to lay cones either in a straight or curve pattern by sliding the machine along the tailgate of the lorry. It is powered by using a 24V lead iron battery or directly connected to the power source of the vehicle. No other types of power sources are permitted. The cone laying and picking machine is built with three central systems, which are the testbed,

cone machine, and the guiding post. The testbed is attached at the rear end of the lorry tailgate and becomes the hooking point of the cone machine. The cone machine is equipped with a mechanism to pick up and lay down the cone. It is the brain of the cone laying and picking system. A guiding post uses to realign the position and orientation of cones before being picked up by the machine.

Figure 2.1: Cone laying and picking machine

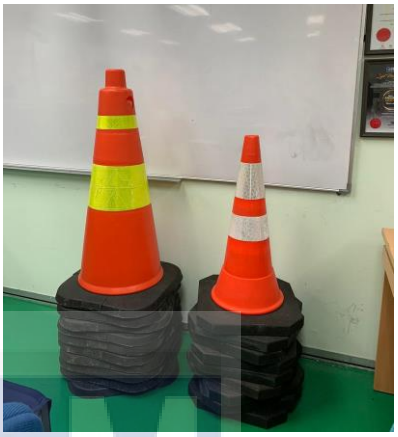

Figure 2.2: Type of cones

2.3 Automated Cone Machine

In the mid-1990s, one of the first automatic cone positioning and retrieval products was developed and tested by researchers at CalTrans Advanced Highway Maintenance and Construction Technology Center (AHMCT). The AHMCT cone system can set cones in the forward travel direction and retrieve them either forward or reverse at speeds up to 10 mph. Just one employee is required to work. The driver monitors the retrieval and placement of cones from inside the cab of the vehicle. The machine was designed like that in unusual situations, manual operation, as currently done, would always be feasible. It was designed to accommodate 28-inch generic cones and can hold roughly 80 cones on-board. On either the left or right side, the AHMCT Cone

System could retrieve upright or knocked-over cones while travelling either in the forward or reverse direction (Jennings et al., 2013). For research purposes, the AHMCT Cone Computer was developed and never used by CalTrans employees in the field. It was promoted by a corporation in California but due to licensing concerns, it is not actually available for purchase. It also not clear if these problems will be settled at any time in the immediate future (Theiss, 2017). This machine's most significant disadvantage is its cost, with a retail value of RM242,670.00 to RM323,560.00. Another disadvantage cannot be used by trucks other than CalTrans truck. These two downfalls are essential, especially comparing to the lower cost and greater flexibility of the AutoCone (Ferreira, 2019).

Figure 2.1: Automated Cone Machine (White, 2007)

2.4 Centreville AutoCone

The Centreville AutoCone is manufactured in both trailer-mounted and truck-mounted formats by Centreville Manufacturing, Inc. The Centreville AutoCone machine is designed and marketed by Centreville Trailer as a fully automatic cone positioning and retrieval system. A standard half-ton pickup truck can be towed and operated by the truck driver using the trucks light switch and turn signals. The trailer

consists of a large circular storage chamber that holds up to 500, 28-inch cones, as shown in Figure 4. There is a mechanical arm at the front of the trailer which distributes cone to either side of the trailer and a retrieving chute that can pick up the cones and return them to the storage chamber (Theiss, 2017).


Figure 2.2: Centreville AutoCone Machine (Theiss, 2017)

The Minnesota Department of Transportation (MnDOT) recently bought a Centreville AutoCone and had the equipment mounted on a truck that owned by MnDOT. In May 2016, MnDOT took delivery of the retrofitted Centreville AutoCone truck at the cost of about RM320,840 and maintenance crews have been using the equipment for one year (Theiss, 2017).

The most significant disadvantage to this system is that the positioning of the cones depends on gravity. It can be inconsistent using gravity and does not always place the cone in the right direction. Another disadvantage is that this approach only fits with cones with a fifteen-inch base, but the Centreville manufacturing is trying to create ways to fit cones of varying sizes (Ferreira, 2019).

2.5 Comparison of cone laying and picking machine

Table 2.1: Comparison of Cone laying and picking machine (Lee & White, 2011), (Theiss, 2017), (Ferreira, 2019).

Characteristics	Cone laying and picking machine	Automated Cone Machine	Centreville AutoCone Machine
Loading space	Rear only	Side panels	Side panels
Cone capacity	400	80	500
Dimension loading space, (mm)	4000 x 2400	4150 x 2080	4000 x 2400
Stowage system	None	Single	double
Operating	Belt and DC motor with a control system (PLC)	Belt with a control system	Actuator mechanism with a control system
Laying shape	Straight and curve	Straight	Straight
Power source	DC motor and belt	Hydraulic and pneumatic	Hydraulic and pneumatic
Sensors	Proximity and metallic sensors	Pressure, potentiometer, detection	Potentiometer, displacement and detection
Control system	PLC	PID	Active force
Attach and detach	Removable	No	No
Cone position	Left and right	left	Left and right
Feature of Truck			
Price, RM	42,000.00 (without truck)	242,670.00 - 323,560.00	320,840.00 and above

2.6 Mean time to repair (MTTR)

Mean time to repair (MTTR) is fundamental manufacturing systems analysis, quality management, and design. In reality, MTTR is used analytically in every method for measuring efficiency and other performance indicators of production systems (Alavian et al., 2019). . It represents the average time required to repair a failed component or device but in this report refers to the amount of time requires to repair a system or restore it to full functionality. The formula that usually used for mean time to repair (MTTR) is as follows in equation 2.1, according to (Daniewski et al., 2018).

$$MTTR = \frac{The\ time\ of\ repair}{Number\ of\ failures} \tag{2.1}$$

2.7 Mean time to failure (MTTF)

Mean time to failure (MTTF) is a non-repairable system and essential reliability measurement. It is the estimated mean time before a piece of a component fails for the first time. MTTF is a mathematical value that is supposed to be the sum of many units over a long time of period. Technically, the mean time between failure (MTBF) should be used only for a repairable component. In contrast, mean time to failure (MTTF) should be used for non-repairable components (Stanley, 2015). According to (Daniewski et al., 2018), the formula for mean time to failure is shown in equation 2.2.

$$MTTF = MTBF - MTTR \tag{2.2}$$

2.8 Mean time between failure (MTBF)

Mean time between failure (MTBF) is a reliability concept used to provide a product with several failures every million hours. This is a regular inquiry about a product life span and it is crucial in the end-users decision-making process (Stanley, 2015). Next, the mean time between failure (MTBF) is the maintenance department