DESIGN OPTIMIZATION ON
POWER TRAIN SYSTEM FOR FIRE FIGHTING MACHINE

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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POWER TRAIN SYSTEM FOR FIRE FIGHTING MACHINE

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This report is presented in

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"I declare this report is on my own work except for summary and quotes that I have mentioned its sources"

Signature : ……..

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Dedicated to my beloved mom and dad, thank you all for all that you have done. Hard times are now turned into times of pride. I have gone through so many different stages changing ideas and goals while searching for the right kind of life for me. You were always ready to help me at all times. It must have seemed like I would never follow one straight path. Now that I know what I am doing and where I am going I can only show you my extreme appreciation for your support by being true to all the ideals and values that you tried to teach me. Thank you forever for standing by me. I love and appreciate you forever. May Allah S.W.T bless you with happiness and give a good health all of the time. Wassalam.

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ABSTRAK

Kajian untuk Projek Sarjana Muda ini adalah berkenaan penambahbaikan rekabentuk pada sistem penghantaran kuasa mesin pemadam api, untuk meningkatkan sistem pacuan Mesin Fire Fighter UTeM, atau dikenali sebagai UFFM (UTeM Fire Fighter Machine). Oleh kerana UFFM masih dalam peringkat kajian dan pembangunan, terdapat beberapa perkara yang boleh dipertingkatkan setelah pemantauan dibuat ke atas mesin. Masalah utama yang terlibat pada mesin adalah kelajuan maksimum yang rendah dan pembelokan yang perlahan. Untuk kajian ini, fokus terhadap peningkatan sistem penghantaran kuasa UFFM untuk mencapai objektif dan skop. Pada rekabentuk yang asal, mesin ini menggunakan satu motor dan satu transmisi dimana kuasa tersebut disalurkan kepada rerantai getah. Semasa membelok, transmisi akan menyahaktifkan syaf pemacu sebelah dalam mesin. Objektif projek ini adalah untuk mengkaji mekanisma sistem pacuan dan rekabentuk pembaikan sistem penghantaran kuasa UFFM, dan mengerjakan pacuan dan membolehkan mesin untuk bergerak lebih lancar. Skop kajian ini difokuskan kepada sistem pacuan mesin, untuk melancar dan mempercepatkan proses membelok. Berdasarkan kajian terdahulu, penggunaan dua unit motor lebih efektif. Seterusnya, rekabentuk sistem pacuan dua motor akan dibawa lebih lanjut, dengan rekabentuk dan ganjalan yang sesuai, selain menaiktaraf sistem stereng UFFM.

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ABSTRACT

The research for 'Projek Sarjana Muda (PSM)' is about design optimization on power train system for fire fighting machine, which is to improve drivetrain of UTeM's Fire Fighter Machine, known as The UFFM (UTeM Fire Fighter Machine). Since the UFFM is still under research and development (R&D), there are several matters have been discovered, that can be improved; after inspecting the machine. The main problems are low maximum speed and slow turning. For this study, the improvement of power train on the UFFM is focused in order to meet the objective and scope. On the existing design, UFFM uses one motor and one transmission where the power is transferred to the rubber track. While turning, the transmission will deactivate inner side drive shaft of the machine. The objective of this project is to study the drive train mechanism and design improvement the power train system of the UFFM. Besides that, the existing drive train is reworked and enables the machine to move more accurately. The scope of this research is focused on the machine's drive train, which is to make the steer process smooth and quick. Based on previous study, the implementation of two motors is more effective. Thus, the dual motor drive setup will be carried further with suitable design and mountings, and improve the steering system.

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LIST OF SYMBOLS

ω	=	Angular speed, rad/s
N	=	Rotational speed per minute, RPM
P	=	Power, W
T	=	Torque, N.m
V	=	Electromotive force/voltage, V
I	=	Current, A
η	=	Efficiency
G	=	Percentage of slip between belt and drive sheave, %
T_c	=	Centrifugal tension, N

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LIST OF EQUATIONS

EQ.	ELEMENTS		UNIT
2.1	Angular Speed,	$\omega = \frac{2\pi N}{60}$	rad/s
2.2	Power,	$P = T\omega$	Watt
2.3	Distance,	$D = \pi d$	m
4.1	Torque,	$T = (5252 \times HP) / N$	lb-ft
4.2	Horsepower,	$HP = (V \times I \times \eta) / 746$	hp
4.3	Velocity,	$N_2 = N_1 / 2$	rpm
4.4	Linear speed,	$v = r\omega$	m/s
4.5	Linear speed,	$v_1 = (\pi d_1 N_1) / 60$	m/s
4.6	Ratio,	$n = N_2/N_1 = d_1 / d_2$	-
4.7	Ratio,	$N_2 / N_1 = [1- (G_1 + G_2) / 100]$	-
4.8	Centrifugal tension,	$Tc = m.v^2$	N
4.9	Torque motor,	$\tau_{motor} = F_1 . r_1$	Nm
4.10	Flat belt ratio,	$e^{\mu\theta} = [(T1 – Tc) / T2 – Tc)]$	-
4.11	Contact angle,	$\theta_d = \sin^{-1} [(D – d) / 2C]$	^{o}

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EQ.	ELEMENTS		UNIT
4.12		$\omega = \gamma bt$	N/m^3
4.13	Centripetal force,	$F_c = (w / g).V^2$	N
4.14	Torque,	$T = (H_{nom}.K_s.\ n_d) / 2\pi n$	Nm
4.15	Allowable force,	$F_1 - F_2 = (2T) / d$	N
5.1	Motor power,	$P = T\omega$	W
5.2	Rotation ratio,	$n = \omega_{motor} / \omega_{drive\ shaft}$	-
5.3	Torque,	$\tau_{drive\ shaft} = \tau_{motor}$. rotation ratio	Nm

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NOMENCLATURE

UFFM	UTeM's Fire Fighter Machine
N/A	Not Available
CAD	Computer-Aided Design
DC	Direct Current
R&D	Research & Development
RPM	Revolutions per Minute
CVT	Continuously Variable Transmission
ICE	Internal Combustion Engine
PDA	Personal Digital Assistant
NEMA	National Electrical Manufacturers Association
FOS	Factor of Safety

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CHAPTER I

INTRODUCTION

In 2007, UTeM has developed its very own fire fighting machine under the Faculty of Mechanical Engineering, in collaboration with local engineering company, Ritz Power Mechanics Sdn. Bhd.. Named as 'UTeM Fire Fighter Machine', the machine is controlled via radio frequency control, which allows the operator to send the machine to potential site while the operator stays at the safe site. This research helps the firemen to put out fire in high risk areas like factory, forests and war site. Many dangerous tasks can be solved and firemen's life can be secured by using the UFFM.

Currently, there are several weaknesses of the machine, such as overall design, cooling system, electrical system, and drive train. In this project, the task is to upgrade the drive train, as the machine is having difficulties to turn quickly. This study is actually the contribution from the past research, where the upgrade and research progress on several setup can be performed on the machine, including improving the machine's drive train and steering system.

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Figure 1.1: UTeM's Fire Fighter Machine

1.1 Project Significant

This project will improve the power train mechanism on the UFFM with variable speed and improve the steering system. Once the objective is achieved, the UFFM will be capable to reach a high risk spot in a short period, thus putting out fire quickly.

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