

**MODULAR DESIGN OF FOURTH GENERATION FOR FIRE FIGHTING
GROUND VEHICLE**

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GROUND VEHICLE**

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**A thesis submitted in partial fulfilment of the requirements for the award of
degree Bachelor of Mechanical Engineering (Automotive) with honours.**

**Fakulti Kejuruteraan Mekanikal
Universiti Teknikal Malaysia Melaka**

JUNE 2013

PENGESAHAN

" Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap - tiap satunya saya telah jelaskan sumbernya."

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Author :

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Special delicate to beloved late mother, father, and to all my family member.

ACKNOWLEDGEMENT

In development to accomplished this thesis, author like to thanks to all people that involves in finish this research either directly or indirectly. many people for guidance and the help of several individuals in one way or another to complete this report successfully.

First, thanks to Allah for giving the strength and health to accomplished this subject successful. A million thanks I would like to my parent and all my family members that give me all the support in accomplished this project. Whether in strength or financially. Without them this project will not complete successfully.

Next, I would like to upon my thank to Ir. Dr. Tan Chee Fai as my project supervisor that give me an opportunity and believe in me to do this research . I really appreciate all the guides that he give to me from the very beginning of this subject until it finish. All the guides and all cooperation that been given I highly appreciate it.

Last but not least, a millions thank to my fellow friends, Noor Azleen binti Tajul Ariffin and Noel Nabor that helps me in this project by giving the helps, guides and useful opinion I need to finish this project successful.

ABSTRAK

Dalam tesis ini menunjukkan, sambungan penyelidikan reka bentuk generasi baru kenderaan darat Bomba (FiGOV) dengan menggunakan pendekatan reka bentuk modular. FiGOV adalah kenderaan darat tanpa pemandu juga dikenali sebagai mesin mudah alih yang telah dipasang pada casis tegar yang boleh digunakan untuk mencapai beberapa tugas, iaitu menyelesaikan tugas bomba. FiGOV dapat mengurangkan jumlah nyawa yang terkorban pada situasi kebakaran. Oleh sebab itu, pembangunan FiGOV berkembang tahun demi tahun. Generasi FiGOV sebelumnya, generasi ketiga, telah dilengkapi secara kekal dengan sepasang tugas iaitu sistem penyemburan air dan kamera pengawasan yang terhad dalam membantu memberikan gambaran yang jelas dalam keadaan kebakaran dan juga menyediakan sistem semburan air yang tinggi dengan menghalakan muncung air pada ketinggian yang berbeza tanpa menanggalkan satu tugas dari FiGOV. Disebabkan masalah ini, generasi keempat FiGOV telah bangunkan dengan meningkatkan pelbagai tugas dengan pendekatan reka bentuk modular kepadanya. Modular boleh menyediakan lebih fleksibiliti, lebih banyak fungsi dan keupayaan mesra pengguna yang tinggi. Pendekatan reka bentuk telah dilengkapi dengan proses yang lengkap bermula dengan taklimat reka bentuk akan diadakan dalam kalangan kumpulan pelajar dan antara jurutera dari industri untuk membincangkan dan menyumbangkan idea reka bentuk modular FiGOV. Daripada idea-idea ini, ia akan digunakan dalam menetapkan penggunaan spesifikasi produk reka bentuk sebagai panduan dalam menghasilkan beberapa reka bentuk konsep untuk dipilih menggunakan kaedah objektif berwajaran. Analisis reka bentuk itu kaedah pemilihan bolt, analisis FEA akan mengukuhkan reka bentuk yang telah pilih. Reka bentuk terperinci akan ditetapkan oleh bantuan daripada CATIA. Akhirnya, salah satu mekanisme modular akan dihasilkan berdasarkan proses kaedah rekabentuk dibincangkan pada tesis ini

ABSTRACT

In this thesis shows, continues research of designing new generation of Fire Fighting ground vehicle (FiGOV) by applying modular design approach. FiGOV is an unmanned ground vehicle also known as mobile machine that been mounted on rigid chassis that can be use to achieve several task in this case completing fire fighting task. FiGOV helps to reduce life sacrifice by fire fighter on fire situation. From this reason, development of FiGOV has been growth in many generation through the years. Previous generation of FiGOV, third generation, has been complete permanently equipped with couple task that are water spraying system and surveillance camera. This two task are attach to FiGOV that occur limited task in helping fire fighter by only provided clear view in fire situation and also provide water spraying system which elevated the nozzle with different heights simultaneously or alternatively without detach one task from the FiGOV. Due to this problem, the fourth generation of FiGOV has been develop by enhance multi tasking with modular design approach. Modularity can provide more flexibility, more functionality and high ability of user friendly. This design approach has been complete with proper design development process starting with design briefing will held among of group of student and between engineer from industry to discuss and brainstorming ideas of modular design of FiGOV. From those ideas, it will be use in set product design specification use as guides in producing several concept design to be choose using weighted objective method. Analysis of design such bolt selection method, FEA analysis will strengthen design that been choose. Detail design will be set by assist of CATIA. Finally, one modular mechanism will be produce based on the design process method discuss on this thesis.

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LIST OF SYMBOLS

SYMBOL	TITLE	UNIT
L_t	Thread Length	<i>mm</i>
K	Torque Factors	
F_i	Preload	<i>kip</i>
F_p	Proof Load	<i>N</i>
A_t	Fine-Pitch Tensile-Stress Area	<i>mm²</i>
S_p	Minimum Proof Strength	<i>MPa</i>
T	Torque Wrench	<i>Nmm</i>
L	Fastener Length	<i>mm</i>
l	Grip Length	<i>mm</i>
l_d	Length of unthreaded portion in grip	<i>mm</i>
l_t	Length of threaded portion in grip	<i>mm</i>
A_d	Area of bolt	<i>mm²</i>
k_b	Bolt Stiffness	<i>N/mm</i>
E	Young Modulus	<i>kg/s</i>
C	Stiffness Constant	
P	Pressure each bolt	<i>N</i>
n_l	Load safety Factor	
n_p	Yielding Factor of Safety	
n_o	Load factor guarding against joint separation	

LIST OF ABBREVIATIONS

LODD	=	Line of Duty Deaths
FiGOV	=	Fire Fighting Ground Vehicle
FEA	=	Finite Element Analysis
UGV	=	Unmanned Ground Vehicle
USA	=	United State of America
RPN	=	Risk Priority Number
CAD	=	Computer Aided Design
CAM	=	Computer Aided Manufacturings
UTeM	=	Universiti Teknikal Malaysia Melaka
PDS	=	Product Design Specification

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Fire fighter is one of most extreme career that involving many risk. Fire fighter involve always in dangerous area due to save other civilian life. Fire Fighter are responsible in many dangerous situation such as fire situation, and hazardous situation whether causing to remove poisonous animal on their house (Jones *et. al*, 2009). Fire fighter fatalities maintain at high level of lives been lost due to this career. Amount of lost of lives of fire fighter keep increasing every year not only in Malaysia but almost every countries in the world. It will continues if no solution have been take to help the fire fighter to complete their task. One of the way by involving development of technologies in improve fire fighting techniques. In additional, effect of fatigue in doing this job also take a big role of one of the problem occur to fire fighter. They must physically fit to really qualified for this job. Task that been involve such as carry their equipment of fire fighter such as flat head axe, halligan bar, tumout jacket, fire retardant or bunker pants, boots, flashlight, helmet, face mask and gloves may contribute to high amount of weight need to lift by fire fighter in complete their rescue mission. To make human to physically fit take a lot of time to develop and the number of lives lost always increase with time. This make difficulty in department of fire fighter to overcome this situation.

In the USA, the traumatic death rate amongst fire fighters shows that 1.9 fire fighters are killed per year, per 100,000 structure fires which is the rate only slightly lower that that obtained in the early 1980's (IAFF, 2000). However, this rate was

increasing to 3.0 per 100,000 structure fires across a thirty year period which is peaking in the 1990s (Kyle, 2007). There are many causes for Line of Duty Deaths (LODD) such as smoke inhalation, burns, crushing injuries and related trauma (Rosmuller *et.al.*, 2008). Cause of this situation that is rarely increase, this make a lot of design company are developing fire fighting technology to helps fire fighter. Design company that born in develop country such as United State of America, Japan and etc are start to pioneer this development. As a result, a lot of research have been create due to this technologies area. There are many studies involves in emphasized on machine development to replace fire fighter to fight fire in dangerous and other dangerous and hazardous task. In this development helps to reduce the fire fighter risk involves in dangerous and hazardous situation. The machine helps fire fighter doing their multitasking task such as water spray, lift their equipment and etc. Amano (2002) highlighted the weakness of existing machine design and suggest integration of all important elements in developing fire fighting machine so that a successful rescuing process can be achieved. One of the elements is performance of the machine that touch the element of complete the multitasking with the fastest and efficient. Therefore, this research integrates required technical aspect in designing and develop a machine that based on the end user requirements which is fire fighting rescue team.

Fire Fighting Ground Vehicle (FiGOV) is define as remote controlled mobility machine that mounted to rigid chassis. It also a system of ground vehicle that can move faster, light weight, able to complete rescue mission with fast and efficient without risking lives. This machine are equipped with wirelessly controlled remote via mobile computer that allow long-range control ability. This machine are design to help putting fire fighting task in user friendly and efficient way such as water spraying system that can direct the nozzle to different angle and can be elevated in order to control fire at different height. This can help to reduce the risk faced by fire fighters in performing their duties. Fire fighter duties are expose to hazardous conditions such as high temperature, dusty, low humidity, dangerous and others which is FiGOV can manage to handle this problem without risking people lives.