



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF EMERGENCY TYRE CHANGING TOOL
KIT WITH USING HARVESTED OF WASTE EXHAUST GAS
AS SECONDARY POWER SOURCE**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

MUHAMMAD AIDILFITRI BIN HUSIN

B071410076

920405115431

FACULTY OF ENGINEERING TECHNOLOGY

2017

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Development of Emergency Tyre Changing Tool Kit with Using Harvested Of Waste Exhaust Gas as Secondary Power Source

SESI PENGAJIAN: 2017/18 Semester 1

Saya **MUHAMMAD AIDILFITRI BIN HUSIN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. ****Sila tandakan (✓)**

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

Alamat Tetap:

Spg 4, Kampung Jongok Batu

23000, Dungun

Terengganu

Cop Rasmi:

Tarikh: _____

Tarikh: _____

**** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.**

DECLARATION

I hereby, declared this report entitled “Development of Emergency Tyre Changing Tool Kit with Using Harvested of Waste Exhaust Gas as Secondary Power Source” is the results of my own research except as cited in references.

Signature :

Author’s Name : Muhammad Aidilfitri bin Husin

Date : 15/1/2018

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

.....
(Azman bin Ibrahim)

ABSTRAK

Tayar adalah salah satu komponen utama dalam mekanisme kereta. Masalah tayar pancit adalah satu kecemasan yang tidak dapat dijangka yang boleh berlaku kepada semua pengguna kereta ketika dalam perjalanan seperti konvoi dan cara lama untuk menukar tayar memerlukan tenaga manusia dan masa untuk menyelesaikan proses menukar tayar. Masalah yang tidak diinginkan dan kemalangan seperti tekanan udara tayar rendah dalam tayar biasanya berlaku. Apabila kereta dalam perjalanan, tayar secara automatik menyentuh dengan permukaan jalan untuk membuatnya bergerak, terdapat pelbagai jenis permukaan yang berlainan di atas jalan raya. Kit alat kecemasan menukar tayar adalah tangki udara bertekanan, pam tayar dan sepana udara. Penyambung ekzos dan komponen yang melekat pada tangki udara bertekanan akan difabrikasi. SolidWorks digunakan untuk melukis reka bentuk produk. Tekanan daripada pemampat dijadikan sebagai penanda aras, tekanan telah ditetapkan pada 1 bar kepada 7 bar untuk mendapatkan masa yang diambil untuk menyiapkan kerja yang dilakukan untuk pam tayar dan 1 bar hingga 4 bar untuk melonggarkan dan mengetatkan nat tayar. Perbandingan data untuk pam tayar, melonggarkan dan mengetatkan nat tayar antara menggunakan antara kit alat kecemasan menukar tayar dan pemampat udara adalah sedikit sama. Penghasilan kit alat kecemasan menukar tayar ini telah pun memenuhi keperluan projek dan mencapai objektif.

ABSTRACT

Tyre is one of the essential components of automobile mechanism. Flat tyre problem is an unexpected emergency that could be happen to all car users while travelling such as convoy and current tyre changing method consuming human energy and time to finish the tyre changing process. The unwanted incidents and accidents problem like tyre puncture, low air pressure in tyre are commonly happened. When car is in traveling automatically tyre make a contact with the road surface to make it move, there is much different type of surfaces on the road. The emergency tyre changing tool kit is pressurized air tank, clip on air chuck and air wrench. An exhaust connector and component that attach to the pressurized air tank will be fabricated. SolidWorks is used to develop the desire product design of the product. The reciprocating compressor pressure is the benchmark, the pressure was set 1 bar to 7 bar in order to obtain time taken to work done for inflate tyre and 1 bar to 4 bar for loosen and tighten tyre nut. Comparison of data inflate tyre, loosening and tightening the tyre nut by using between reciprocating and emergency tyre changing tool kit was similar. The development of emergency tyre changing tool kit with using harvested of waste exhaust gas as secondary power source has fulfilled the project requirement and achieved the objective.

DEDICATION

To my beloved parents Haji Husin bin Jusoh and Hajjah Maziah binti Muda, family,
lecturers, teaching engineers and friends

ACKNOWLEDGEMENT

I am grateful and would like to express my sincere appreciation and thanks to my supervisor, Azman bin Ibrahim for his invaluable guidance, encouragement and support to me in order to complete my final year project. I really appreciate and grateful for his guidance to me from beginning until the final process of the final year project. Not to be forgotten to Luqman Hakim bin Hamzah as the Co-Supervisor that continuously support and give the valuable technical assist to complete my final year report.

My sincere thanks goes to assistant engineer especially Mohd Syakir bin Mohtarudin that help me a lot during testing session of my final year project, all lecturers and members of the staff of the Mechanical Engineering Technology Department, UTeM, who helped me in many ways and make my education journey at UTeM pleasant and unforgettable. I would like to thanks to my classmates with their excellent co-operation, inspiration and supports during this study.

TABLE OF CONTENT

Abstrak	v
Abstract	vi
Dedication	vii
Acknowledgement	viii
Table of Content	ix
List of Tables	xiii
List of Figures	xiv
List Abbreviations, Symbols and Nomenclatures	xvii
CHAPTER 1: INTRODUCTION	1
1.1 Historical Development of Tyre	1
1.2 Tyre Technology Overview	2
1.3 Road surface factor related to the tyre problem	2
1.4 Statistical of vehicle registered in years	3
1.5 Problem statement	4
1.6 Objective	5
1.7 Scope	5
CHAPTER 2: LITERATURE REVIEW	7
2.1 Air pressurize source	7
2.1.1 Different between car engine and reciprocating compressor	7
2.2 Car Engine	8
2.2.1 Historical Development of Car Engine	8
2.2.2 Operation	10
2.2.3 Compression ratio	12
2.2.4 Cubic Centimetres (CC) of car engine	14
2.2.4.1 1000cc engine	15
2.2.4.2 1500cc engine	16
2.3 Compressor	17
2.3.1 Dynamic	18
	ix

2.3.2	Positive displacement	19
2.3.2.1	Reciprocating	19
2.3.2.2	Single acting and double acting	19
2.4	Previous method	20
2.4.1	Tyre inflate	20
2.4.2	Tyre changing	22
2.4.3	Previous tire repair tool kit	24
2.4.3.1	Slime 50107 Smart Spair Emergency Tire Repair Kit	24
2.4.3.2	Fix-A-Flat S50073 Ultimate 1-Step Tire Repair Kit	24
2.5	Car convoy in Malaysia	26
 CHAPTER 3: METHODOLOGY		27
3.1	Flow chart overview	27
3.2	Project flow chart	28
3.3	Project requirement	29
3.4	Design process	31
3.4.1	Conceptual design	31
3.4.2	Detailed design	32
3.4.3	SolidWorks as design software	32
3.4.4	Final design	33
3.5	Material selection	33
3.6	Fabrication	35
3.7	Prototype	35
3.7	Data collection	35
3.7.1	Engine compression pressure measurement	36
3.8	Result	38
 CHAPTER 4: RESULT & DISCUSSION		39
4.1	Introduction	39
4.2	Product design specification	39
4.2.1	Product design specification for development of emergency tyre changing tool kit	39
4.2.2	House of quality	41

4.2.3	Morphology Chart	44
4.3	Conceptual design	46
4.3.1	Concept design of emergency tyre changing tool kit	47
4.3.1.1	Concept design 1	47
4.3.1.2	Concept design 2	48
4.3.2	Concept design of exhaust connector	49
4.3.2.1	Concept design 1	49
4.3.2.2	Concept design 2	50
4.4	CAD drawing concept	51
4.4.1	Concept design of emergency tyre changing tool kit	51
4.4.1.1	Concept design 1	51
4.4.1.2	Concept design 2	52
4.4.2	Concept design of exhaust connector	53
4.4.2.1	Concept design 1	53
4.4.2.2	Concept design 2	54
4.5	Conceptual evaluation	55
4.5.1	Concept screening	55
4.6	Detail design	57
4.6.1	Part drawing	57
4.6.2	Assembly drawing	57
4.6.3	Exploded view	59
4.7	Material selection	60
4.8	Prototype	64
4.9	Testing and data collection	65
4.9.1	Direct from exhaust	65
4.9.2	PVC tank	67
4.9.3	Steel Tank	68
4.10	Inflate tyre	68
4.10.1	Using reciprocating compressor	70
4.10.2	Using steel tank	72
4.10.3	Comparison	73
4.11	Loosen and tighten the tyre nut	74
4.11.1	Using reciprocating compressor	75

4.11.2 Using steel tank	76
4.11.3 Comparison	78
4.12 Inflate tyre using exhaust gas	79
CHAPTER 5: CONCLUSION & FUTURE WORK	80
5.1 Conclusion	80
5.2 Future work	81
5.3 Potential Commercialization	82
REFERENCES	83
APPENDICES	88
Part drawing and dimension	
Torque setting for wheel bolts and nuts	
Procedure to measure the tyre pressure	
Procedure to check the tyre nut torque	

LIST OF TABLES

1.1	Summary of new passenger & commercial vehicles registered in Malaysia for the year 1980 to 2016	4
3.1	Four stage of material selection	34
4.1	Product design specification for development of emergency tyre changing tool kit	40
4.2	Morphology chart for development of emergency tyre changing tool kit.	45
4.3	Parts with option	47
4.4	Parts with option	48
4.5	Parts with option	49
4.6	Parts with option	50
4.7	Concept evaluation using screening matrix of emergency tyre changing tool kit	56
4.8	Concept evaluation using screening matrix of exhaust connector	56
4.9	Material selection for tank	60
4.10	Material selection for piping	61
4.11	Material selection for valve	62
4.12	Material selection for fitting	63
4.13	Inflate tyre using reciprocating compressor	70
4.14	Inflate tyre using steel tank	72
4.15	Loosen nut using compressor	75
4.16	Tighten nut using compressor	76
4.17	Loosen nut using steel tank	77
4.18	Tighten nut using steel tank	77
4.19	Inflate tyre by using exhaust gas	79

LIST OF FIGURES

2.1	Basic operation of an engine	10
2.2	Basic operation of four stroke engine	12
2.3	Compression ratio 7:1 and 8:1	13
2.4	Bore and stroke of an engine	15
2.5	Three cylinder engine	16
2.6	Four cylinder engine	17
2.7	Type of compressor	18
2.8	A three-stage single-acting reciprocating compressor	20
2.9	Reciprocating air compressor	21
2.10	Reciprocating air compressor at petrol pump station	21
2.11	Inflate tyre at petrol pump station	22
2.12	Tyre changing by using cross wheel spanner	22
2.13	Air wrench specification	23
2.14	Tyre changing by using air wrench	23
2.15	Slime emergency tyre repair tool kit	24
2.16	Fix-A-Flat emergency tyre repair tool kit	25
3.1	Project flow chart	28
3.2	Six major components of HOQ	30
3.3	Example of House of Quality	30
3.4	Example of Morphology Chart of chair	31
3.5	Data of engine compression pressure	36
3.6	Motometer	36
3.7	Position of Motometer mounted into engine	37
3.8	Observation process	37
4.1	House of Quality for development of emergency tyre changing tool kit	43
4.2	Concept design 1	47

4.3	Concept design 2	48
4.4	Concept design 1	49
4.5	Concept design 2	50
4.6	CAD concept design 1	51
4.7	CAD concept design 2	52
4.8	CAD concept design 1	53
4.9	CAD concept design 2	54
4.10	Assembly drawing of emergency tyre changing tool kit with using harvested of waste exhaust gas as secondary power source	58
4.11	Exploded view of the product	59
4.12	Prototype of emergency tyre changing tool kit with using harvested of waste exhaust gas as secondary power source	64
4.13	Direct exhaust testing	65
4.14	Additional parts	66
4.15	PVC tank	67
4.16	Steel tank	68
4.17	Procedure to inflate tyre	69
4.18	Reciprocating compressor	70
4.19	Inflate tyre process	71
4.20	Compress air into steel tank	72
4.21	Before and after inflate	73
4.22	Time versus Pressure graph for inflate tyre	74
4.23	Wheel rim hub flange	74
4.24	Loosen and tighten tyre nut	78
4.25	Time versus Pressure graph for loosen and tighten nut	79

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

BC	-	Before Century
BC	-	Bottom-Center
CC	-	Cubic Centimetres
CI	-	Cubic Inches
CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
CAM	-	Computer Aided Manufacturing
HOQ	-	House of Quality
kPa	-	Kilopascal
MAA	-	Malaysian Automotive Association
NMVCCS	-	National Motor Vehicle Crash Causation Survey
OICA	-	Organisation Internationale des Constructeurs d'Automobiles
PLM	-	Product Lifecycle Management
psi	-	Pounds per Square Inch
QFD	-	Quality Function Deployment
R_c	-	Compression ratio
RM	-	Ringgit Malaysia
RMA	-	Rubber Manufacturer's Association
rpm	-	Revolutions per minute
TC	-	Top-Center
TPMS	-	Tire Pressure Monitoring System
V_c	-	Clearance volume
V_d	-	Displacement volume

CHAPTER 1

INTRODUCTION

1.1 Historical Development of Tyre

In American English its called tire, while is in British English its called tyre. The first tyre in history was ever found is made from leather in ancient Mesopotamia (Bertman, 2009). The purpose of the tyre in ancient Mesopotamia is to move the Mesopotamian chariots and researchers agreed that the first wheel for transportation purposes is approximated to 3200 BC. Long time ago the invention of tyre started with the use of the wheel, using a log or its x-section. The tyre then was invented into common use on the wheels of carts or horse carts. Tyre is one of the essential components of automobile mechanism, without tyre the vehicle cannot move because tyre provides traction between the road and the vehicle while it is acting as cushion that absorbs shock. The tyre produces the braking forces and conveying driving in transmission system. The tyre facilitating steering of the vehicle while turning and acting as the bearing to support load of the vehicle (Wong, 2001).

In the middle of the 19th century, the Scottish inventor R.W. Thomson was invented the first pneumatic tyre; however this never went into production, after that pneumatic tyre for automobile was invented at the end of 19th century after another scots-born, John Boyd Dunlop reinvented pneumatic tyre to reduce the vibration of tricycle that ridden by his son Johnnie that cause of headaches while riding his tricycle on the rough pavements (Ishikawa, 2011). During that time it was a perfect timing because bicycles was become the most popular topics and the lighter tire gave a vastly improved ride and Dunlop turned out to be popular with bicyclists (Du Cros,

1938). The pneumatic invention is began after an upgrade from solid rubber tyre that made up from only firm rubber without inflate of air into tyre. The solid tire rubber is used for the low speed vehicle despite lack if poor shock absorption ability. Although these tyres are strong and resisted to the cuts and abrasions, it was a heavy tyre and cannot provide a smooth ride.

1.2 Tyre Technology Overview

Tyre basically made up over 20 or more component with more than 15 rubber compound that assembled together in typical radial passenger car tire and big grandeur amount of machinery and well prepared involved many process to the finished product. Tyre basically involving in four basic functions that is vehicle to road interface which is provide interface between vehicle and the road, support the vehicle load, road surface friction involving start, stop and steer the tyre that produced from contact between road surface and surface of tyre, and absorbs road irregularities in which absorbs impacts during vehicle on travel.

There are several type of tyres, diagonal, belted bias and radial. On achieving the safety of the tyre, an organization known as The Tire and Rim Association, Inc (TRA) provide the standards of tyre industry about the sizing and dimension. Load capacity of the tyre also should not be ignored, TRA provide the table of load rating and load carrying capacity of tyre. TRA also established the load index and speed rating for the tyre (Potenger, 2006).

1.3 Road surface factor related to the tyre problem

In leading of the benefit of automotive to the people there is also presence of the problem that related to the car that is the flat of tyre. The unwanted incidents and accidents problem like tyre puncture, low air pressure in tyre are commonly happen when the car is in travelling (John et al. 2016). Unwanted incident is one of the unpredicted problems to occur that is out of our vision. Many of factor that influence

to the potential of the problem to be occur such as environment, temperature, edged object, road surface and many more that can change the some properties in the tyre. On other hand lack of concerned by the car user to check their tyre regularly and not take it as a habit they just let away their tyre run without the observation and maintenance.

A survey was conducted in United State of America on 2012, National Motor Vehicle Crash Causation Survey (NMVCCS) recorded between January 2005 and December 2007 there is 6,949 crashes involving tyre-related factor. From this survey it means that tyre is the main factor that causes an accident happened to the car and maybe it will be lead to the fatal or make the human handicapped (U.S. Department of & Transportation 2008).

1.4 Statistical of vehicle registered in years

Throughout the 21th century, our country witnessed a rapid development in the transport sector. The development is never ending, human everyday make an invention on transportation system. They always invent and improve all new thing everyday and it will continuously. Based on 2016 production statistic by Organisation Internationale des Constructeurs d'Automobiles (OICA) also known as International Organization of Motor Vehicle Manufacturers, Malaysia was ranked 24th country in the world that produce the vehicles in amount of 469,720 cars and ranked 7th country in asia behind China, Japan, South Korea, India, Indonesia and Thailand.

Information that retrieve from Malaysian Automotive Association(MAA), summary of new passenger and commercial vehicles registered in Malaysia for the year 1980 to 2016 is shows the increasing amount of vehicles registered. The data is shown in table 1.1.

Table 1.1: Summary of new passenger & commercial vehicles registered in Malaysia for the year 1980 to 2016 (Malaysian Automotive Association, 2016)

Year	Passenger Cars	Commercial Vehicles	4x4 Vehicles	Total Vehicles
1980	80,420	16,842	-	97,262
1985	63,857	26,742	4,400	94,999
1990	106,454	51,420	7,987	165,861
1995	224,991	47,235	13,566	285,792
2000	282,103	33,732	27,338	343,173
2005	416,692	97,820	37,804	552,316
2006	366,738	90,471	33,559	490,768
2007	442,885	44,291	-	487,176
2008	497,459	50,656	-	548,115
2009	486,342	50,563	-	536,905
2010	543,594	61,562	-	605,156
2011	535,113	65,010	-	600,123
2012	552,189	75,564	-	627,753
2013	576,657	79,136	-	655,793
2014	588,341	78,124	-	666,465
2015	591,298	75,376	-	666,674
YTD 2016	514,545	65,579	-	580,124

1.5 Problem statement

Flat tyre problem is an unexpected emergency that could be happen to all car users while travelling such as convoy event with mostly involving long distance and travelling along road where tyre workshop and pump station are not reachable and current tyre changing method consuming human energy and time to finish the tyre changing process. When car is in travelling automatically tyre make a contact with the road surface to make it move, there is much different type of surfaces on the road. Contact between the tyre and road is extremely complex and highly non-linear. tread block make a contact with the road surface due to the mechanical behaviour

and predefines to the way of contact between tyre and the road. The road surface is made out of stones, sand, filler and fastener and consequently involves a substantial scope of surface wavelengths that straightforwardly impact the tire's execution. Tyre is the most important part that is to transmit the all normal and tangential forces (Gäbel et al. 2008). Without the tyre the car will resulted the useless of their role and that is why tyre is remain one of the first thing to be concerned among the another parts

In other hand, it is the difficult work to changing tyre for some individuals particularly ladies and elderly individuals. This because women have the limitation of energy compared to the men and this task is not suitable task for ladies to perform. For the elderly individuals also have the same reasons as the women. If older people that have reach age in 50 and above there easily will lead to the illness.

1.6 Objective

- Development of Emergency Tyre Changing Tool Kit with Using Harvested of Waste Exhaust Gas as Secondary Power Source
- To test the newly fabricated tool kit

1.7 Scope

This study will focus on development of emergency tyre changing tool kit with using harvested of waste exhaust gas as secondary power source. Below are the listed scopes of this project:-

- 1 Mpa@10 Bar Pressure tank
- Single tip exhaust
- 2 inch exhaust tip size
- Conventional 1500cc engine

- Vehicle type car

Below are the parameter of this project;-

- 29 PSI@200 kPa to inflate tyre pressure
- 120Nm to tighten tyre bolt

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will provide the literature review about the project since is development of emergency tyre changing tool kit with using harvested of waste exhaust gas as secondary power source. As mentioned early the waste car exhaust gas is act as the secondary power source, mean that the source is coming from car engine after the working process during the engine is in running state which is from the intake stroke until the exhaust stroke. In this chapter also provide the literature review about the compressor that has the similarity with the working principle of car engine.

2.1.1 Difference between car engine and reciprocating compressor

The reciprocating compressor is the positive displacement compressor which utilizes the piston in the cylinder as to decrease the volume of cylinder to produce the high pressure. The reciprocating can be divided into single acting and double acting. This compressor called as the reciprocating since the movement of piston is back and forth in a reciprocal motion. The car engine is use the same principle with the reciprocating compressor, however it was in reverse which is the combustion of gases push the piston, instead of the piston pushing the gas (Air Compressor Works, Inc, 2014).

2.2 Car Engine

Engine is the power plant of a vehicle (Melior, 2007). Rapid development of automotive engine seen drastically gone through tremendous change since the industry of automotive was began in the late of 19th century. Engine is the machine in order to convert the heat energy into mechanical energy that we can see through the engine working. The source of fuel basically came from coal, petrol and diesel. To feed the working substance at high temperature this heat energy acting as the supplier then the heat energy is changed over into valuable work. Heat engine is divided into two types which is External Combustion and Internal Combustion. External Combustion engine generally such as steam engine, the ignition of fuel happens outside the engine and the steam thus formed is utilized to run the engine and that why it's called as external combustion engine.

For the internal combustion engine it is opposed to the external combustion engine which is the combustion of fuel happens inside the engine cylinder (Salazar, 1998). The internal combustion engine categorized into three type which is spark ignition engine that being used for primarily automobile such as car, diesel engine that are being used by buses and trucks which is categorized as large and heavy duty vehicle and gas turbine which is utilized as a part of airplane because of its powerful and weight ratio and furthermore is utilized for stationary power generation (Flagan & Seinfeld, 1988).

2.2.1 Historical Development of Car Engine

The historical of internal combustion engine was begun in 1680 invented by Dutch physicist named Christian Huygens. He invents an internal combustion engine that use gun powder as the fuel of the engine, but it never went into production (Bram, 2006). On 1807 another inventor came from Sweetish-born, Francios Isaac de Rivaz built the first internal combustion engine that utilized a blend of hydrogen and oxygen for fuel. Unfortunately it was come up an unsuccessful design (Bizub et al., 2010). Seventeen years