



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**OPTIMISATION OF TYRE PRESSURE AND FUEL TYPE  
TOWARDS FUEL EFFICIENCY USING DESIGN OF  
EXPERIMENT METHOD**

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

by

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## DECLARATION

I hereby, declared this report entitled Optimisation of Tyre Pressure and Fuel Type towards Fuel Efficiency using Design of Experiment Method is the results of my own research except as cited in references.

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## **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 Electrical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

.....  
(Project Supervisor)

## **ABSTRAK**

Petrol atau diesel merupakan bahan bakar atau medium yang digunakan untuk menggerakkan kenderaan. Tanpa bahan bakar, kenderaan tidak akan dapat beroperasi. Kereta menggunakan bahan bakar, jadi penggunaan bahan bakar menjadi faktor yang penting yang mesti diambil kira untuk menjimatkan kos pembelian bahan bakar. Objektif utama di dalam kajian ini adalah untuk mengoptimumkan tekanan tayar dan jenis petrol yang digunakan untuk mengurangkan penggunaan bahan bakar. Objektif lain pula adalah untuk mengenalpasti faktor yang memberi kesan kepada penggunaan bahan bakar di dalam industri automotif serta jenis ujian yang berkaitan dengan ekonomi bahan bakar. Sebelum mencapai objektif, kawasan yang akan digunakan untuk eksperimen dan kelajuan tetap sepanjang perjalanan di bandar mahupun lebuh raya perlu dipilih terlebih dahulu. Faktor yang dipilih untuk menjalankan eksperimen adalah jenis petrol dan tekanan tayar. Kemudian, analisis untuk mendapatkan penggunaan bahan bakar dijalankan bagi mengenalpasti kombinasi faktor yang sesuai dengan menggunakan kaedah Design of Experiment yang diperolehi daripada perisian Design Expert versi 10. Keputusan yang diperolehi daripada pengoptimuman model bagi memaksimumkan penggunaan bahan bakar untuk kereta adalah di level yang rendah untuk jenis petrol dan level yang tinggi untuk tekanan tayar bagi ujian di lebuh raya. Manakala, bagi ujian di bandar pula, jenis petrol berada di level yang tinggi dan tekanan tayar berada di level yang rendah.

## **ABSTRACT**

Petrol or diesel are the main fuel or medium used in order to move a vehicle. It is important because without it the car cannot be operated. Car consume fuel, hence the fuel consumption is an important factor which will determine the cost spent on the fuel. The main objective of this study is optimizing the pressure of tyre and the fuel type which will minimize the fuel consumption. The other objective is to identify the factors affected the fuel consumption in automobile industry and type of test related to fuel economy. Before achieveing this objective, the place for conducting the experiment and the constant speed for driving through city and highway needed to be selected. The factors chosen for this experiment are fuel type and tyre pressure. Next, the analysis to get the fuel consumption was done to find the optimize combination of chosen factors by using Design of Experiment Method obtained from Design Expert software version 10. The result shows that the optimize model for maximizing fuel consumption of vehicle are low level of fuel type and high level of tyre pressure for highway test and high level of fuel type and low level of tyre pressure for city test.

## **DEDICATION**

To my beloved parents, my friends my Project Supervisor and whoever know the author of this report.

## **ACKNOWLEDGEMENT**

I would like to thank my Project Supervisor, Puan Norhamizah binti Miswan for her encouragement for us throughout the whole process in making this project in success. I am so glad to have my parent that always help me whether for my financial purpose and their pray. Furthermore, I also would like to thank my friend in my rent house and my classmate because they have been of help and always support me to always finish the project in my up and down.



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# CHAPTER 1

## INTRODUCTION

### 1.0 Background studies

This report focus on the study of fuel. By definition, fuel is known as material such as coal, gas or oil that is burned to produce power. As the function stated, fuel is a medium that use to produce and will distinguish as it used. In other word, fuel is a material that can be made to react so that it will release chemical energy as heat or to be used for work. The function of fuel are only been used as material to release a chemical energy but then it develop and also being applied to several work using heat energy. The way it uses heat energy is by the reaction of fuels that convert it into mechanical energy via heat engine or nowadays we use it as our vehicle.

There are several type of fuels exist which is in solid state, liquid stet and gaseous state. They are shown in the picture below. Fuel in solid state include wood, charcoal, peat, coal, hexamine fuel tablets, and some pellet made from wood such as corn, wheat, rye and other grains. For liquid type of fuel is the one that we use in the automobile which are petrol and diesel of several type. While the gaseous state fuel are the one that stored inside several types of tank such as methane or propane.



**Figure 1.1: Solid, Liquid, and Gaseous Type of Fuel**

There are many type of fuel that has been used widely throughout the world ranging from gasoline, ethanol, petroleum and even jet fuel. All of it is useful according to their thickness of fuel and it must perform for their respective machine or mechanical parts. Gasoline or which we know as petrol is a very common type of fuel used which runs the automobiles, powers up our lawn movers, use in a generator, and even used in some remote control cars.

Only about a decade ago that the fuel is much cheaper than it is right now as the demand for the fuel has increased substantially which most of us had it hard on refueling without sharing. Fuel is an important product after all and is the key resource in today society. Furthermore, fuel is being used without being thought of how to saving it and use it wisely.

For the purpose, this research will help to find a solution for fuel consumption. As fuel consumption is being used widely and for most of the people nowadays, it must be sort in order to find a way which either we find a way to reduce its consumption or a way to reduce its usage.

## **1.1 Problem statement**

This project is aimed to find the solution to minimize fuel consumption for vehicles. This research is being conducted as a way of finding a way to reduce fuel consumption as well as a method used for reducing fuel usage.

Today, there are many wastes in fuel consumption that people ignore and not consider as important information for them. Fuel as the main source to operate the automobile whether it is a car, lorry or even jet, helicopter and many other machines are non-renewable sources that worth preserve. Due to its properties of non-renewable sources, it will get to extinct in few more years. As this occurred, fuel is getting more expensive by the day.

The way used to research this problem is by using the Design of Experiment. Using this method, a set of experiment will be conducted in order to find the best condition that required for reducing fuel consumption. The detail of this method will be discussed further in the Chapter 3.



## **1.2 Objectives**

- (a) To identify the factors affected the fuel consumption in automobile and type of test related to fuel economy.
- (b) To set up the experiments of fuel consumption versus pressure on the tyres.
- (c) To find the optimum pressure of tyres and fuel type which minimize the fuel consumption by using Design of Experiment methods.

## **1.3 Scope**

Optimize the tyre pressure and fuel type towards fuel efficiency of petrol driven car using Design of Experiment methods.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

This chapter will cover on fuel efficiency, fuel economy, design of experiment and some related research.

#### **2.1 Fuel efficiency**

##### **2.1.1 Basic knowledge**

Fuel efficiency is known as the capacity of an engine, especially of a vehicle, to obtain energy from fuel. In engineering term, it is known as the proportion of energy released by a fuel combustion process which is then converted into something useful. It is often measured in miles per gallon or kilometres per litre.

Fuel efficiency is important these days are mainly because the price of the fuel has increase substantially. The following table shows the difference in fuel consumption of two cars for two different periods.

**Table 2.1: Difference in fuel consumption of two cars**

	Car A	Car B
Yearly driving average	14,750 km	14,750 km
Fuel economy	4-litres/100km	5-litres/100km
Liters required	590 liters	737 liters
Fuel cost for year (@ \$1.25/liter	\$737.50	\$921.25

The Table 2.1 shows that car A saves more than car B while travelling at the same distance. It all depends on the fuel economy of a car. If the car is running the same as car A with only 4-litres/100km, it will save more than \$100 for every full tank or every refill. Only with 1 litre different, it can be shown that the fuel efficiency are better as it only need 590 litres to travel the same distance which is 14 750km.

Furthermore, fuel efficiency is important due to high price of world fuel and increase in household sending. There are several factors that affecting fuel efficiency such as driving techniques or the driver behaviour, tyre pressure, weather condition, extra weight carried by the vehicle, aerodynamics of the vehicle and route planning or traffic congestion.

The first factor that affecting the car is from the attitude of the driver. Rapid acceleration, reckless driving, inconsistent speeding and braking will increase the fuel consumption. To avoid this, the driver must drive smoother which will give better results. Thus it will save up to 25% of fuel consumption.

The second factor is the weather condition which we could not control. The third factor is the extra weight carried by vehicle. This factor also differs to all users. As there are no people with the exact same weight all the time. The fourth and last factor is traffic congestion. This factor also can't be avoided, as there are peak hour which contribute to congestion. In addition, traffic congestion also can happen due to unpredictable accident. Due to all this factors, fuel can't be used efficiently.

## 2.2 Fuel economy

### 2.2.1 Fuel consumption

Fuel efficiency is known as the amount of fuel a vehicle uses to travel a particular distance at a particular speed. In engineering term, it is known as the process in which the fuel is completely destroyed, used up or incorporated or transform into something else such as energy or power.

It is simple on how to calculate whether a vehicle is fuel economy or not which is simply by dividing the amount of fuel used per distance travel during a journey. For example, 4 litres per kilometres is more economy compare to 5 litres per kilometres which used more fuel for the same trip. Hence, before selecting our personal car, first check the fuel economy because it will save us a lot due to the increasing in fuel price. There are several factor that affecting the fuel economy which are quick acceleration and heavy braking, cold weather or frequent short trip, carrying excessive weight or cargo, running electrical accessories.

These factors are seriously affecting the fuel consumption. If the driver drives with quick acceleration, the engine will need more fuel to burn in order to produce more power to accelerate the car. Same goes to the heavy braking, which consume the fuel as the car decelerate because fuel are consume all the time the engine running, hence by reducing the speed suddenly won't stop the usage of fuel but only will waste the amount of fuel. On the other hand, cold weather as well as frequent short trip will also require more fuel in order to heat up the engine. The engine in cold weather need to consistently provide more heat to resist the cold weather outside.

Carrying excess cargo also consume more fuel as the fact says that lighter car consume less fuel as it only need small amount of power to carry the weight forward. Nowadays, vehicles are designed to let the air slip easily through its body in order to reduce friction. Additional cargo such as bike or ski rack will make the car less aerodynamics which will increase the fuel consume to move the car forward.

Furthermore, route planning and avoiding traffic congestion is the best way of saving fuel as the fuel will always be used as the engines run.

### **2.2.2 Fuel economy standards and testing procedures**

There are several countries that emphasize the testing procedure to achieve the fuel economy and be the best in saving the fuel of their vehicles. The countries involved are Australia, Canada, New Zealand, and United States.

Starting from October 2008, Government of Australia had made compulsory for all car sellers to provide a sticker on the windscreen with information of the fuel consumption and the CO<sub>2</sub> emission. The information are stated in words as urban, extra urban and combined. This country also uses star rating based on the greenhouse effect with pollution which start from 0 to 10 with ten being the best.

As for Canada the vehicle manufacture follow strict laboratory testing to generates fuel consumption which then being submitted to the government for approval. There are 5 cycle test being conducted at this country to ensure the fuel consumption achieve is acceptable. The test consists of city test, highway test, cold operation test, air conditioning test and high speed or quick acceleration test. City test is an experiment which simulates urban driving in stop and go traffic with an average of 34 km/h and top speed of 90 km/h. This test runs for 31 minutes with total of 23 stops. It begins with cold engine start which resembles vehicle parked overnight during summer. The next test is a highway test which involve driving the car in mixture of open highway and rural road driving with an average of speed of 78 km/h and top speed of 97 km/h. The test ends in approximately 13 minutes which does not include any stops. This test begins with a hot engine start.

**Table 2.2: City test and highway test parameters**

	City test parameter	Highway test parameter
Test cell temperature	20 <sup>0</sup> - 30 <sup>0</sup>	20 <sup>0</sup> - 30 <sup>0</sup>
Total time	31 minutes, 14 seconds	12 minutes, 45 seconds
Distance	17.8 km	16.5 km
Top speed	90 km/h	97 km/h
Average speed	34 km/h	78 km/h
Maximum acceleration	5.3 km/h per second	5.2 km/h per second
Number of stops	23	0
Idling time	18% of total time	0
Engine start	Cold	Warm

The third test for Canada is the cold temperature test which is the same as the city test except the test is set at -7 °C of surrounding temperature. The fourth test is based on air conditioning which starts the test with surrounding temperature of 35 °C. The air conditioning is then used to lower the internal temperature. The last test is based on driving speed or acceleration of range from 78 km/h to 129 km/h. four stops included and the test begins with warm engine and no air conditioning used.

New Zealand used the methods almost similar to Australia which made the car sellers provide fuel economy sticker that shows the rating from one half to six stars with the most economic cars having the most stars while the fuel hungry has the least star. They also provide the information of fuel consume annually for driving 14 000 kilometres along with the fuel economy in litres for every 100 kilometres.

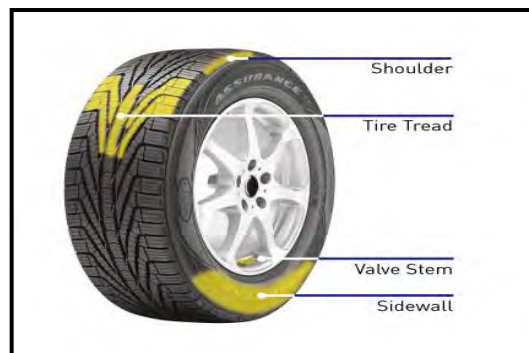
While United States establish a gas guzzler tax on the sale of new model which does not fulfil the minimum requirement of certain statutory levels. The taxes only applied for cars and to be collected by Internal Revenue Service (IRS).

## 2.3 Characteristic of tires

### 2.3.1 Tire

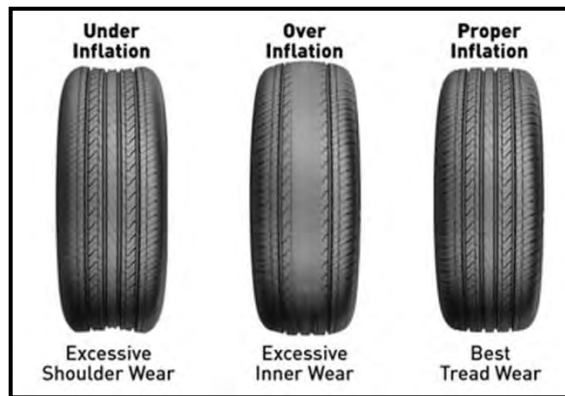
Tire plays an important part in a vehicle no matter it traverse in the road or use for take-off the flight. Without it, life would be much tougher than the way it already been. Tires which are always a ring-shaped vehicle component should be able to provide traction between the vehicle and the surface of the road while absorbing the shock.

The material used to make tire are consist of synthetic rubber, natural rubber, fabric and wire along with carbon black and chemical compound. They should have tread which provide traction and a body which provides containment for a quantity of compressed air.



**Figure 2.1: Tire characteristic**

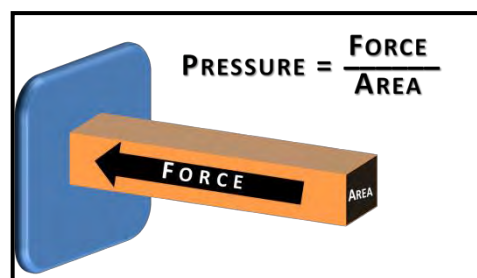
The condition of tire is important to be checked before making any journey no matter it is a long journey or a short trip to the relatives. It is a must to check whether the tire are under inflated, over inflated or normal inflated. Under inflated tires make the vehicle to work harder because of excessive sidewall flexing which will reduces vehicle carrying capacity as well as fuel economy.



**Figure 2.2: Condition of tire**

### 2.3.2 Pressure

Pressure is the continuous physical force on or against an object by something in contact with it. It is said that pressure is the force perpendicular to the surface of an object per unit area over which that force is distributed. There will be no movement or no change in shape if there is no pressure on an object. Pressure is normally derived in its own SI unit which is pascal (Pa) or seldom in pound-force per square inch (psi) which is the traditional unit of pressure.



**Figure 2.3: Pressure acting on a surface perpendicularly**