REAL TIME STUDY ON VEHICLE TIRE PRESSURE

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In the name of Allah, the Most Merciful and the Most Beneficent

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Real-Time Study on Vehicle Tire Pressure

(Keywords: Tire Pressure Monitoring System [TPMS], Tire Pressure, Tire Temperature, Compressed Air, Nitrogen Gas, Rims)

Tire is the most important component for a vehicle and tire failure during driving may cause fatality. By naked eyes it is very hard to identify the reduction of tire pressure or increase of it’s temperature, therefore the usage of TPMS is very useful to indicate any inconsistency behavior of both items. A Tire Pressure Monitoring System (TPMS) is an electronic system designed to monitor the air pressure or tire temperature inside the pneumatic tires on various types of vehicles. The TPMS system also report real-time tire-pressure and tire temperature which manage to trigger the driver when the level of pressure or temperature reaching the alarming level.

This paper is about gathering data on tire pressure and tire temperature information while driving on Malaysian highway base on two rims sizes (15 inch and 17 inch rims). This research also will provide information on the effect of changing the tire size towards the behavior of tire pressure and temperature in Malaysia highway. The data collection will base on morning, afternoon and night highway driving.

Nitrogen gas commonly recommended from a tire shops by mentioning a lots of advantages such as reducing tire temperature, slower pressure loss and higher pressure stability but additional cost require. In this research, compressed air and Nitrogen gas also will be assessed to understand the effects towards tire behavior in Malaysia highway condition.

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<td>Nitrogen</td>
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<td>TPMS</td>
<td>Tire Pressure Monitoring System</td>
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<td>Std Dev</td>
<td>Standard Deviation</td>
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<tr>
<td>Km/h</td>
<td>Kilometre per hour</td>
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<tr>
<td>MPV</td>
<td>Multi Purpose Vehicle</td>
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<tr>
<td>cc</td>
<td>Cubic Centimetres</td>
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<tr>
<td>PSI</td>
<td>Pound Force per Square Inch</td>
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<tr>
<td>kPA</td>
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CHAPTER 1
INTRODUCTION

Chapter one provides an overview about the whole short grant research which evaluate tire pressure and temperature consistency using compressed air and Nitrogen (N2) gas as a medium in a tire. The study done based on Malaysia’s highway environment. The research involved two rim sizes (15 inch and 17 inch) to understand the effect towards tire pressure and temperature. The data for both tire pressure and temperature then will be analysed for morning, afternoon and night driving. This chapter includes the background, problem statement, objectives and scope of the study.

1.1 Background

Electronic devices now had been widely use in automotive for safety application. This research proposal is about a study on vehicle tire using electronic device called TPMS (Tire Pressure Monitoring System). TPMS was designed to monitor real time tire pressure & tire temperature for a vehicle. TPMS normally is a standard feature on luxury car such as Audi, BMW and Mercedes Benz however in this study, a stand alone TPMS had been purchased and installed on a vehicle for data collection purpose.

In this assessment, a research on tire pressure & tire temperature base on Malaysian Highway route had been done. Highway been chosen because it offer more consistent speed driving due to lower traffic issues. It also offers high speed driving which based on maximum 110 km/h Malaysia highway speed limit. We know that driving in high speed condition is very critical towards the tire performance which may cause accident to happen. This is because tire
malfunction is one of the factors for road accident and higher speed may contribute to fatality especially on highway area [1]. From MIROS (Malaysian Institute of Road Safety Research) data showed numbers of car accidents were increasing every year with latest 2010 car accident data continuously increased to 1.13% [2]. The performance of Nitrogen (N2) gas also will be assessed towards Malaysian Highway driving condition. Nitrogen gas in literature review showed better results in terms of tire pressure and tire temperature performance. Racing car and aerospace use Nitrogen gas in their tire because it claimed Nitrogen is a dry gas and does not carry water resulting to consistent tire pressure [3] but so far there is no study had been done towards Malaysia environment. Some article which assessment done outside of Malaysia showed N2 gas performance should be better than compressed air for consistent tire pressure and lower tire temperature. However the performances of N2 gas in Malaysia still a question mark and need to be assessed.

1.2 Problem Statement

Tire pressure and tire temperature are hardly measured when using national car because they do not equip with TPMS feature. The awareness of tire pressure for Malaysian citizen also low due to unavailability of TPMS as a standard feature in national cars. We can observed three types of tires behaviour which can be referred in Figure 1.2 a

![Figure 1.2 a: Types of Tire Inflation](image)

Low tire pressure is hard to justify using naked eyes, however TPMS able to trigger the driver on the tire pressure and tire temperature status. Base on some
study, with tire pressure drop to 5 PSI could lead to tire failure [4]. A proper inflated tire being defined when all tire areas touching the road surface and this will provide optimum handling and optimum tire life.

When the tire is under inflated it will have excessive contact area and this will cause rapid tire wear especially at tire edge resulting to poor handling condition. While over inflated may cause rapid wear at center of tire position and not recommended due to uncomforted driving which sometimes may cause vehicle to vibrate more.

We could observe that the vehicle owners like to modify their cars and one of the modification items is changing the standard rim size to a bigger rim diameter. Base on the survey done, vehicle owner will increase their rim size in the range of 7 to 13% from the original rim size. In this case we will evaluate the worst case scenario which is 13% increase from the standard diameter to understand the impact of changing bigger rim sizes towards the performance of tire pressure and tire temperature. In this situation the increase of 13% from standard 15 inch rim size is equivalent to 17 inch rim size.

In Malaysia, there is no sufficient information that recommends when is the best time to start a journey for stable tire pressure with lower tire temperature. From the results, it will provide information to the drivers in Malaysia for safer journey and as well will help the drivers to extend their tire life. This is because tire is the most important part for the safety aspect whereby tire pressure and tire temperature plays a vital role towards the tire performance. [5]

1.3 Objective

The main objectives of this research is to understand the performance of tire pressure and tire temperature with below setting

1. Driving in Malaysian’s highway at morning, afternoon and night.
2. Driving using compress air vs Nitrogen air
3. Driving with different rim sizes (15 inch rim vs 17 inch rim)

From the results later hopefully it will provide some information to the Malaysian citizens to understand further the behaviour of tire pressure and tire
temperature base on Malaysian Highway’s road condition. With the results, then we could gather the information on the tire behaviour towards starting a journey in the morning, afternoon and night. We able to understand the performance of Nitrogen gas towards the Malaysia’s road environment versus the conventional compressed air which being normally used. With this information, the Malaysian drivers can be advised whether worth it to pay more for N2 gas to be filled up into their tires.
CHAPTER 2
LITERATURE REVIEW

Literature review chapter will provide a brief overview on TPMS, compressed air, Nitrogen gas and tire. In this section it will cover some information on mentioned items and the technical aspects of it.

2.1 Tire Pressure Monitoring System (TPMS)

TPMS is an electronics device which used to provide real time tire pressure and temperature. It triggers alarm to drivers when the pressure / temperature reach the warning level. It consists of 4 pneumatics valves which must be installed inside the tires. Some cases there are 5 pneumatics valves which covering the spare tires. The pneumatics valves then transmit a signal to the display channel which will provide real time tire pressure and tire temperature condition. TPMS is basically a sensing system which designed for vehicles tire safety purpose. TPMS consists of two main units [6]:

1) Component for checking & transmitting tire pressure & temperature (inside rim)

2) Component for receiving and display the reading (display panel)

For component inside rim consists of RF transmitter, microcontroller, sensor & battery. From the technical specification, the battery could last up to 5 years. The sensor has four functions which manage to check real time tire pressure, temperature, acceleration & power source checking. The microcontroller handles & examined the signal and makes the RF emitter transmit signal to the display panel module. While the receiving module (display panel) receives the radio frequency transform them into digital signal and then send it to the
microcontroller. The system will trigger an alarm if the tire pressure and temperature at the dangerous states, therefore, tire exploration can be effectively avoided [7]

2.2. Compressed Air

For compressed air normally it will allocated at fuel station and tire’s workshop. It is a conventional method used to inflate tires and there is no charge when using compressed air. This is why more drivers choose compressed air because it is free and easy to find for tire inflation. Compressed air is relatively safe and it is non-flammable. Compressed air consists of 78 % nitrogen which is just under 21 % oxygen, and the rest is water vapour. The existing of water vapour or moisture inside the tires may cause corrosion on the wheels. It is hard to feel any difference in the ride or handling or braking, unless the tire pressures were seriously out of specification and changing to back to the recommended figure will ensure smooth driving.

2.3 Nitrogen Gas

Nitrogen in its natural form, had larger molecule than oxygen resulting to slower tire pressure loss [8] when inflate it with Nitrogen gas. Nitrogen claimed to be good for those who rarely check their tire pressure because of the slower deflation rate. Racing car and aerospace use Nitrogen gas in their tire because it is a dry gas and does not carry water resulting to consistent tire pressure [9]. Base on the usage on the racing car, the Nitrogen now become a trend to be inflated into normal vehicle with the expectation to have same performance with it. There are few benefits Nitrogen gas claimed to be better than compressed air for tires inflation [10] such as:

- Reduces the tire’s running temperature
- Improves the ride quality
- Increases tire life
- Keeps tire pressures more constant
- Slower tire pressure loss rate
- Doesn’t react with the tire and rim materials since Nitrogen do not contain water vapor

If the current tires being filled up with Nitrogen and then being top up with the compressed air when the tire pressure is low, it won’t harm the tires however it will end up with oxygen mixture in tires which will affect the overall tire performances. It is highly recommended to top up the tire pressure with the same medium gas used. However the challenges for Nitrogen gas are the availability / supply and as well additional cost require for tire inflation.

2.4 Tire

The vehicle tire is made of natural rubber and covered by several component [11] which can be referred to Figure 2.4 a

![Parts of a Tire](image)

Figure 2.4 a: Parts of a Tire

The bead is at the edge of the tires which provide the tire strength when rim installation was made. It is made of a high strength steel cable which being coated with the rubber that can stand the force produced by the tire mounting machines. The body of the tire is made of several layers of fabrics which name as plies. The polyester cord is the most common ply fabric that been used for tire fabrication
and then coated with the rubber. The number of plies used will determined the tire’s strength but most car tires had two body plies.

The steel belts in the tires are made of steel which been used to strengthen the area under the thread and provides puncture resistance. It also helps the tire to stay flat for having maximum contact with the road. Some tire feature includes cap plies which is an extra layer of polyester fabric which helps to hold the components in place when at high speed condition and these feature mostly used on high speed rating tires. The sidewall of tires is one of the important components that helps the air from escaping and may contain additional component to increase the lateral stability and protect the body plies.

The tread of the tire is the one gripping the road surface and factor that make the vehicle move. It is made of some mixture of many different kinds of natural and synthetic rubbers. The tread on tires had many design to improve the performance on dry or wet condition. Normally the factory recommended tire pressure value will be allocated at vehicle’s door panel area for reference purpose. This is to ensure the driver will get smooth driving when sitting in the car. However the reference of tire pressure value only applicable for the tire profile which provided by the manufacturer. If the changes of tire profile had been done by enlarging the rim size, then the tire pressure value for inflation depends on the driver preference. In this assessment the same tire pressure value been used (35 PSI) for evaluation purpose.
CHAPTER 3
METHODOLOGY

The methodology chapter provides the information on how the assessment been carried out. It describes the manner on how the data was being collected and shows the schedule of the data being collected. The experiment’s materials also will be shared in this chapter.

3.1 Scopes of the assessment

The scope of assessment had been fixed based on below criteria’s during the assessment. This is to limit the activities and ensure the research base on fixed items. The items that been fix are

3.1.1 Vehicle’s type

The vehicle used in the assessment was a Multi Purpose Vehicle (MPV) Nissan Grand Livina brand as fix test drive vehicle. The overview of the assessment vehicle can be referred to Figure 3.1.1 a. Why MPV being selected because the trend is increasing for family car and the number of fatality for MPV if accident happened is high since it involve high number of passenger. Nissan Grand Livina can load up to 7 peoples including the driver. This is why MPV now is very popular because it can carry more peoples and larger boot space if the back seats being folded. With the increasing trend of MPV it is important to understand the behaviour of it’s tire so that the information could be a reference for the drivers.
Below are the basic specifications of the MPV
Engine cc: 1600
Standard Rim size: 15 inch
Kerb weight: 1785 kg
( Kerb weight is the total weight of an automobile with standard equipment, oil, lubricants, coolant, a full tank of fuel and not loaded with either passengers or cargo)

3.1.2 Loading weight
Loading during the assessment consists of 2 adults and 4 children with estimate weight of 220 ± 10 kg. These are the selected loading for the assessment and consider as usual weight for a MPV.

3.1.3 Vehicle’s speed
Malaysia highway maximum speed limit is 110 km/h. Since Nissan Grand Livina do not equipped with auto cruise feature the assessment speed is define with 110 ± 10 km/h tolerance.

3.1.4 Assessment route
The assessment route was based on Malaysian Highway base on 1 hour data collection (for non raining condition) base on Ayer Keho and Sg Besi Highway route. The overview of the road condition could be referred to Figure 3.1.4 a
3.1.5 Assessment schedule

Data of tire pressure and tire temperature collected at morning, afternoon and night base on below schedule

i) morning  (time ranging from 7.00 a.m to 10.00 a.m)

ii) noon    (time ranging from 12.00 p.m to 3.00 p.m)

iii) night  (time ranging from 8.00 p.m to 11.00 p.m)

3.1.6 Vehicle rim sizes

In this assessment only two rim sizes were selected to understand the impact towards tire pressure and tire temperature. The rim sizes selected were 15 inches and 17 inches which had been fixed to the vehicle during assessment. In this assessment both rims were using same tire brand to minimize the material variation. The tire brand selected was Falken ZIEX which for 15 inch rim sizes using tire profile 195/60R15 and 17 inch rim using profile 215/45R17. The coding of the tire definition could be referred to Figure 3.1.6 a.