The Effect of Tire Pressure to Fuel Consumption of G19 Garuda Urban Cars

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Abstract. The purpose of this study was to determine the effect of tire pressure on fuel consumption for Garuda Urban Gasoline G19 in the Shell eco-marathon Asia, 2019. This research is a type of experimental research using FDR tires on the UG19. The research was conducted by applying the tire air pressure 50 Psi, 75 Psi, 80 Psi, and 90 Psi in each pressure test, the calculation of fuel consumption is carried out to determine the effect of energy consumption in each test of each pressure. The data analysis method was carried out by using descriptive analysis. The results showed that: By applying FDR tire pressure for UG19 cars with a pressure of 90 Psi, the fuel consumption reached 5.1 ml with the calculation of the achievement of energy consumption of 395 km/l. With the test results, it shows that giving an increase in tire pressure will greatly affect fuel consumption and energy consumption achievement.

1. Introduction

Shell Eco Marathon (SEM) is an energy-efficient car competition organized by Shell, a world-renowned company engaged in oil and gas processing. SEM challenges young students to design, create, test, and compete for world-class energy-efficient vehicles.

The Shell Eco-Marathon competition is divided into two main classes, namely the Urban Class and the Prototype class. In the Urban Concept class, vehicles are required to follow the design of a four-wheeled vehicle with all its accessories.

The vehicle dimensions for the Urban Concept class according to the applicable regulations must have a height of 100-130 cm, a width of 120-130 cm. The vehicle must also be 220-350 cm long. Minimum wheel track of 120 cm, minimum Track Width of 100 cm (front) and 80 cm (rear) and the maximum weight of the vehicle without a driver is 250 kg. As for the Prototype Vehicle class, the vehicle design does not have to have four wheels, and does not have to follow the current four-wheeled vehicle design.

Some of the problems that arise in each competition include vehicle weight, wind resistance, rolling resistance of the wheels on the vehicle, uncontrolled air pressure on the tires. One of the factors that influence the amount of fuel consumption is the rolling resistance of the wheels.

With the weight and shape of the body that are still relatively high and it is difficult to make sudden changes, what might be done to reduce the engine load to move the vehicle is by controlling the air pressure on the tires. By controlling the pressure used on the vehicle, the condition of the tire’s contact with the road will be monitored which will minimize the occurrence of vehicle slide resistance. With this, it will strengthen the concept of efficiency, which is comparable, the higher the contact and the resistance of the slide, the energy needed will also be more, with the increase in energy needed, which
will increase fuel consumption. To obtain a minimum fuel consumption figure, one must be able to master and apply technology.

The first advanced technology is how to make a vehicle with low wind resistance (aerodynamic drag) and design a lightweight vehicle structure. The second advanced technology that must be mastered or obtained is to minimize tire friction and shaft bearing friction (Santin J.J et.al, 2007). Conventional car tires have a rolling resistance coefficient or what is called rolling resistance

The coefficient on asphalt roads is 0.013, bicycle tires are 0.006, while the tires made by Michelin cross ply used in competitions have a rolling resistance coefficient of 0.0024 40% of the resistance of bicycle tires and 19% of car tires. Radial ply tires are also developed by Michelin with a rolling resistance coefficient of 0.081, or 13.5% of bicycle tires and only 6.2% when compared to car tires. Meanwhile, shaft bearings made of ceramic material have a rolling resistance coefficient of only 40% of conventional bearings.

Rolling resistance has a considerable influence on vehicle efficiency. Many factors affect rolling resistance, one of which is the air pressure (Inflation Pressure) of the tire itself. In tires, air pressure is something that must always be considered because it is related to driving safety and comfort. In fact, the air pressure on the tires also affects the rolling resistance which ultimately affects fuel consumption.

2. Methodology

This study aims to develop a model for implementing the in-service Teacher Professional Education Program that can be used as a basis for implementing the in-service Teacher Professional Education Program in the Automotive Engineering Education Study Program, Engineering Faculty UNY. Efforts to develop the in-service Teacher Professional Education Program model are oriented towards increasing graduates of the in-service Teacher Professional Education Program participants. To develop a model, it is done by using research and development methods or what is often abbreviated as R&D (research and development). The reason for using this method is because in many ways this R&D method is often used to produce products and test the effectiveness of the resulting product. In many ways this R&D research is very suitable for the development of fields related to technology and industry as well as management.

The type of research used is experimental research. In this study the changes used in the Garuda car vehicle Urban Gasoline 19, so it is necessary to do research, this study compares the results of the test data on the effect of tire pressure on fuel consumption.

This research was conducted at the Garuda UNY Racing Team workshop. The Garuda UNY Racing Team Workshop is located in the FT UNY parking area or behind the LPPMP UNY building. Dynamic testing is carried out in the parking lot of Maguwoharjo Stadium in Sleman. The research data collection began in December 2018 to August 2019.

The Sample used in this study was the FDR MP27 ring 17 tire on the Garuda Urban Gasoline vehicle 19, the changes made were the tire pressure used on Urban Gasoline 19 cars. The population of this study was the Urban Gasoline 19 car. 4 (four) different types of testing samples.

The difference lies in the change in tire pressure used for the four wheels of the Urban Gasoline 19 car, the variable air pressure on the tires used, namely, 50 psi, 75 psi, 80 psi and, 90 psi. The variables used in this study to obtain measurable and relevant data are as follows: The independent variable in this study is the air pressure

In this research, it was carried out on 4 (four) times testing of variable air pressure on different tires, each variable was tested 2 (two) times so that the total test was carried out 8 (eight) times, Then the effect would be examined and studied on the fuel consumption. achieved by the Urban Gasoline 19 car. 4 (four) samples of the tests to be researched are: Testing 1 to 4, the object used is the Urban Gasoline 19 car with all 4 (four) wheels using FDR MP27 tires by applying air pressure to tires 50 Psi, 75 Psi, 80 Psi and 90 Psi. Do alternately applying pressure.
Of all these tests will be analyzed and studied to obtain the best results to be applied to the Urban Gasoline 19 car at the 2019 Shell eco-Marathon Asia competition. This test is carried out using a measuring cup to refuel the glass tank on the car with a cc size value. At the end of the test, this tool will be filled with fuel to be filled in the car tank so that you can read how many milli liters (ml) of reduced fuel consumption is. To get the final result unit, it is necessary to calculate the following equation:

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Fuel\, consumption = \frac{\text{travel distance (meters)} \times 100}{\text{fuel reduction (cc)}}
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After testing the data analysis technique used is descriptive analysis method. This is done to provide an overview of the phenomena that occur after changes in tire pressure. To make it easier to read, the test results will be displayed in tables and graphs. The next step is to describe the data in the tables and graphs into sentences that are easy to read, understand and present so that in essence it is an effort to find answers to the problems under study.

3. Result and Discussion
In testing the effect of using the MP27 FDR tire pressure used on Urban Gasoline 19 cars, which was carried out with 4 (four) different types of test samples.

| No | Testing | Tire Specification | Tire pressure |
|----|---------|-------------------|---------------|
| 1  | Urban Car | FDR MP27 (80/90 – 17) | 50 Psi |
| 2  | G19     |                   | 75 Psi |
| 3  |         |                   | 80 Psi |
| 4  |         |                   | 90 Psi |

Based on the table and graph of the data from the results of testing the fuel consumption that has been carried out, it can be seen that the results of field testing with measurements are made to determine the effect of changes in tire pressure used by UG19 cars on fuel consumption. These results indicate the reach of the vehicle range with a high level of efficiency. Data retrieval is done by directly testing the object under study, the test data is obtained as shown in Figure 1.
Based on this graph, the test with the same variable is carried out twice testing for each variable change. From these data, the mean of the two tests shows the difference in the area of contact between the tip of the tire and the asphalt in every air pressure applied to the tires used by the UG19 car. This can occur because the nature of tires with rubber materials has flexible properties, with these flexible properties it will be very easy to accept a change either changing shape due to pressure or loading.

This form of pressure occurs because of the filling of the air carried out on the tire, the nature of the air that can be compressed and can fill the empty space inside the tire, when air pressure is given from outside to fill the empty space in the tire, the air density inside the tire will increase, with the elasticity of the tire, the air will push out the wall of the tire wall to the limit of tire tension, causing the tire to become hard.

This will also apply when the pressure on the tire is reduced or the pressure is low, the air density that fills the space in the tire also decreases, this is followed by the ability of the tire to withstand the load of the vehicle, with its elasticity properties the tire is unable to maintain its shape due to the load factor, which will resulting in wider contact of the tire end with the road.

Thus, the increase in air pressure on the FDRMP27 UG19 tires can reduce the contact area of the tire tip with the asphalt, but it can also affect the hardness of the tire. Deflection created by less tire pressure can increase resistance and cause the vehicle to use more energy. The effect of tire pressure on the caster force or the vehicle's slide rate. In this test, the tester measures the time required for the deceleration of the vehicle to pass through wind resistance and tire friction. Only changes the pressure in the tire the tester chooses.

Wind speed and road variation were controlled by performing all tests consecutively on the same road, in the same direction and on the same day, the UG19 car was used for all experiments, so that the vehicle aerodynamics remained constant. Control testing is carried out by positioning the vehicle without a drive train, all testing and timing are carried out when the car is in neutral transmission condition which does not create obstacles. This restriction is used to isolate tire pressure as a single variable which regulates the power required to maintain constant speed.

Based on the results of the tests carried out, there are various variants of the distance traveled from the vehicle's slide, with clearly visible effects

![Figure 2. Rolling slide test.](image)

Based on Figure 2, which is formed from the test, it can be seen that there is an interrelated relationship between tire pressure and speed and range, namely when the tire air pressure on the UG19 car is increased by adding air pressure on the tires, there is also an increase in the ability to increase
vehicle reach, this is due to increasing air pressure on the tire, with the flexibility properties of the material used to make this tire will be easy to accept changes such as applying pressure

With this the tire will become hard due to the density of air in the tire, the tougher the tire is in line with the formation of the contact of the tire end with the road, the smaller it will be, with the formation of small tire contact, the rolling resistance on the tire will also be reduced, the reduced rolling resistance will be able to lighten the motion of the vehicle so that the UG 19 vehicle or car can go at a constant speed and can cover an increased distance.

This picture is reinforced by an incident experienced by one of the same teams from Indonesia using the same type and specifications of tires, the tires they used when the race exploded, after we learned they took the attempt when the air temperature and the track were in the 30-37°C range. At noon at 14.30, the overall data obtained after testing states that an increase in tire pressure will reduce the rolling resistance of tires when the vehicle is driving.

Based on the test data depicted in graph 3. It was found that tire pressure had an effect on fuel consumption. Based on this figure, it can be understood that the lower the tire pressure, the higher the fuel consumption. The 90 Psi pressure of the UG19 car consumes 5.1 ml (milliliter) of fuel with the vehicle mileage calculated as 395 km/l while at 50 Psi tire pressure the UG19 car consumes as much as 6 ml (milliliter) of fuel by calculating the ratio. The test mileage with fuel consumption was 334 km/l (kilo meter per liter) by testing according to competition regulations.

This result is caused by changes in tire pressure which as a research variable, this discussion shows that fuel consumption is equivalent to the energy required, with reduced tire pressure followed by the extent of tire tip contact to the road, with this the value of rolling resistance also increases, this results in moving a car requires a lot of energy, the amount of energy needed will affect fuel consumption which will also increase.

![Figure Fuel Consumption](image)

**Figure 3.** Fuel consumption test.

The least fuel consumption in this test is shown when the tire pressure test is variable, the pressure of 90 psi is tested, showing a decrease in fuel consumption, from other pressure variables that are below it, meaning that the higher the tire pressure is followed by a smaller tire tread area and also the value small rolling resistance, the small value of rolling resistance has an effect in making it easier for the vehicle to drive without requiring large amounts of energy, which can result in increased fuel consumption. From the data obtained, a straight line can be drawn the conclusion that it takes more
energy to move the car so that it can go according to road conditions, an increase in rolling resistance is followed by a decrease in tire pressure used on the UG19 car.

With the higher the inflation pressure air pressure on the tires, the smaller the tire tread will be. In the tests carried out, it was found that the widest tire tread was 32.9 mm which occurred at the lowest tire pressure of 50 Psi and the smallest tread was 25 mm which occurred at the highest tire pressure of 90 Psi. With the area contacting the end of the tire with the road, the lower rolling resistance is also followed.

This can be shown by the glide test which was carried out with the ability of the vehicle to slide at a distance that the farthest from the test data found the farthest slide with the inclined plane test, the car slide was able to travel a distance of 390 m (meters) at 90 Psi tire pressure and the closest slide was 340 m. (meters) with a pressure of 50 Psi. Retrieval of fuel consumption test data on the UG19 car which is obtained at a test pressure of 50 Psi consumes more fuel needed to drive the car with a total consumption of 6.5 ml while the lowest fuel consumption is at a pressure of 90 Psi with a consumption of 5.1 ml.

With this it can be concluded that the lower tire air pressure will lead to a larger contact area of the tire tip with the asphalt. Likewise, a greater contact will increase the rolling resistance, with increasing rolling resistance it will require a large amount of energy to drive the car with this the fuel consumed by the engine will also increase. With this will also be followed by mileage achievements that are unable to cover long distances, which is the only judgment taken to determine the winner in the Shell eco-marathon Asia competition. 2019. Therefore, one of the effects of UG19 car fuel consumption is caused by changes in tire pressure used in the car.

4. Conclusion
Based on the results of research and discussion, research on the effect of tire pressure on fuel consumption in Urban Gasoline 19 cars can be concluded that (a) tire pressure affects fuel consumption, the higher the air pressure on the UG19 car tires, the less fuel consumption, and vice versa; (b) the least fuel consumption at the variable pressure of the tires used is 90 Psi; and (c) tire pressure affects the rolling power ability of the UG19 car.

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