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The Effect of Tread Pattern Tires on Hard Compound Coefficient Rolling Resistance

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Abstract

Rolling resistance is the resistance of a wheel that will roll or rotate due to friction between the outer surface of the wheel and the track surface. This study aims to determine the effect of tread patterns on the coefficient of rolling resistance. The tires that will be used in this study are hard compounds with a ratio pattern and tread pattern raised by 2 mm with a tire hardness of 79.5 Ha, and using pressure variations at 30 Psi, 40 Psi, and 50 Psi. Coefficient value rolling resistance is 1.39% with a rolling resistance of 8.05 N. These results are produced by a hard compound with a tread pattern of 2 mm at a pressure of 50 Psi. Meanwhile, the rolling is 2.04% with a rolling resistance of 11.82 N. These results are produced by hard compound tires with a pattern at a tire pressure of 30 Psi.

Keywords: *compound, tread pattern, rolling resistance.*

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INTRODUCTION

Technological developments are increasingly rapid and can no longer be dammed due to artificial intelligence technology which makes many innovations appear in creating an appropriate product [1-2]. Especially in the transportation technology

sector, one of which is the development of electric cars that are environmentally friendly and have good efficiency. The means of transportation in Indonesia are dominated by oil-fueled motor vehicles. In 2018 the Badan Pusat Statistik (BPS) released the number of motorized vehicles reached 146.85 million units of vehicles, which were dominated by motorcycles with a total of 120.10 (81.8%) followed by passenger cars with 16.44 (11.2%), freight cars 7.77 (5.3%), buses 2.53 (1.8%). Electric cars are considered a good solution because they do not produce exhaust gases that can cause air pollution and do not use fossil energy materials to reduce the use of oil fuel [3-5].

Three basic factors can affect the efficiency level of a vehicle, namely the mass of the vehicle (mass), aerodynamic resistance, and rolling resistance [6-9]. Rolling resistance is the force generated by the wheel against the direction of motion, equivalent to the force required to run the wheel that will move forward [10]. Rolling resistance has a significant role in vehicle fuel consumption ranging from 7 to 10%, and a 10% decrease in rolling resistance will increase by 2 to 3% in reducing vehicle fuel consumption [11]. Tires are one of the components that affect rolling resistance. The results of research that have been carried out [12], in the study "The Effect of Air Pressure on Radial PLY Type Tires on Rolling Resistance". The higher the pressure, the smaller the tread area, the higher the tire pressure, and the lower the rolling resistance value. Tires that have a simple groove type will get rolling resistance when compared to a complex groove type tire, this is because tires with a complex groove type have a larger pressure value [13-15].

In this study, observations will be made on tires with a hard compound using a standard tread pattern and a tread pattern width of 2 mm and air pressure on the tires of 30 Psi, 40 Psi, and 50 Psi. From the research results, the effect of widening the tread pattern and the effect of tire air pressure on the rolling resistance will be known.

RESEARCH METHOD

In this study, the method used is an experimental method by observing the value of the tangential force that appears on the rolling resistance both before the tire is loaded (Ft_0) and after the tire is given a radial load of 580 N (Ft_1) which comes from the pneumatic cylinder. This value can be obtained from the tangential f orce experienced by the lever arm.

Figure 1 Pneumatic cylinder on rolling resistance test equipment

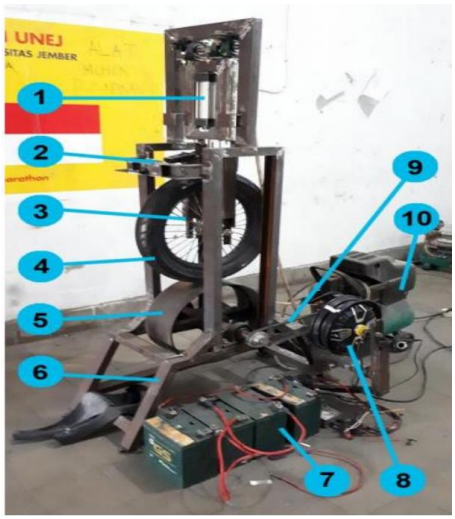

Figure 2 Rolling resistance test equipment

Description of the parts of the test equipment:

1. Pneumatic cylinder, used for loading.
2. Digital scales, as a measuring tool for tangential loads.
3. Tire clamp to be tested.
4. Tires, test variables.
5. Drum, turning the wheel to be tested.
6. Test apparatus frame Rolling resistance.
7. Battery, electric motor energy source.
8. Electric motor, as a drum player.
9. Transmission V-belt
10. Compressor, to provide air supply for pneumatic cylinders.

To measure the surface contact area, the tire will be colored on the surface then the tire will be printed on paper glued to the drum, the traces of the print will later be scanned and analyzed, and measured. The tool used to load the tires is a pneumatic cylinder as shown in Figure 1. While a certain pressure can be set on the air entering the pneumatic cylinder to adjust to a certain load. In measuring rolling resistance, a rolling resistance tester is used. The schematic of the test equipment for measuring rolling resistance is shown in Figure 2.

The outer surface contact area of the rolling resistance tester is shown in Figure 3. Figure 3 explains that the tire surface contact area has two conditions. These conditions are marked in red and green. Images with red color mean high tire pressure while images with green color mean normal tire pressure. The area is to measure the area of the tire in contact with the road surface. In this way, the pressure per unit area will be known.

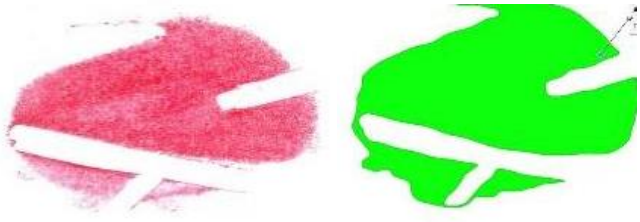

Figure 3 Tire surface contact area

To find the value of the rolling resistance (as shown in equation 1-6), further analysis is needed, the first step is to find the rolling resistance force by calculating the tool loss force, by entering the test results without loading (Ft_0).

$$Fp_f = F_{t0} + \frac{F_{t0} \cdot Rb}{Rd} \quad [1]$$

After obtaining the value of Ft_0 then the results are entered into the following formula.

$$F_r = F_{t1} + \frac{F_{t1} \cdot rb}{Rd} - F_{pf} \quad [2]$$

Furthermore, the results of these tests need to be calibrated by test equipment by calculating constants. After getting a constant value of 0.26, it will be multiplied by the value of the rolling resistance from the data retrieval results, so that the rolling resistance (F_{rs}) is obtained.

$$F_{rs} \approx kF_r \quad [3]$$

$$K = \sqrt{\frac{(Rd1+Rd2)(Rd2+Rb)}{(Rd1+Rb)}} \quad [4]$$

The value of the rolling resistance coefficient rolling resistance (Cr) by dividing the load used in the study by 580 N.

$$C_r = \frac{F_{rs}}{W} \quad [5]$$

Next, find the pressure (P) each tire has tested. By dividing the contact area (A) of the tire with a predetermined load of 580 N.

$$P = \frac{F}{A} \quad [6]$$

RESULT AND DISCUSSION

Tangential Force

The test results obtained that the tangential force that occurs on the wheel is obtained from the axle force of the wheel axle. Measurement data as a tangential force before loading (Ft_0) and after loading (Ft_1). The loading used is the normal force of 580 N, the results are shown in Table 1 and Table 2. After taking the data, the calculation will then be carried out so that the results of the rolling resistance as shown in Table 3.

Table 1 Tangential force without load (Ft_0)

Type of Tire	Air Pressure (Psi)	Test Ft_0 (N)					Average
		1	2	3	4	5	
Hard Compound Pattern Standard	30	2.45	2.43	2.41	2.55	2.57	2.48
	40	2.70	2.71	2.71	2.65	2.60	2.67
	50	2.45	2.57	2.64	2.65	2.69	2.60
Hard Compound Pattern 2mm	30	1.55	2.07	2.15	1.88	1.87	1.90
	40	1.45	1.85	1.47	1.50	2.01	1.66
	50	1.20	1.27	1.18	1.21	1.15	1.20

Table 2 Tangential load 580 N (Ft_1)

Type of Tire	Air Pressure (Psi)	Test Ft_1 (N)					Average
		1	2	3	4	5	
Hard Compound Pattern Standard	30	21.93	22.40	21.91	22.61	22.42	22.25
	40	20.42	20.40	21.51	19.91	21.22	20.69
	50	19.13	19.34	18.83	19.13	20.30	19.35
Hard Compound Pattern 2mm	30	18.44	18.89	18.97	18.85	18.57	18.74
	40	16.61	16.89	16.77	16.69	17.09	16.81
	50	14.81	14.91	14.74	14.48	14.41	14.67

Table 3 Test Result Rolling Resistance

Type of tire	Air Pressure (Psi)	Ft_0 (N)	Ft_1 (N)	Frs (N)	Cr (%)	A (cm^2)	P (N/m^2)
Hard Compound Pattern Standard	1.90	1.90	18.74	11.82	2.04%	17.61	329425.66
	1.66	1.66	16.81	9.34	1.61%	12.81	506298.18
	1.20	1.20	14.67	8.05	1.39%	9.75	594761.99
Hard Compound Pattern 2mm	2.48	2.48	22.25	11.82	2.04%	14.59	397420.88
	2.67	2.67	20.69	10.77	1.86%	10.02	579021.45
	2.60	2.60	19.35	10.01	1.73%	9.92	5845547.78

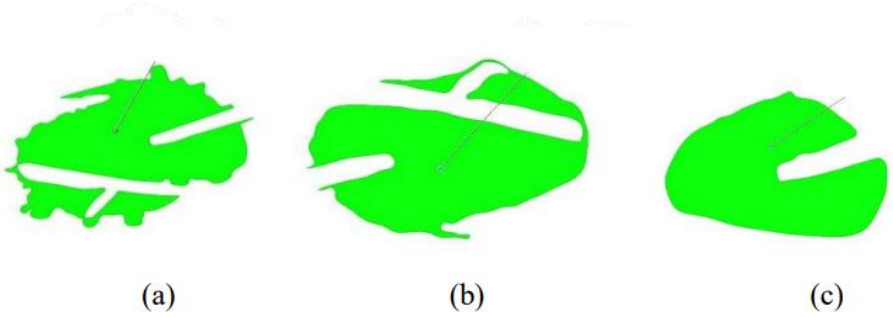

Figure 4 Standard hard compound footprint (a) 30 Psi, (b) 40 Psi, (c) 50 Psi

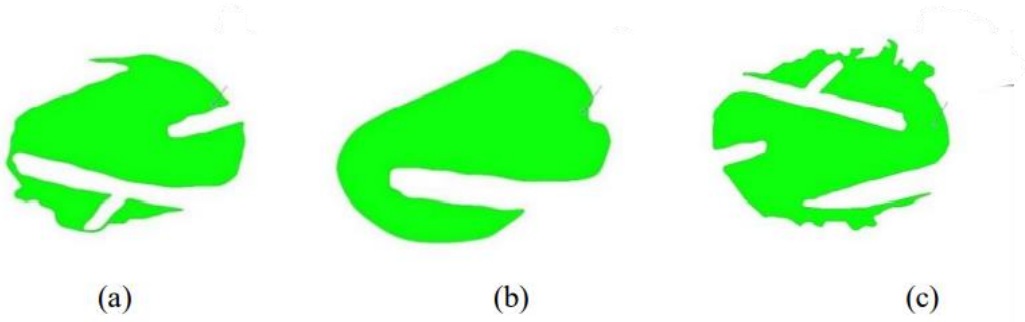

Figure 5 Tread width of hard compound pattern 2mm (a) 30 Psi, (b) 40 Psi, (c) 50 Psi

Figure 4 shows the difference in the tread on variations of the hard compound with different pressures, Figure (a) shows the surface contact area of a 30 Psi tire with a width of 17,606 cm^2, and Figure (b) shows a tire contact surface area of 40 Psi with a width of 11,455 cm^2 and Figure (c) shows a tire surface area 30 psi with a width of 9,719 cm^2.

Figure 5 shows the difference in the tread on variations of the hard compound with different pressures, Figure (a) shows the surface contact area of a 30 psi tire with a width of 17,766cm^2, Figure (b) shows a tire contact surface area of 40 PSI with a width of 12,816 cm^2 and Figure (c) shows a tire surface area 30 psi with a width of 9,752 cm^2.

Variable analysis Rolling resistance was carried out using tires with a hard compound type, this tire has a compound of 79.5 Ha, and the hardness value can be obtained from testing using a Digital Durometer. To find the effect of the width of the tread pattern on the value of the rolling resistance, a comparison of the rolling resistance tire hard compound tread pattern with a hard compound tread pattern 2 mm. With variable air pressure of 30 psi, 40 psi, and 50 psi, from the rolling resistance (Cr) it can be concluded that the hard compound pattern is 2mm smaller than the hard compound pattern. If the smallest value of each data is taken, then the smallest Cr value of the hard compound pattern increased by 2 mm by 1.39% and the hard compound pattern by 1.73%. And when viewed from the value of the tire surface contact area (A), the results show that the smallest value for the hard compound pattern raised by 2 mm by 9,752 cm^2, which is smaller than the hard compound pattern with a value of 9,719 cm^2.

Figure 6 shows the coefficients of each tire tested at 30Psi, 40Psi, and 50Psi pressures. In a hard compound, the Cr value decreases in every pressure variation which has the smallest Cr at a pressure of 50Psi, this is because at higher tire pressures the surface contact area decreases so that the frictional force generated when rubbing against the drum during testing increases. small. This also applies to other types of tires, namely hard compound tread pattern standard hard compound 2mm standard soft compound tread pattern, and compound tread pattern so this is in line with research on the effect of wheel pressure were increasing the pressure will reduce the value of rolling resistance [12].

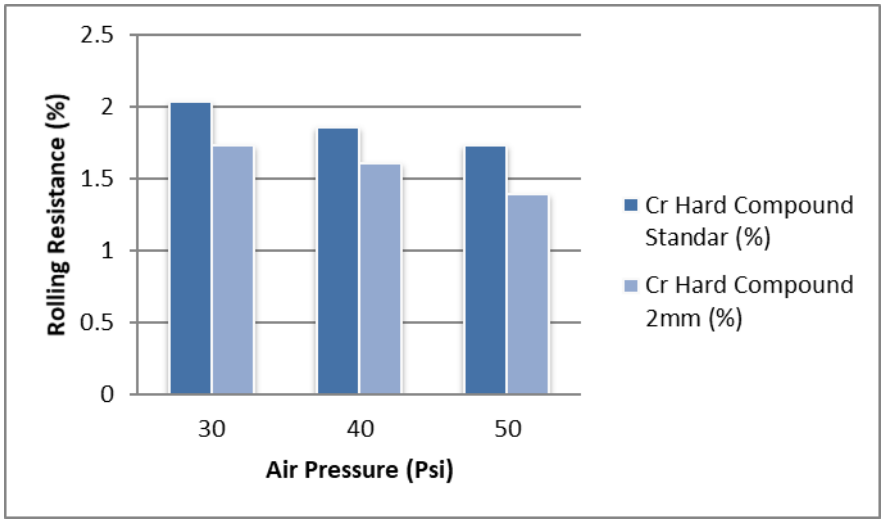

Figure 6 Graph of Cr Hard Compound Standard and Cr Hard Compound

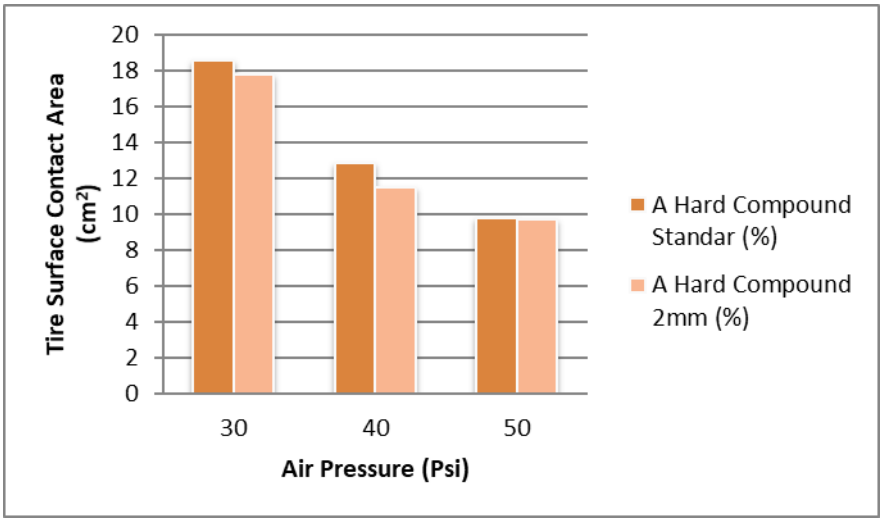

Figure 7 Graph of A Hard Compound Standard and A Hard Compound

Figure 7 shows the surface contact area of the tires tested at 30Psi, 40Psi, and 50Psi pressures. In the hard compound, the value of A decreases in every pressure variation, which has the smallest area value experienced by hard compound tires with the tread pattern has been increased and the tire air pressure is 50 Psi. This also happens to other types of tires, namely, compound tread pattern, hard compound tread standard hard pattern 2 mm, soft compound tread pattern standard, and soft compound tread pattern 2 mm. coefficient value rolling resistance, is in line with previous research which states that differences in the tire surface contact area will result in rolling resistance [6].

CONCLUSION

In the research analysis of the effect of the width of the tread pattern on hard compound tires on rolling resistance, several conclusions were obtained. First, the rolling resistance value of the best tread pattern width for hard compound tires is the

variation using a 2 mm tread pattern width with a Coefficient Rolling Resistance (Cr) of 1.39%. With these results, it can be seen that the wider the tread pattern used, the lower the Coefficient Rolling Resistance (Cr) value that works. Second, the rolling resistance value at the best pressure for hard compound tires is the variation using a pressure of 50 Psi with a Coefficient Rolling Resistance (Cr) of 1.39%. With these results, it can be seen that the greater the pressure on the tire, the lower the Coefficient Rolling Resistance (Cr) value that works.

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