Differences in braking time in symmetric and asymmetric tire tread pattern type

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Abstract. Identification of tire tread type characteristics needs to be taken into consideration when choosing a tire. The accuracy of choosing a tire will help ensure the safety of the rider. The identification procedure is by comparing symmetrical and asymmetrical 1-way direction tires. The parameter is the braking time needed for the vehicle to stop. The braking time required by asymmetric type 1-way direction tires is shorter than symmetrical type. So, motorists are advised to choose asymmetric type 1-way direction tires to get a shorter braking time.

Keywords: brake system, tire tread pattern, motorcycle

1. Introduction
The braking system is one of the most important parts of a vehicle[1]. This system serves to maintain driver and passenger safety during driving. This system can prevent accidents by allowing the vehicle to reduce the velocity or stop it[2]. Besides, the braking system can also minimize the impact of accidents since the vehicle velocity is succeed reduced. Hard braking is often done by the driver whenever avoiding collisions or in emergency conditions. The brake system is even more useful when the current traffic conditions often experience congestion which required the vehicle to stop and go driving[3].

The driver is obliged to carry out routine inspection and maintenance of the brake system. This is to ensure that the brake system functions normally while driving. Inspection and maintenance are not only on the brakes. In the brake system, there are several parts that we need to pay attention to as well. Other parts that need to be checked and maintained in the brake system are the condition of the tires. Examinations can be carried out, among others: tire age, tire air pressure, and tire tread wear. This part is often not noticed by the driver, even though tires are also an important part of maximizing the work of the brake system.

One component that supports the braking system is the tire. Tires are components of the vehicle that contact to the road surface. Damage to the tires will affect the stability and safety of the vehicle[4]. The tire surface rubs the road surface during the driving. This friction can increase tire temperature. Tire temperature can affect the properties of the constituent materials and tire
behaviour[5]. Besides, the tire tread wear increases due to the increase in temperature during braking [6]. If the tire temperature exceeds its limit, it will reduce the traction of the tire on the road surface. A weak grip can cause the tires to slip. There is a close relationship between tire contact and the road surface to the coefficient of friction that occurs[7].

The friction between the tire and the road surface will become even greater when the braking occurs. This high friction is resulted by the differences in wheel rotation speed and vehicle speed. This difference is then called the wheel and vehicle speed slip ratio. The value of the slip ratio can affect the friction between the tire and the road surface, which is the longitudinal force on the tire increase with an increase in slip. Besides, the value of the slip ratio affects the braking time. Tire slip condition has a big influence on tire braking performance and driving comfort[8].

The value of the braking slip ratio can be influenced by several factors, including road surface conditions, tire tread type, and braking system type. However, in this paper, tire tread type is the factor that will be studied, thus the effect of different tire tread types is explored. Moreover, many variants of tire tread types are made and sold by tire manufacturers. However, there are only a few consumers who can figure out the advantages and disadvantages of those tire tread variants. Hence, the performance of two types of tire treads is studied and compared concerning the braking time. On the other hand, consumer behavior in choosing tire types and brands can be influenced by the information provided by technicians[9]. Tire modeling provides an overview of the forces that can be transferred from the wheels to the ground and is therefore an important part of vehicle modeling. The pneumatic model defines the force that can be transmitted from the wheel to the ground and is therefore a vital part of the design of the vehicle[10]. This study is important because braking time is an aspect that can be considered by the driver in preventing accidents during braking.

2. Methods and Experimental Apparatus
2.1 Methods
Experimental testing is carried out on a test bench to evaluate the performance of several types of motorcycle tire treads. The tire tread sample used is symmetrical and asymmetric type 1-way direction. Both types of tire treads can be seen in Figure 1. The tests carried out represent vehicle maneuvers when braking in straight road conditions and with the same type of road surface (constant road surface friction coefficient value) with $\mu = 0.55$, and the ambient temperature of 26 ° C. The roller surface temperature is raised to 40 ° C which represents the average road surface temperature in the tropics, especially in Indonesia.

![Figure 1. Tire tread pattern 1-way direction. a) symmetric, b) asymmetric](image)

Each trial for data retrieval of the wheel is given an acceleration up to the speed of the vehicle reaching 55 km / h or about 15.28 m / sec. Furthermore, after the wheel speed reaches the desired speed, braking operation begins by pressing the brake pedal as much as possible until the
wheel or roller completely stops. At the same time, the rotation of the electric motor that drives the wheels and rollers is cut off by the system. Thus, the remain wheel rotation is generated by the wheel inertia. While the roller remains to rotate caused by the roller and flywheel inertia since both roller and flywheel are fitted at the same shaft. The data obtained is then stored on a memory card and then analyzed.

2.2 Experimental Apparatus
Experiments were carried out using the quarter-car model brake system test bench as shown in Figure 2. This quarter-type braking test bench model can simulate the conditions and dynamic behavior of the wheels and tires that come in direct contact with the road surface. Thus, the experimental data can approach the real conditions as when the vehicle drove on the road surface. By using this test bench brake system, repeated braking testing is possible with a variety of variables that may vary according to the functions indicated during the test time, such as vehicle speed $v$, wheel linear speed $v_w$, wheel longitudinal slip ratio $\lambda$, variation brake fluid pressure on the brake system $P$, braking distance $S$, and other parameters. On the brake test bench system, there are two wheels. The first is the upper wheel consisting of a set of rim and tire (tube type) motorcycle; and the lower wheel is a roller made of solid steel. Outer tires can be replaced according to tire samples with different tread models provided. Two tires with different tread types as shown in figure 1 manufactured by Kenda tires are used for the experimental samples.

![Figure 2. Brake system test bench facilities](image)

3. Result and Discussion
Each sample test shows that shortly after the braking process begins, the wheel rotation immediately decreases dramatically and locks quickly. At the same time, the vehicle speed decreases slowly causing a slip on the wheels. Asymmetric type 1-way direction tread braking time is shorter than symmetric type tread. The graph of the test results can be seen in Figure 3 below.

When braking occurs it will increase the temperature of the tire. The increase in temperature occurs due to friction between the tire and the road surface. So, the higher the speed before braking occurs, the potential increase in tire rubber temperature will be higher too[11]. If this happens the tire will wear out quickly. Wear tires will cause slippage so the braking system cannot work optimally.

Tire tread patterns also affect the performance of the braking system[12]. Tire tread patterns have different characteristics. Tire characteristics will influence driving style and safety. Road surface conditions become a consideration in choosing the type of tire[13]. In particular, the tire tread pattern affects the braking time. Braking time is needed to determine the speed at which the
vehicle stops. The faster the vehicle stops, the safer the driving process. Especially when there is sudden braking. Therefore, through testing two variants of 1-way direction tire tread we will find out whether the symmetrical type is better than the asymmetric type. The parameter used is the braking time needed for the vehicle to stop.

![Figure 3. Experimental test results of both tire tread pattern 1-way direction, a) symmetric; b) asymmetric](image)

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4. Conclusion
In this study, the effect of the different tire tread patterns of 1-way direction model on the braking performance has been carried out. Two tire tread types of symmetric and asymmetric have been tested on a braking test bench with the initial braking test of 55 km/h and dry road surface condition.

According to the experiment results, it is confirmed that both symmetric and asymmetric tire tread patterns result in the different characteristics of the braking performance, where the asymmetric type shows better performance. The braking time of the asymmetric type shows to stop faster than the symmetric type as well as the braking distance. Thus, the asymmetric type 1-way direction tires help the vehicle to stop faster than the symmetrical type during the braking. Subsequently, in this case, the asymmetrical 1-way direction tire type guarantees better driving safety.

This experimental result can be considered for the driver to choose the type of tire for their vehicle to optimize safety. However, there are several considerations in choosing tire tread types, such as road conditions, driving style, and vehicle type. The road bikers need to have a well understanding, hence they can choose an appropriate type of tire that will be used for their bike.
5. References

[1] Nadanasabapathy S, Raj Kumar SM. Analysis of fluid behaviour inside the brake lines in non anti-lock braking system. Materials Today: Proceedings [Internet]. 2020 Feb 11 [cited 2020 Jul 31]; Available from: http://www.sciencedirect.com/science/article/pii/S2214785320304727

[2] Daryanto. Teknik Merawat Automobil Lengkap. 1st ed. Bandung: Yrama Widya; 2013.

[3] Huertas-Leyva P, Nugent M, Savino G, Pierini M, Baldanzini N, Rosalie S. Emergency braking performance of motorcycle riders: skill identification in a real-life perception-action task designed for training purposes. Transportation Research Part F: Traffic Psychology and Behaviour. 2019 May 1;63:93–107.

[4] Haq MT, Zlatkovic M, Ksaibati K. Assessment of tire failure related crashes and injury severity on a mountainous freeway: Bayesian binary logit approach. Accident Analysis & Prevention. 2020 Sep 1;145:105693.

[5] Mousavi H, Sandu C. Tire-ice model development for the simulation of rubber compounds effect on tire performance. Journal of Terramechanics. 2020 Oct 1;91:97–115.

[6] Chen S, Zhao G, Wang H, Tao G, Wen Z, Wu L. Study of wheel wear influenced by tread temperature rising during tread braking. Wear. 2019 Nov 15;438–439:203046.

[7] Yu M, Xiao B, You Z, Wu G, Li X, Ding Y. Dynamic friction coefficient between tire and compacted asphalt mixtures using tire-pavement dynamic friction analyzer. Construction and Building Materials. 2020 Oct 20;258:119492.

[8] Gao X-L, Zhuang Y, Liu S, Zhu C-W, Chen Q. Digital image correlation to analyze slip state of tire tread block in the cornering condition. Optik. 2019 May 1;185:571–84.

[9] Mahama-Musah F, Vanhaverbeke L, Gillet A. The impact of personal, market- and product-relevant factors on patronage behaviour in the automobile tire replacement market. Journal of Retailing and Consumer Services. 2020 Nov 1;57:102206.

[10] Vogt P, Lenz E, Klug A, Westerfeld H, Konigorski U. Robust Two-Degree-of-Freedom Wheel Slip Controller Structure for Anti-lock Braking. IFAC-PapersOnLine. 2019 Jan 1;52(5):431–7.

[11] Wu J, Chen L, Wang Y, Su B, Cui Z, Wang D. Effect of temperature on wear performance of aircraft tire tread rubber. Polymer Testing. 2019 Oct 1;79:106037.

[12] Wu J, Wang Y, Su B, Dong J, Cui Z, Gond BK. Prediction of tread pattern block deformation in contact with road. Polymer Testing. 2017 Apr 1;58:208–18.

[13] Hassan MA, Abdelkareem MAA, Mohyeldin MM, Elagouz A, Tan G. Advanced study of tire characteristics and their influence on vehicle lateral stability and untripped rollover threshold. Alexandria Engineering Journal. 2020 Jun 1;59(3):1613–28.