**INSPECTING THE BUMP TEST ON MAINTENANCE OF DAIHATSU SIGRA 1200 CC DISC BRAKE**

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*Abstract –*Motorized vehicles need a system that can not only reduce speed and stop the vehicle but also functions as a safety tool and ensure the safe distribution which is called a system. It is important to conduct maintenance of a disc brake that is part of the braking system. Therefore, this research developed a technique for inspection of Daihatsu Sigra 1200 CC Disc brake through vibration measurement using a bump test. The disc brake is divided into three fields: A (located next to the center of the disc brake), B ( in the middle diameter), and C ( in the outer diameter of the disc brake). Each field has 10 measurement points. In this study, it was shown that disc brake damages that occurred in field A were at points 1 to 3 and it appeared after the frequency of 250 Hz. Whereas in the B and C fields, at all measurement points, there were no any changes on the frequency.

***Keywords:*** braking system, Disc brake, bump test, measurement point, frequency

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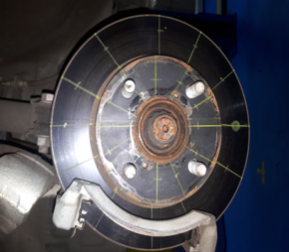
# **INTRODUCTION**

In motorized vehicles, there should be a system that can reduce speed and stop the vehicle as well ass functioning as a safety tool which ensures a safe distribution. The system is called a braking system. Antara (2018) mentioned that the brake system is very important for driving safety and also allows the vehicle to stop anywhere in various conditions properly and safely.

The combustion process will produce a force which leads the wheel to rotate affecting the disc brake to rotate too. When the component moves, there is an inertial force and another force coming from the power transmission. These forces will cause the disc brake to vibrate. In a well-designed disc brake, the vibration generated is lower, but the long usage period will cause the vibration amplitude to be larger which will affect the condition of the disc brake. The vibration signals generated has a certain frequency spectrum and vibration characteristics. The vibration that appears on the disc brake has a huge effect, which in turn will shorten its operating life. Ghazaly et al. (2012) conducted a study on commercial disc brakes to determine noise using FEA modeling and testing capital analysis. Joo et al. (2018) conducted numerical simulations and experiments on the contact stiffness distribution and surface roughness of materials by using Complex Eigenvalue Analysis (CAE). Noise is generated in a Disc brake resulted from the transition from static to dynamic conditions or vice versa. Measurement of frequency response is more often used as a step to eliminate or reduce the disc brakes on experimental brake results than on CAE results carried out by Aniket, et al (2016).

The purpose of this research was to conduct preventive maintenance on disc brakes using the excitation force method applied to the bump test. Bump test is a fast and economical mean for engine vibration and structure modes. "Bump" test (or collisions) is the best way to ensure that destructive end-wall vibrations do not occur in new engines, and is usually carried out on turbine generators (KAPLER, etc, 2014). Gilberto, etc (2016) detected cracks in the shaft using the bump test method. This method was being carried out on Daihatsu Sigra 1200 CC disc brakes made in Indonesia with the hydraulic system, as shown in Figure 1. Bump test procedure includes the measurement of frequency response function (FRF), Capital Excitation Technique, and Estimated Capital Parameter. In this paper, we will discuss the bump test by a measurement.

FRF measurements have been carried out by a number of researchers, such as Masahiro (2015) comparing the FRF method with multibody dynamic, showing a similar trend in bolt stiffness, both at the amplitude or phase that occurs in the steering system. The FRF method is also used to determine the comfort level of passengers related to the intensity of vibrations in the bus frame (Dahil, et al, 2016). The FRF method is also used to detect the level of damage or cracks that occur in gears (Mohamad et al., 2016). Chen, et al. (2017) studied the effect of the coefficient of friction between tires and road to the steering system using the FRF method, and then validated the experiment and simulation. The performance of a vehicle attenuation measured by the FRF method obtained from the excitation force is then compared to the vibration obtained from the speed level with measurements at the same point (Saha, 2017). Mathematical modeling of vibration responses that occur in piston motors has been carried out by Riri Sadiana (2016). Subekti (2018) tested the dynamic characteristics of a cylindrical piston motor and resulted in data about global vibration mode frequency. Chen, et al. (2017) studied the effect of the coefficient of friction resulted by tires and road to the steering system with the FRF method, which was then validated between experiment and simulation. The performance of a vehicle attenuation measured by the FRF method obtained from the excitation force was then compared to the vibration obtained from the speed level with measurements at the same point (Saha, 2017). A nonlinear Identification using FRF method and analysis using wavelet packet decomposition was done by Subekti, Hamid, A., and Biantoro (2018)



**Picture 1**. Disc Brake Sigra (Repair manual Daihatsu Sigra, 2016)

In addition to the application on the vehicle, FRF measurement has also been used to detect damage to a structure (Homaei, et al., 2015) and detect cracks that occur in a beam (Lin, 2015). This research aims to develope a technique for inspection of Daihatsu Sigra 1200 CC Disc brake through vibration measurement using a bump test.

**LITERATURE REVIEW**

The frequency response function (FRF) is a transfer function, expressed in the frequency domain. It is a complex function with real and imaginary components. It may also be represented in terms of magnitude and phase. Frequency response functions can be formed from data measurement or analytical functions. The frequency response function expresses a structural response to the force applied as a function of frequency. Responses can be given to the displacement, velocity or acceleration. The relationship in Figure 2 is equated as follow.



**Figure 2**. Block Diagram of an FRF.

F (ω) is the input force as a function of the frequency of the angle w. H (ω)is the transfer function. X (ω)is the displacement response function. Each function is a complex function and can be represented in the forms of magnitude and phase. Each function is thus spectral. There are many types of spectral functions. Yet, for simplicity reason, we should consider each of the Fourier transforms.

Normally, squeal brakes occur in the frequencies between 1 to 20 kHz. The squeal is a complex phenomenon, on one hand, because of its strong dependence on many parameters and, on the other hand, due to mechanical interactions in the brake system. Thus the Frequency response, in this case, is considered to be between 1 to 16500Hz.

**RESEARCH METHODS**

The damage that occurs on the disc brake was identified by measuring the frequency response function (FRF). The excitation force given to the disc brake was a bump test which was then measured using a vibration analyzer. The bump test style was given to the surface of the disc brake in a vertical or perpendicular direction. The response of vibration measured is carried out at three points, namely point A (located in the disc brake diameter and in line with the the sensor and bump test, as shown in the picture), field B (located in the middle of the diameter line), while field C (located in the outer diameter line which is also the FRF point). Each field consists of ten points, as shown in Figures 3 (a), (b) and (c).

The selection of measurement points was conducted as a follow-up study of the characteristics of vibrations that occur in the three regions, especially on the disc brake component, when the disc brake works in the silent condition and received a vibration input. In the measurement of FRF in this study, a frequency range of 1 - 1000 Hz was applied. It is to identify the range of frequency which can be used for testing. The photo of the test set to obtain experimental data can be seen in Figure 3. A bump test was carried out on the disc brake specifically in part C, which was then read by the vibration analyzer. Data obtained from the measurement were then analyzed using Matlab.

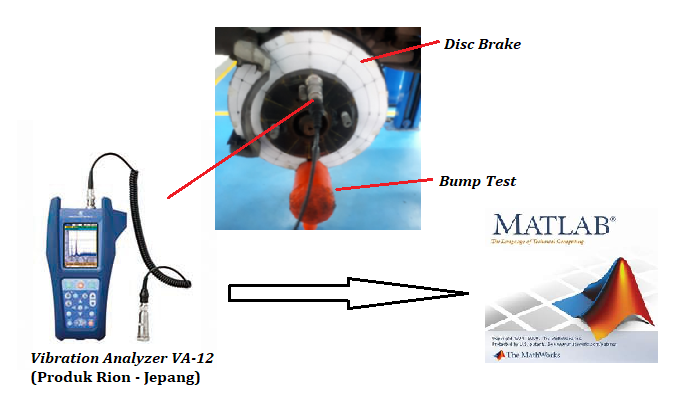
The arrangement of FRF measurement devices is shown in Figure 4. This shows the types of equipment used, as follows:



1. (b) (c)

**Figure 3**. The measurement of the frequency response function

* Accelerometer, which was, in this case, the piezoelectric accelerometer made by Rion Japan Corporation type CCLD type, PV-571. Accelerometer served to measure response vibration.
* - Frequency span of 100 Hz with analysis line 1600 using a linear function window.
* - Actual sensitivity Num 510 and actual sensitivity magnify x 0.01.

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**Figure 4.** Photo of Set-up testing of frequency response functions

While the test object in this study was the Daihatsu Sigra brake disc made in Indonesia shown in Figure 5, with the specifications as follows

- Outside diameter: 234 mm

- Inner diameter: 148 mm

- Disc thickness: 44 mm

- Tightening point: 4 positions

- Air conditioner

**RESULTS AND DISCUSSION**

The analysis of damages on the Disc Brake was conducted by comparing the frequency, which will be shown in the form of FRF as shown in the Figure of Log-log plot of the same FRF as shown in Figure 5. That figure shows that at point A1, damage occurred on the frequencies of 412 Hz, 504 Hz, and 558 Hz. This also happens at point A3 where a new frequency appears resembling the frequency at point A1, as shown in Figure 5 (b).

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(a)

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(b)

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(c)

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(d)

Figure 5. FRF measurement in field A

In Figure 5 (c) there appears to be no new frequency but there is a frequency shift in the disc brake in a damaged condition. This is the same as what happened at point A6 as shown in Figure 5 (d).

In field B, point B1, there is no new frequency but there is a frequency shift where the condition of the disc brake is broken. There is a frequency shift from 40 Hz to 35 Hz, as shown in Figure 6 (a). in Figure 6 (b) it is shown that at point B3 there is a frequency shift as happened at point B1.

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(a)

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(b)

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(c)

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(d)

Figure 6. FRF measurement in field B

In Figure 6 (c) there appears to be no new frequency but there is a frequency shift in the disc brake in a damaged condition, this is also the same as what happened at point A6 as shown in Figure 6 (d).

In field C, point C1 there is no new frequency but there is a frequency shift in the broken disc brake with the frequency shifts of from 40 Hz to 35 Hz, as shown in Figure 7 (a). In Figure 7 (b) it is shown that at point C3 there is a frequency shift as happened at point C1.

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(a)

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(b)

**

(c)

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(d)

Figure 7. Measurement of FRF in field C

In the field C, at point C5 and C6, there were no very different changes happening between on the good and on normal brake discs.

Using the FRF method, we compared the conditions of the good and bad disc breaks. A further research measuring vibration characteristics when the disc brake is subjected to loading and the effect of speed is required.

**CONCLUSION**

The results of the bump test on the disc brake showed that:

- Disc Brake damage occurred almost throughout the Disc Brake surface, especially at points A1, and A3, with the appearance of new frequencies that occurred at both points.

- There was a personal frequency that appeared at more than one measurement point. This showed the existence of a global vibrational mode. Global vibrate mode occurred at personal frequencies of 35, 53, 124, 128, 504 Hz.

This follow-up study will be conducted to determine the vibration characteristics of vibration characteristics when the disc brake is subjected to loading and speed effects, as the basis of vibration monitoring.

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