

Transient Response Performance Test on Aftermarket Motorcycle Rear Suspension in Indonesia

Journal of Mechanical Engineering,
Science, and Innovation
e-ISSN: 2776-3536
2021, Vol. 1, No. 2
DOI: 10.31284/j.jmesi.2021.v1i2.2297
ejournal.itats.ac.id/jmesi

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Abstract

Modification parts are found in Indonesia, one of which is suspension. This paper proves which after-market suspension has the best performance. These three suspensions were tested with a transient response with a test instrument that has an excitation height of 30 mm with a shaft rotational speed of 322 rpm. The observed responses are displacement and settling time. The test results without the addition of mass obtained a displacement of 25 mm for Aspira, 39 mm for AHM and 39 mm for Combiz. The addition of 30 kg mass resulted in 29 mm for Aspira, 38 mm for AHM and 23 mm for Combiz. Settling time without adding mass 1 s for Aspira and 1.2 s for AHM and 0.9 s for Combiz. With the addition of 30 kg mass obtained settling time of 1.3 s for Aspira, 1 s for AHM and 0.7 s for Combiz.

Keyword: *aftermarket, suspension, transient response, setting time dan displacement*

Date received: October 14, 2021; accepted: October 29, 2021

Handling Editor: Hasan Maulana

INTRODUCTION

Suspension is one of the important parts of the vehicle. Suspension plays a role in control and comfort in the vehicle. However, determining the quality of modified suspensions (aftermarket) in Indonesia is a challenge. The first challenge is the incomplete standardization of vehicle components, one of which is the suspension. In



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the United States almost all vehicle part has a standard. Including for wheels and suspension sold in the United States must have standards. [1].

The lack of product standards on the suspension makes buyers only rely on product quality based on what people say. In this study, we will test several types of modified suspensions that are easily available in Surabaya. A good suspension system is to have a fast settling time, has a small amplitude and eliminates the frequency that causes motion sickness [2]. The quality of the suspension can only be obtained from the active suspension system [3], [4]. However, active suspension cannot be found in aftermarket suspension products.

The first part of observing suspension quality is to look at the amplitude or displacement when the suspension is disturbed. The large displacement makes the vehicle difficult to drive and uncomfortable. Previous research has tried to control the displacement and car body mass estimator on the vehicle so that the vehicle's performance becomes better [5], [6]. The result can reduce the displacement of vehicles with wheels. However, both studies are still in the modeling stage and can only be applied to active suspensions.

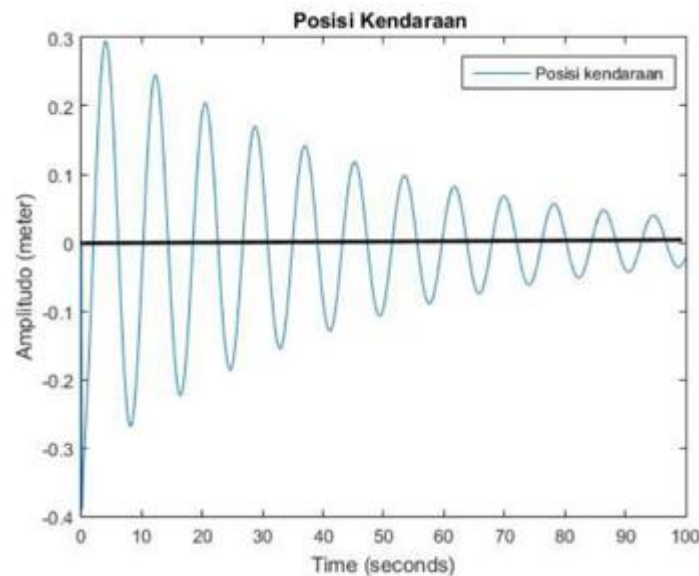


Figure 1. Example of vehicles with slow settling time [7]

The transient response and settling time of the suspension is the length of time it takes for the suspension to return to its original position. Vehicles that have a fast settling time will have good vehicle maneuvering and handling, especially when entering corners. Vehicles with good handling tend to have a large damping ratio, so their transmissibility is small [8], but there is always a trade off with driving comfort. A large damping ratio is usually used by racing vehicles, because it prioritizes good vehicle maneuvering and handling. In contrast to vehicles in general, they prioritize driving comfort but have a longer settling time. An example of a vehicle response with a long settling time can be seen in Figure 1.

In addition to displacement and settling time, there are tests of driving comfort and reliability. Comfort and reliability testing is difficult to observe, time consuming and expensive with a 1/2 vehicle suspension system for motorcycles. Driving comfort can be found in the active suspension system [9] and requires an adaptive control system [10].

With an active suspension system, increased comfort and handling will increase [11], even with bad road conditions [12].

METHODS AND ANALYSIS

There are two main components of the suspension, namely the damper and the spring. These two components affect the dynamic motion of the suspension. This is a device that produces a force proportional to the speed at which it is being stroked and always acts to oppose the motion, so the force on the damper is

$$F_D = C (\dot{y} - \dot{x}) \quad (1)$$

where $(\dot{x} - \dot{y})$ is the speed difference between the body and the base and C is the damping coefficient. While the force experienced on the spring becomes

$$F_{SP} = k(y - x) \quad (2)$$

where k is the spring constant and $(x - y)$ is the change in position between the base and the vehicle body.

The result of the addition of the force that occurs on the suspension must be zero, it shows that the position of the suspension returns to its original position after getting the force. The inertia of the mass of the vehicle is $m\ddot{x}$, So the equation of motion of the suspension system is

$$m\ddot{x} + c(\dot{y} - \dot{x}) + k(x - y) = 0 \quad (3)$$

The classical response that will be generated from the suspension system with step input can also be modeled in the form of an equation. Fixed suspension system using step input with equation of motion (3). Equation (3) is then simplified to

$$m\ddot{x} + c\dot{x} + kx = 0 \quad (4)$$

The response of the suspension is highly dependent on the damping ratio, where the damping ratio is termed zeta, ζ . The damping ratio can be obtained from the comparison of critical damping with the damping that occurs in the system. The value of critical damping is

$$C_c = 2\sqrt{kM} \quad (5)$$

where k is the spring constant and M is the mass of the vehicle, so the damping ratio can be obtained by

$$\zeta = \frac{c}{c_c} \quad (6)$$

The suspension being tested is likely to experience an underdamped transient response. The analysis carried out is the underdamped transient response equation. The equation of motion of the single degree of Freedom (SDof) transient response can be seen

$$x(t) = X e^{-\zeta \omega_n t} \sin (\omega_d t + \phi) \quad (7)$$

In equation (7) $x(t)$ is the displacement of the vehicle with a function of time. With X as dictates the magnitude of the response. Natural frequency ω_n can be obtained by

$$\omega_n = \sqrt{\frac{k}{m}} \quad (8)$$

Where k is the spring constant and m is the mass of the vehicle. However, the vehicle moves at an angular speed and is measured in rad/s, so the true natural frequency can be seen.

$$f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \quad (9)$$

The above equations are used as an analysis of the suspension performance. The suspension tested there are 3 different types and in the sale, there is no technical info and standard controls in the purchase. Figure 2 shows the suspensions of Aspira, AHM and Combiz. These three suspensions are used by Honda Supra X 125 motorcycles. The physical difference is clearly visible with the Combiz type, there is an air tube to add damping hardness. All three suspensions are brand new and have no damping tube leaks.



Figure 2. Types of suspension in order Aspira, AHM and Combiz.



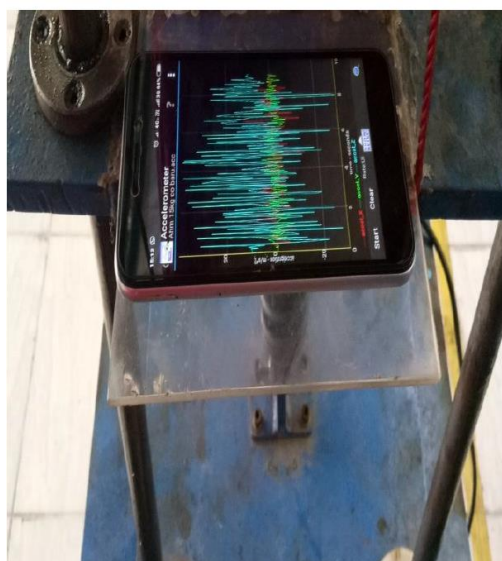
Figure 3. Installation of the three types of suspension on the test equipment.

Three suspensions are mounted on the test equipment. Installation of the suspension on the test equipment can be seen in Figure 3. The three suspensions use a 30 mm exciter as a disturbance and the exciter rotating speed is 322 rpm. In this test, the three suspensions were not added with an additional mass load. So, the resulting response is from the exciter.

The exciter on the test equipment can be varied in height. However, in this test using an exciter height of about 30 mm. The rotating speed is set at 322 rpm which rotates the shaft of the exciter. Figure 4 shows the test method by adding a 30 mm exciter and measuring the rotational speed.

**Figure 4.** Use of 30 mm exciter and exciter shaft measurement

The sensor used is the ICM20607 sensor. This sensor is found in a smartphone that is used to get acceleration data. The sensor is placed on top of the test device. After the data is obtained from the sensor, the data can be sent via email in the form of a spread sheet. Figure 5 shows the installation of the sensor on the test equipment.

**Figure 5.** Installation of sensors on the test equipment.

RESULTS AND DISCUSSION

The first test was conducted to determine the transient response of the three types of suspension. How to get the data can be seen in Figures 3, 4 and 5. In addition to the transient response data, this test also obtained data on amplitude and settling time. The results of this test can be seen in Figure 6.

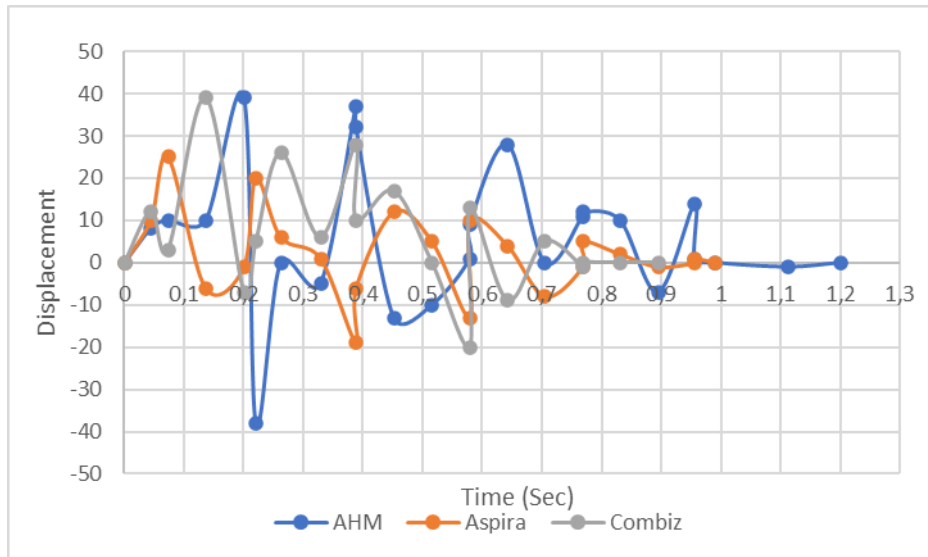


Figure 6. Transient response test without adding mass.

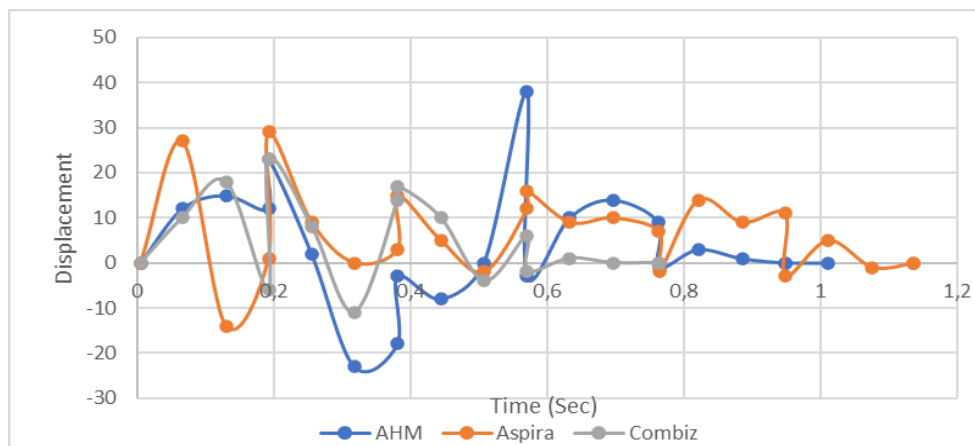
The results obtained in Figure 4 are quite interesting because the largest amplitude value is obtained from the Combiz and AHM type suspensions with each position shift of 39 mm. While Aspira has the highest displacement of 25 mm. From these data, there is a possibility that the Aspira type suspension has a large damping ratio, but if we look at the settling time and transient response, it is the Combiz type suspension that gets the best value with 0.9 seconds returning to its original position.

The next test is to add a mass of 30 kg to the three types of suspension. The addition of mass can be seen in Figure 7. The addition of mass is used to simulate the addition of passengers. The average passenger or adult mass is 60 kg, but because this suspension is usually 2 suspensions, so each suspension receives a mass of 30 kg.



Figure 7. Addition of mass to the suspension test.

The test by adding a mass of 30 kg still uses the same procedure as the previous test, namely by using an exciter of 30 mm, and 322 rpm. These results can be seen in Figure 8. The results of the addition of mass show the highest displacement in the AHM suspension even though this suspension is original from the manufacturer. Meanwhile, the Aspira brand gets the 2nd highest displacement, but the settling time takes the longest, which is more than 1 second. The best results are obtained from the Combiz brand suspension with the lowest displacement and the fastest settling time, which is less than 0.8 seconds.

**Figure 8.** The results of the suspension test with the addition of a mass of 30 kg.

The results of the 2 tests showed that the characters of the three suspensions were not much different, this happened because these three suspensions might follow the manufacturer's standards. From the performance test results, which are not much different, it is difficult to determine which type of suspension is the best. The next research can be done with the durability and reliability of the three types of suspension.

CONCLUSION

The results of the test without the addition of the best displacement mass obtained by the Aspira brand with 25 mm, while with the addition of the Combiz brand mass it is better with 23 mm. The best settling time test results were obtained by the Combiz brand with 0.8 seconds without adding mass and 0.7 seconds when adding 30 kg of mass. These results show that there is no difference in the performance of the displacement and settling time of these three types of brands. Reliability testing can be done in the next research.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FUNDING

The author(s) disclosed receipt of the following no financial support for the research, authorship, and/or publication of this article.

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