Study of suspended handle materials for reducing hand-arm vibration in backpack grass trimmer

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Abstract. Backpack-type petrol-driven grass trimmers are a widely used grass trimmer. However, the high vibration on its handle causes machine operator to be at risk of “Hand Arm Vibration (HAV)” or vibration exposure on the arms that can damage the nervous system. This research aims to study the effect of suspended handle materials in reducing the vibration on the handle of the backpack-type grass trimmer. There are three types of materials used in this study, they are natural rubber, rubber silicone and foam EVA (Ethylene-vinyl acetate). The material is layered around the handle and then the vibration on the handle is measured. The result shows that foam EVA has better performance in reducing the vibration acceleration rather than natural rubber and rubber silicone.

1. Introduction
The backpack grass trimmer is most commonly used rather than other mowers. The high vibration in the handle of the machine exposed at the operator's hands poses a risk of Hand Arm Vibration (HAV) or vibration that can paralyze the nerves in the hand.

Previously there have been pieces of research on the effect of this grass trimmer on the operator. The grass trimmer operator in the area of Universitas Syiah Kuala has an activity limit of less than 1 hour per day based on vibrations received and it takes 30 minutes of rest time for each activity [1].

Several pieces of research have been conducted to overcome the magnitude of the vibration of this cutting machine to reduce the risk of usage in a long time. One of them has been studied making several types of handles with several different shapes and also different materials. The results of this study obtained a decrease in vibration acceleration of 76% of the engine tray handle, where the vibration acceleration on the default handle of 11.30 m/s² can be reduced to 2.69 m/s² with handles made [2].

Then there is a research with simulation method, where the simulated handle shape is covered with rubber material and PVC 0.007 Plasticized. The result of this study is that the effect of rubber material and PVC 0.007 plasticized is not too significant, even though the rubber material is more appropriate to be used for acceleration absorption compared to PVC material 0.007 plasticized [3].

There is also a balancing process on the handle of this type of grass trimmer with structural optimization. Through the analysis of vibration handles and pipes, it turns out to have a high effect on vibration. Then try to reduce the resonance frequency and response rate at high frequency to increase the vibration characteristics of the pipe handle given that it does not add to the total weight [4].

Vibration is a regular movement of objects or media in the direction back and forth from the position of balance. Vibration is a physical factor caused by subjects with oscillating vibrations, for
example, machines, equipment or work tools that vibrate and expose workers through transmission [1]. These movements can be continuous and repetitive and can be irregular or random movements. Generally, vibrations are caused by the force that varies with time. Whereas what is meant by mechanical vibration is the vibration caused by the means and equipment of human activities. In occupational health, in general, is divided into two namely: the vibration of the whole body and the vibration of the arms of the arm.

Vibration in the whole body is a vibration that affects the whole body, which is delivered through the body parts of the labour that supports the entire body. For example: from the legs when standing, from the back when leaning, from the buttocks when sitting, or from the arms when leaning. Usually, the frequency of these vibrations is 5-20 Hz. Hand-arm vibrations are vibrations that travel through the hands due to the use of vibrating equipment. The frequency is between 20-500 Hz. The most dangerous frequency is at 128 Hz because the human body is very sensitive to this frequency. These vibrations occur in jobs such as chain saw, grass trimmers, grinding and drilling operators [3].

There are many different ways to control vibration. One way is to just absorb it. This is a process known as vibration damping. Over the years, many different materials have been developed that can help absorb and dampen vibrations from various sources. Dampening material is used to reduce or eliminate noise and vibration that occur in the industrial world caused by resonance. The dampening agent works to change the natural vibration frequency of the vibrating surface. The purpose of this research is to study the effect of suspended handle materials in reducing the vibration on the handle of the backpack-type grass trimmer.

2. Methods
The research is conducted by experimental method. The vibration is measured by using an accelerometer sensor (see Fig. 1) mounted on the handle of the grass trimmer. The result is collected by the data acquisition to processing the signal received by the sensor then the signal is converted to digital numeric that can be manipulated by a computer. The accelerometer can be used to measure acceleration, detect and measure vibrations, and measure the acceleration due to graphitization (inclination). An accelerometer can be used to measure vibrations in a car, engine and building. An accelerometer can also be applied to earthquake activity and electronic equipment. For more advanced applications, this sensor is widely used for applications [5].

![Accelerometer](image1.jpg)

Figure 1. Accelerometer
By using the Data Acquisition System (DAQ), as can be seen in Fig. 2, the vibration signals are retrieved and then converted into digital numeric values, which can be processed by the computer. The data acquisition system usually changes the analogue waveform into a digital value to further processing [6].

![Data acquisition](image)

**Figure 2.** Data acquisition

The main equipment used in this study was a 30.5 cc backpack grass trimmer, which is STHIL. FR. 3000 model, with the size of 345x290x401 in millimetres and a weight of 9.4 kg. The damper materials used was in sheet type with a thickness of 10mm each. The materials are Natural Rubber, Silicone Rubber, Foam EVA (Ethylene-vinyl acetate). Each of sheet type materials is wrapped on the handle and bound.

The vibration sensor used in this study is the PIEZOTRONICS PCB production accelerometer sensor with a 352c33 model, and for signal reading it is used the Dynamic Signal Acquisition NI 9250 with BCN.

In this study, data collection was done on the handle of a grass trimmer, where the sensor is an accelerometer in the paste directly on the handle.

3. **Result and discussion**

The focus of this research is the damping materials that the material was tested under vibration. The test was carried out twice with two different vibration sources but the dimensions and materials alike.

In the first test, the materials were tested by using a vibration exciter with the vibration acceleration of 0.3092 m/s². The setup can be seen in Fig. 3. The test result shows that the three materials have a good performance in reducing vibration acceleration as can be seen in Table 1. However, Foam EVA has a better performance compared with two other materials.
Figure 3. Setup of the vibration system by using vibration exciter

Table 1. Percentage of Acceleration Reduction when The System Vibrates at The Acceleration of 0.3092 m/s²

| Damper                      | Acceleration [m/s²] | Percentage of Acceleration Reduction [%] |
|-----------------------------|---------------------|-----------------------------------------|
| Natural Rubber              | 0.1362              | 56                                      |
| Rubber Silicone             | 0.0860              | 72                                      |
| Foam EVA (Ethylene-vinyl acetate) | 0.0446             | 85                                      |

In the second test, the material sheet was layered around the grass trimmer handle and an accelerometer was set above it to investigate the vibration acceleration. The result is shown in table 2. From the table, it can be seen that the Foam EVA has the best performance. Compared with the two other materials.

Table 2. Percentage of Acceleration Reduction when applied on The Grass Trimmer Handle

| Damper      | Acceleration [m/s²] | Percentage of Acceleration Reduction [%] |
|-------------|---------------------|-----------------------------------------|
| Handle      | 23.56               | 0                                        |
| Natural Rubber | 18.27             | 22                                      |
| Rubber Silicone | 16.24            | 31                                      |
| Foam EVA    | 14.80               | 37                                      |

From these two tests, we can see that the result shows a similar trend as can be seen in Figure 4. The graph shows that Foam EVA has the best performance in reducing the vibration acceleration, and Rubber Silicon and Natural Rubber has the second and third respectively.

From Fig. 4 we also can see the comparative level of vibration acceleration absorption ability of each damper material. The higher the vibration acceleration, the lower the acceleration reduction of the material, but the ratio of acceleration reduction between each material is not much different. Here it is found that EVA foam has the highest vibration acceleration reduction ability.
Figure 4. Comparison graph of vibration reduction between each damper with different vibration magnitude

4. Conclusion
The three types of damping material have good performance in reducing vibration acceleration on grass trimmer, which in this study EVA foam is the best compared with the other two dampers.

The higher the vibration acceleration, the lower the vibration acceleration reduction of the material, but the ratio of acceleration reduction between the material is not much different.

5. Reference
[1] Hasanuddin I Syahriza and Yulistia S 2017 Analisa Pengaruh Mesin Potong Rumput pada Badan Manusia Ditinjau dari Aspek Ergonomi Desain Proceeding of SNTTM XVI
[2] Hao K Y Ean O L and Ripin Z M 2011 The Design and Development of Suspended Handles for Reducing Hand-arm Vibration in Petrol Driven Trimmer, International Journal of Industrial Ergonomics 41 1 469
[3] Zainuddin 2016 Desain dan Simulasi Peredam Getaran pada Dua Handle Mesin Potong Rumput Jenis Backpack Type FR3000 A Thesis Universitas Syiah Kuala
[4] Yoshida J Uemura M Miyakawa S Oono T and Ishikawa D 2013 Reduction of High Frequency Vibration of Brush Cutter by Structure Optimization Proceedings of the World Congress on Engineering
[5] Riyadi M Wahyudi and Setiawan I 2010 Pendeteksi Posisi Menggunakan Sensor Accelerometer MMA7260Q Berbasis Mikrokontrol Atmega32 TRANSMISI 12 2 76
[6] Nataliana D Albuyani U A Parawansa M S A and Darlis A R 2016 Simulasi Data Acquisition Alat Uji Flight Control Actuator Pesawat Menggunakan Software Labview Jurnal Elektro Telekomunikasi Terapan 3 1 280