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Hand Arm Vibration of Coconut Grater Machine

M. T. Abu Seman, M. N. A. Hamid, N. R. Mat Noor

Abstract: Vibration are found almost everywhere in rotating machines. Solving or reducing vibration in rotating machinery is difficult engineering task. The impact of exposure to the vibration operating the coconut scraper machine at conventional method will affected the health, exposure to the physical injury and exposure to the Hand-Arm Vibration Syndrome (HAVS). Basically, Vibration-induced White Finger (VWF) is the most condition the user will suffer when operating the vibration tools. The aim of this study was to measure the level of hand-arm vibration when operating using conventional method at coconut scraper machine and to analyse hand-arm vibration level during operating while using proposed adapter. During measurement, spindle speed of coconut scraper machine operating with 1485 RPM. In this study, for the first measurement between conventional method (free hand) and using glove (latex and leather glove) shows leather glove is better compared with others (free hand and latex glove). The reduction of hand-arm vibration in orthogonal direction (X, Y and Z- axis) are X-axis is 33%, Y-axis is 38% and Z-axis is 8%. The second measurement is using the proposed adapter that was designed and fabricated. The percentages reduction of the proposed adapter as compared to conventional method are X-axis is 38.3%, Y-axis is 51.9% and Z-axis is 25.5%.

Index Terms: Coconut scraper machine, Hand-arm vibration (HAVS), Vibration-induced white finger (VWF), The proposed adapter, LMS test lab

I. INTRODUCTION

Vibration in rotating machinery is an important engineering problem to solve. Vibration are found almost everywhere in rotating machines. Rotating machinery vibrate cause of unbalances, misalignment and imperfect bearing. The effect of vibration at machinery have many risks. Unchecked machine vibration can accelerate rate of wear (i.e. reducing bearing life) and damage equipment. Vibrating machinery can create noise pollution and cause safety problem. Coconut scraper machine is popular in Asia, the user use coconut scraper machine is to remove the husk from the interior of coconut shell by using rotating curved or grater of scraping members. Normally, the coconut must be separates into two pieces then hold the coconut shell by hand to the coconut scraper machine. This process is risky and expose to Hand-Arm Vibration Syndrome (HAVS) if the vibration an exposure continues. This process is risky because if the vibration level is high it will affect the durability of coconut shell. Then, coconut shells may break when exposed to the grater of coconut scraper machine with high vibration level.

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This will affect the user's safety risk if these problems occur and will cause serious injury or permanent disability if the problem is not solved. Vibration-Induced White Finger (VWF) is the most common condition the user will suffer when using vibrating tools. Besides that, vibration can cause changes in tendons, muscles, bones and joints, and will affect the nervous system. Generally, these effects are known as Hand-Arm Vibration Syndrome (HAVS). The symptoms of Vibration-Induced White Finger (VWF) are, the patient will feel tingling and loss of sensation in the finger, loss grip strength, loss light touch, bone cysts in fingers and wrists, and when the patient exposed to the cold environment, whitening will attacks to the one or more fingers [1]. Based on researches, have several guidelines to minimize or reduce vibration level. For examples, the user does not exert to much grip pressure when holding the vibration tools, ensure the equipment is maintained and in good condition before use, the user must use protective clothing especially on the hand to keep warm, ensure that regular break was taken and that the user must exercises their fingers, and the user must have selected suitable tool for the tasks. Based on focus study, the improved new equipment or adapter must be designed and fabricate to reduce vibration level. The objectives of study are to measure the level of hand-arm vibration during operating using conventional method at coconut scraper machine, to design and fabricate the proposed adapter to reduce hand-arm vibration during operating machine and to analyse hand-arm vibration level during operating while using the proposed adapter.

Nowadays, technique to scraping a coconut is holding the coconut shell by hand to the coconut scraper machine. When the coconut scraper machine is an operating, it exposed vibration to the user. Vibration induced health condition progress slowly, in the beginning it starts as a pain. As a vibration exposure continues, the pain may develop into injury or disease to user. The main disease is Hand-Arm Vibration Syndrome (HAVS). Basically, Vibration-induced White Finger (VWF) is the most condition the user will suffer when using the vibration tools. Besides that, high vibration level during operating machine also give negative effect to the user's safety like physical injury. High vibration level during operating machine may cause broken coconut shell. In the worst case of the coconut shell was broken and the effect of user's hand, user will get serious injury if grater of coconut scraper machine touching to user hand. Therefore, the design of a new equipment or mechanism that can hold coconut shell was needed to reduce vibration level.

II. LITERATURE REVIEW

The method of Hand-Arm Vibration (HAV) is vibration and transmitted to the hand during using hand-held power tools and hand-guided equipment, or holding material being machine operation. HAV mostly practised by worker that common use tools such as Jackhammer, Chainsaw, Grinders, Riveters, and Impact Wrenches [2]. The worker that tedency and always exposure to HAV can contribute permanent adverse effect on health. The Hand-Arm Vibration Syndrome (HAVS) is cause of ange of condition and without ergonomic is clearly efect such as White Finger or Raynaud's Syndrome, Carpel Tunnel Syndrome and tedinitis. The fingers, adverse circulatory and neural effect which has adverse circulatory. The injured and symptoms are numbness, blanchingn and pain. [3]

Vibration biodynamic are a huge base for determined the devices of the vibration sences and for anti-vibration devices [4]. It has been predicted and initially proven that the biodynamic sences such as vibration forces, stresses, strains, and power absorbed and dissolute in the system are closely connected with vibration-encouraged injuries and abnormality of the tissues or biological structures of the system [5]. The vibrations measured at bodies joint muscle may also be directly used to expose the vibration-induced disorders and injuries in these joints, similar to the method for assessing the shock-induced health effects in the human lumbar spine recommended in ISO 2631-5. [6]

In theory, the basic method is that the dynamic forces, stresses, and strains at these locations are quite similarly with the conducted of vibrations measured at these locations. Beside that, the vibration transmissibility can also be used to find and built location specific frequency weightings for reducing the risk of vibration exposure [7]. Vibration transmissibility can also be used to evaluate the impactness of anti-vibration devices and the upgrading of powered hand tools [8]. Therefore, the calculation of the transmitted vibrations becomes one of the important tasks for continue studies of hand-transmitted vibration exposures and health contributions. The transmissibility of a substructure was measured on a bony anatomy, it is assumed as conventional method [9]. The hypothesis of vibration is consistent by primaruly transmitted through the joints and bonesof the human body. However, this pridiction is not proper for human vibration exposures research, mainly on exposures of hand-transmitted vibration. First, unlikely to be direct related the major components of the hand-arm vibration syndrome (HAVS) cousing by bone vibration, this is related with soft tissue injuries and disorders [10]. Second, the total mass of the human body, only less 20% is bone mass [11]. The overall motion of the substructure is unlikely to be representative by bobe vibration. The reason is the bone and its surrounding soft tissues may vibrate largely differently at some frequencies in the major frequency range (5–1500 Hz) of concern [12].

The surfac transmissibility of the hand-arm system was inverstigated in many research. The reported data are considerable differences. Some differences are reflected the natural characteristics of the hand–arm biodynamic responses to vibration and are functions of influencing factors such as vibration frequency, direction, magnitude, location on the system, hand and arm postures, applied hand forces, and individual differences [13]. Generally, miniature accelerometer is used in measurement as a major reported studies. The local dynamic properties of the hand-arm system may change by the acccelerometer on the skin, and the mass of the accelerometer and fixture was affected in measurement, as well as the attachment tightness. The measurement of the transmitted vibrations also was affected, if the accelerometer is vibrated rotationally on the deformable skin base. The rotational effect is reduces by a tight attachement and the bone response is more representative in measurement, especially at a bony location. [14]

III. METHODOLOGY

The section is discuss the process beginning of study until the end of results. This process is including the fabrication, designed and experiment. This section also describes the procedure step for an experiment setup that conducted.

A. Vibration Meassurement

Figure 1(a) show that coconut scraper machine being use in hand-arm vibration experimental. The coconut scraper spindle speed was operating with 1485 RPM. For measurement without using adapter, this project being conducted with three series of experiments to define the differential of maximum amplitude with their frequency range. The first series was conducted with measurement on free hand. The second series experiment was conducted by using latex glove on the hand. The third series experiment was conducted by using leather glove. The basic setups of the three experiments are similar. The standardized method is requiring the attachment of an accelerometer on the tool handle to measure the hand transmitted vibration. But in this case study, was needed to fabricate the accelerometer mounting and tied at hand to measure hand transmitted vibration. The attachment of the accelerometer on the skin of hand-arm may change the local dynamic properties of the hand-arm system. Figure 1(c) was show accelerometer mounting after finished the fabr5icate and be ready to be use in measurements of hand-arm vibration study.

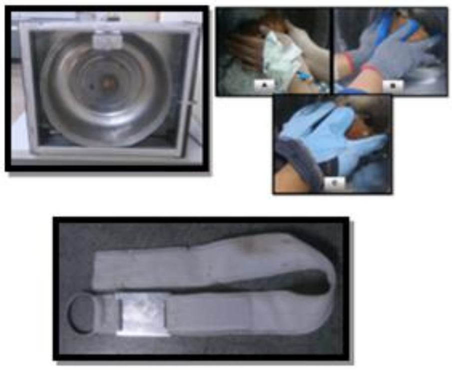

Figure 1.(a) Coconut Scraper Machine being using in Experimental; (b) Type of parameter was use in first measurement; (c) Accelerometer mounting

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This experiment needed one (1) healthy male person to conducting experiment. The basic subject posture use in the experiment is show in Figure 2. The experiments were using three types of parameter. A pictorial view of subject that holding the coconut shell during the measurement is shown in Figure 1. (b). The subjected test was instructed to hold the coconut shell at the grater of coconut scraper machines during measurements. Figure 1. (b) (A) show subject test was holding coconut shell at the grater by free hand; Figure 1. (b) (B) show subject test was using latex glove to holding coconut shell at the grater; and Figure 1. (b) (C) was show the subject test using leather glove to holding coconut shell at the grater on coconut scraper machine during measurements. To examine the accelerometer effect on the skin vibration, the vibration transmissibility on the skin at one (1) location (hand) was measured using accelerometer. The measurement point was shown in Figure 3. (a). The vibration is delivered to the subject hand through grater of coconut scraper machine that is contact with coconut shell during machining. The measurements were repeated on five (5) trials in each parameter.

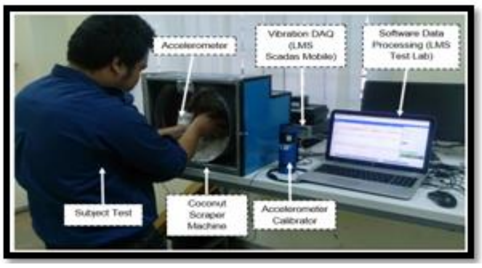

Figure 2. Experimental test setup without using adapter

Figure 3. (a) Measurement point; (b) An acelerometer attach on aluminium plate

B. Instrumentation and Check-up Test

The experiment being started with subject test needed tied the aluminium plate on hand. After that, the trial-axial accelerometer was attached at aluminium plate. The pictorial of accelerometer was attached at aluminium plate show in Figure 3 (b) accelerometer is a device that measures the vibration, or acceleration of motion of a structure. The accelerometer should have a small mass compared with object under test, although the extra mass can be taken into account. The factors to consider when selecting accelerometer during experimental of hand-arm vibration are sensitivity axis, frequency response, dynamic range, sensitivity and size and mass. The procedure of experimental are an apparatus and others equipment connection were setup including coconut scraper machine, the laptop, LMS Scadas Mobile (DAQ system), accelerometer calibrator, and subject test, as show in Figure 2. The mounting accelerometer was being tied on top of the hand. The LMS Scadas Mobile (DAQ system) was connected to the laptop and tri-axis accelerometer cable were connected to channel of LMS Scadas Mobile. The LMS Test lab (spectral testing) software was launched. The channel configuration was set, and the sensitivity values of trial-axial accelerometer were key-in, the sensitivity values of tri-axial accelerometer are X-axis: 10.66 mV/g; Y-axis:9.65 mV/g; Z-axis: 10.55 mV/g) The accelerometer was calibrated using accelerometer calibrator orthogonal axis. The direction of orthogonal axis was calibrated based on Figure 4. The required parameters in the LMS Test lab (spectral testing) software were set. (Bandwidth: 0- 512 Hz). The measurement was started by holding coconut shell on grater member parts of coconut scraper machine. Measurement was repeated in 5 trials for each parameter. In navigator module, all data was selected, and the response spectral existing graph was shown on amplitude (g) vs Frequency (Hz) graph.

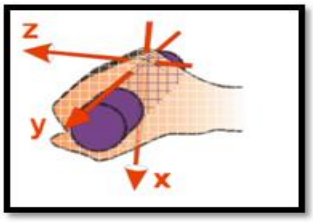

Figure 4. The axial-orientation of orthogonal axis were calibrated using accelerometer calibrator (UNI EN ISO 5349-1, 2001)

C. Development of the Proposed Adapter

In this section, the proposed adapter was designed by using the SolidWorks software. The main function of the proposed adapter is to reduce a vibration which is transmit to the hand-arm during machining. Figure 5 (a) shows the proposed adapter model that was designed by using SolidWorks software. The proposed adapter consists several parts such as body, plate, handlebar and spring base. The body of the proposed adapter function is the main supporting structure of other components attached including spring, plate and handlebar. The material use for the body of the proposed adapter is Polypropylene (PP). PP was selected because of PP has good mechanical properties such as low water absorption, low gas permeability, lighter, low density, good heat resistance, high tensile strength, high surface strength, high chemical resistance and safe for food handling. However, the disadvantages of PP are flammable, impossible to weld, varnish and glue. The body was fabricated by using Didactic 'Computer Numerical Control' (CNC) Milling. The proposed adapter's handlebar is a tubular component of a proposed adapter's steering mechanism. Handlebar provide the mounting place for controls the brake and to hold the proposed adapter during machining. The brake is the mechanism to open and release the clamp hold to the coconut shell. The handlebar was made from mild steel pipe. The mild steel pipes were selected because it is strong and easy to fabricate. The handlebar was fabricated through the welding process.
Aluminium plate (Aluminium Alloy 6082) was used as a mechanism to clamp coconut shell. Aluminium plate was selected because it is lightweight, strong, good corrosion resistance, ductility, recyclability, and easy to fabricate.

However, the disadvantage of Aluminium plate is difficult to weld. Aluminium plate was cut by using hand cutting tool and the hole was drilled by using milling machine. Spring base function is to support and act as the foundation of the spring during machining. The spring base position is between the spring and coconut shell during machining. It was fabricated by using 3-D printer. The material used for the spring base of proposed adapter is Plastic Propeller. A spring is an elastic object used to store mechanical energy. Spring is usually made out of spring steel. The spring been used as a damper during machining at the proposed adapter to absorb a vibration transmit. The spring was attached at the proposed adapter's body. The type of spring was selected is the compression spring as a damper, it is designed to operate with compression load, so it is gets shorter during the load was applied to it. Figure 5 (b) show the proposed adapter after finish fabricated and will use in experimental test.

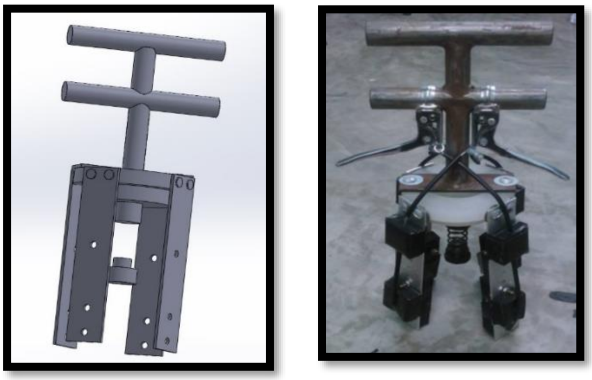

Figure 5. (a) The proposed adapter model; (b) The proposed adapter

D. Experiment Test for the Proposed Adapter

The experiment test for the proposed adapter has been carried out. The purpose of the experiment is to verify the proposed adapter concept, as well as to study the reduction of hand-arm vibration level by using proposed adapter. The overall experiment setup for the proposed adapter are identical with the previous experiment. However, there is single addition in step, which is the addition one accelerometer (single axis) at the proposed adapter's handlebar, as show in Figure 6. The accelerometer was attached at the handlebar to measure the vibration that transmit to the proposed adapter during machining. Target frequency for this experiment is at 24.5 Hz, because based on data collected during experimental without the proposed adapter that maximum amplitude occurs at frequency range 24 Hz until 25 Hz. The data was collected by using LMS Test lab (spectral testing) software from the experiment that had been conducted.

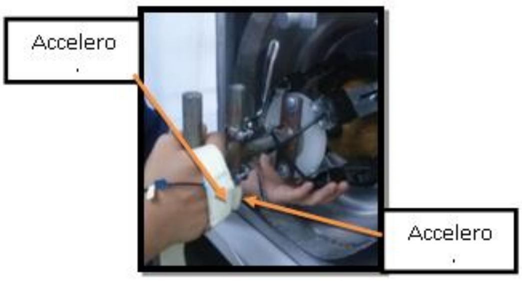

Figure 6. The proposed adapter during machining

IV. RESULTS & DISCUSSION

The results have two section, for first section there are comparison that subject test hold coconut shell at the grater of coconut scraper machine with free hand and using glove (latex glove and leather glove). The second section that comparison between free hand and the subject was hold the coconut shell at coconut scraper machine using the proposed adapter.

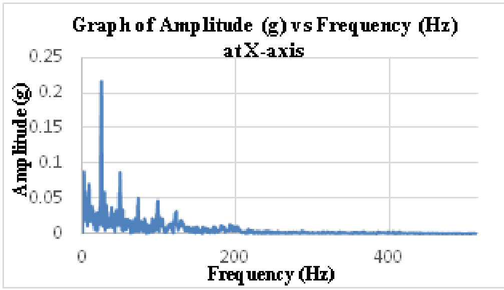

Figure 7. Sample of response spectral existing at parameter 1 (X-axis)

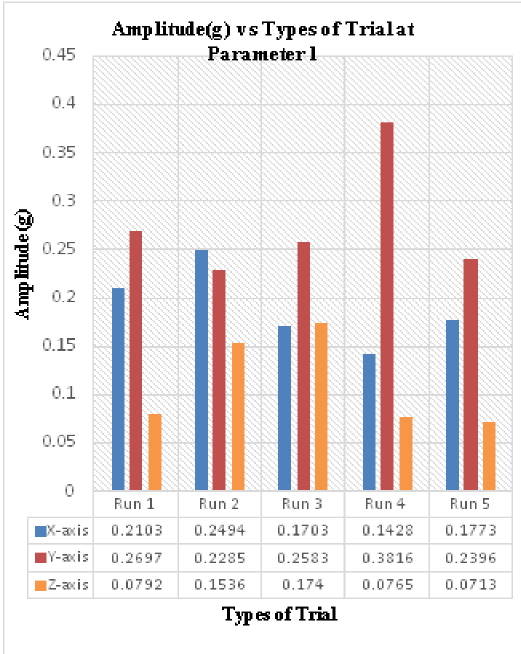

Figure 8. Amplitude value at each trial on parameter 1 (Free Hand)

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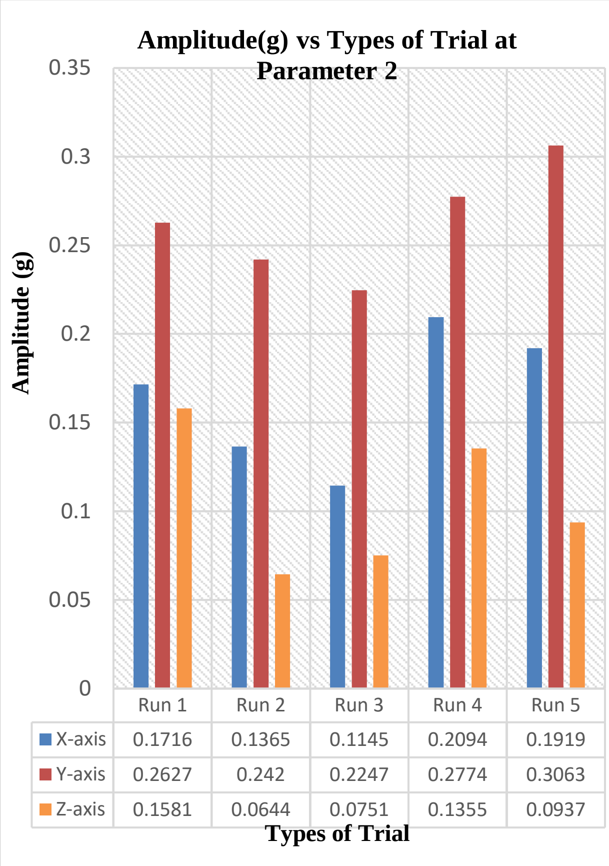
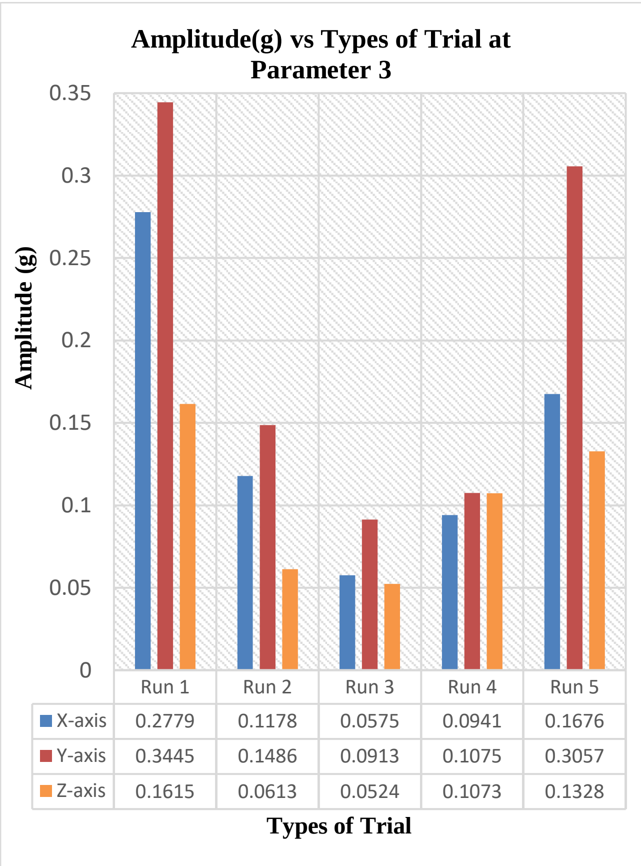


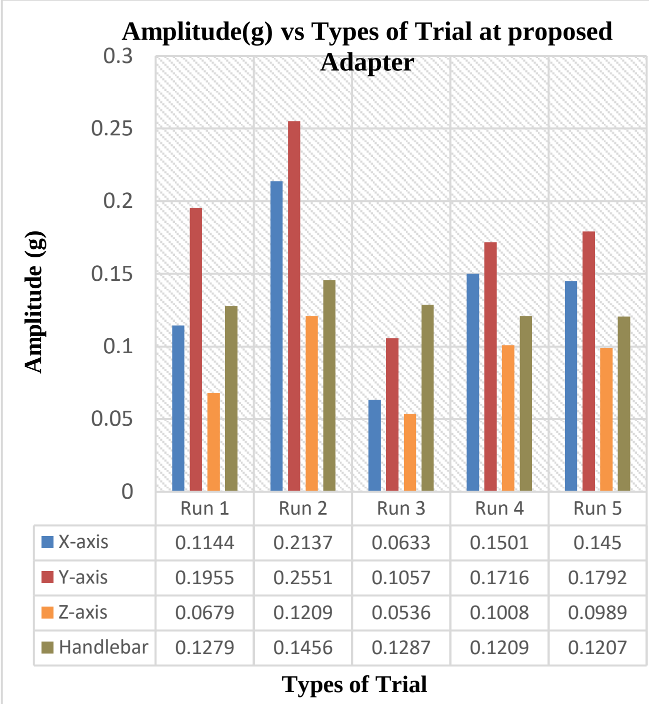
	Run 1	Run 2	Run 3	Run 4	Run 5
X-axis	0.1716	0.1365	0.1145	0.2094	0.1919
Y-axis	0.2627	0.242	0.2247	0.2774	0.3063
Z-axis	0.1581	0.0644	0.0751	0.1355	0.0937

Figure 9. Amplitude value at each trial on parameter 2 (Latex Glove)



	Run 1	Run 2	Run 3	Run 4	Run 5
X-axis	0.2779	0.1178	0.0575	0.0941	0.1676
Y-axis	0.3445	0.1486	0.0913	0.1075	0.3057
Z-axis	0.1615	0.0613	0.0524	0.1073	0.1328

Figure 10. Amplitude value at each trial on parameter 3 (Leather Glove)



	Run 1	Run 2	Run 3	Run 4	Run 5
X-axis	0.1144	0.2137	0.0633	0.1501	0.145
Y-axis	0.1955	0.2551	0.1057	0.1716	0.1792
Z-axis	0.0679	0.1209	0.0536	0.1008	0.0989
Handlebar	0.1279	0.1456	0.1287	0.1209	0.1207

Figure 11. Amplitude value at each trial on the proposed adapter

Figure 7 show the sample of Fast Fourier Transform (FFT) graph at parameter 1(free hand), the data show the maximum amplitude value is 0.2103 g and it occur at 24.5 Hz. Figure 8, Figure 9, Figure 10, and Figure 11 shows the maximum amplitude value in each trial that was measured. Figure 8 shows the value of maximum amplitude against type of trials when experiment test done at parameter 1 (free hand). The higher value of maximum amplitude on X-axis is at trial 2 (0.2494 g) and the lowest at trial 4 (0.1428 g). The higher maximum amplitude value on Y-axis is at trial 4 (0.3816 g) and the lowest is at trial 2 (0.2285 g). Lastly, the maximum value on Z-axis is at trial 3 (0.174 g) and the lowest is at trial 5 (0.0713 g). Figure 9 shows the value of maximum amplitude against type of trials when experiment test done at parameter 2 (latex glove). The higher value of maximum amplitude on X-axis is at trial 4 (0.2094 g) and the lowest at trial 3 (0.1145 g). The higher maximum amplitude value on Y-axis is at trial 5 (0.1919 g) and the lowest is at trial 3 (0.2247 g). Lastly, the maximum value on Z-axis is at trial 1 (0.1581 g) and the lowest is at trial 2 (0.0644 g). Figure 10 shows the value of maximum amplitude when experiment test done at parameter 3 (leather glove). The higher value of maximum amplitude on orthogonal direction is at trial 1. The value of X-axis is 0.2779 g, Y-axis is 0.3445 g and Z-axis is 0.1615 g. the lowest value of maximum amplitude is at trial 3. The value of X-axis is 0.0575 g, Y-axis is 0.0913 g, and Z-axis is 0.0524 g. The data collected shows Y-axis is higher and be followed by X-axis and the lowest is Z-axis. Figure 11 shows the value of maximum amplitude when experiment test done with the usage of the proposed adapter.

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The data shows trial 2 have maximum value of amplitude compared to the other trials. The value of maximum amplitude on X-axis is 0.2137 g, Y-axis is 0.2137 g, Z-axis is 0.1209 g, and the value of maximum amplitude of the accelerometer attached at handlebar is 0.1456 g. The lowest value of maximum amplitude occurs at trial 3. The value on X-axis is 0.0633 g, Y-axis is 0.1057 g, Z-axis is 0.0536 g and at handlebar is 0.1287 g. The value of maximum amplitude when accelerometer was attached at hand is higher compared with the maximum amplitude when accelerometer was attached at handlebar.

A. Experiment Data without Using Proposed Adapter

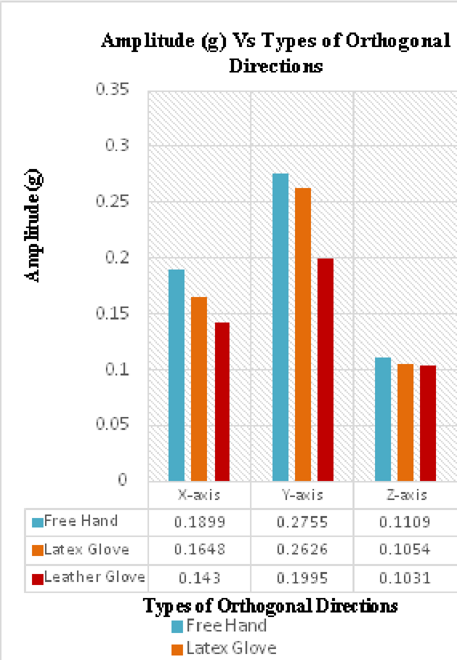

Figure 12. The averages value of amplitude vs types of orthogonal directions (X-axis, Y-axis and Z-axis).

Figure 12 above shows the average values of amplitude at three (3) types of parameters was being measured. The average value of amplitude at parameter 1 (free hand) is higher compared with parameter 2 (latex glove) and parameter 3 (leather glove). The dominance direction with high amplitude values is Y-axis, was followed by X-axis and the lower amplitude value is on Z-axis. The average value of amplitude at parameter 1 on X-axis is 0.1899 g, Y-axis is 0.2755 g, and Z-axis is 0.1109 g. The average value of parameter 1 show more high compare with others because during operating machines, the transmitted vibration directly contacts to the subject test upper extremities. The average value of amplitude at parameter 2 (latex glove) is second maximum**.** The averages value of amplitude at X-axis is 0.1648 g, Y-axis is 0.2626 g, and Z-axis is 0.1054 g. The amplitude value reduction on parameter 2 from parameter 1 at X-axis is 15.2 %, at Y-axis is 5 %, and at Z-axis of the values amplitude's reduction is 5.2 %. The parameter 3 (leather glove) show the lower of average amplitudes value, compares with parameter 1 and parameter 2. The amplitudes value of average at X-axis on parameter 3 is 0.143 g, at Y-axis is 0.1995 g and at Z-axis is 0.1031 g. The percentages of amplitude value reduction on X-axis at Parameter 3 from parameter 1 is 33 %, for amplitude value reduction on Y-axis at parameter 3 from parameter 1 is 38 %, and lastly for Z-axis of amplitudes values reduction is 8 %. The percentages of amplitudes reduction at parameter 3 is decreases compare with amplitude reduction at parameter 2 on each orthogonal direction. This is because the palm glove surface of leather glove in parameter 3 more thickness compare with latex glove at parameter 2. The thickness of glove surface may have manipulated the absorption of the vibration transmitted at the palm of the subject hand. In this project, parameter 3 (leather glove) being use in measurement more thickness compare with parameter 2 (latex glove). The case study confirmed that the vibration isolation effectiveness of the gloves was frequency-specific. While the gloves did not significantly reduce vibrations at low frequencies (those below 25 Hz), they did provide some reduction of the vibration transmitted to the palm of the hand. Glove effectiveness was generally better at higher vibration frequencies. Effectiveness also varied significantly among the glove models, primarily depending on the isolation materials of the gloves. The tested gloves were ranked in terms of vibration attenuation and grip strength reduction.

B. Comparison between using the Proposed Adapter and without using the Adapter (Free Hand)

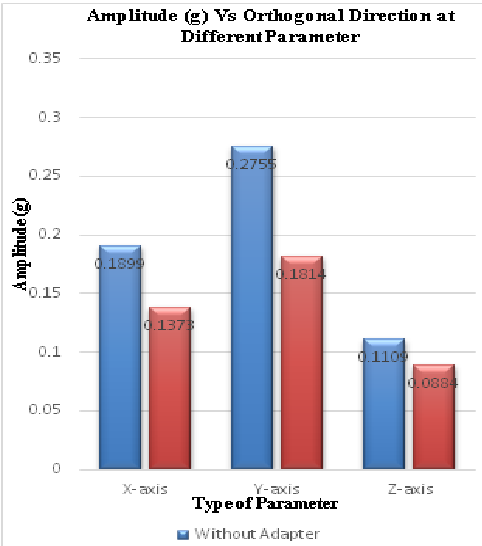

Figure 13. Amplitude value at measurement without adapter and using the proposed adapter

Figure 13 shows the comparison between experiment test with using the proposed adapter and without using the adapter (free hand) during operating at coconut scraper machine. The comparison based on an amplitude reduction on orthogonal axis (X-axis, Y-axis and Z-axis). The blue colour represents experiment test without using the adapter and the red colour represent experiment test with using the proposed adapter. For the X- axis, the average maximum amplitude for experiment test without using the adapter is 0.1899 g, and it changes after using the proposed adapter (0.1373 g). The amplitude percentages of reduction on X-axis is 38.3%. On Y-axis the average maximum amplitude value without using the adapter is 0.2755 g and it was reducing after using the proposed adapter (0.1814 g).

The amplitude percentages of reduction on Y-axis is

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51.9%. Lastly, the average maximum amplitude value for the experiment without using the adapter on Z-axis is 0.1109 g and the average maximum amplitude value reducing is 0.0884 g after using the proposed adapter. The amplitude percentage reduction on Z-axis is 25.5%. The reduction occurs because spring was used as a damper at the proposed adapter, friction spring dampers consists of a series of concentrically stacked steel rings with mating taper faces. The spring have inner and outer rings alternate down the length of the friction spring. For the proposed adapter's spring, the spring have 6 rings. When the spring compressed during operating, each solid ring on a taper can absorb the shock and impact produced by coconut scraper machine.

V. CONCLUSION

In this section, the discussion from the research conducted are summarized. The research conclusions follow it. Next, the contributions of this research are highlighted, and the few suggestions are recommended for future work.

This paper presents the study to reduce the hand-arm vibration level by using the proposed adapter when machining at coconut scraper machine. The objective of this case study was achieved by completing the designed and fabricated the proposed adapter to reduce hand-arm vibration during operating machine. This study found that machining at coconut scraper machine when using the adapter will be reducing the hand-arm vibration level. After the experiment was completed, there are several recommendations to improve this proposed adapter. The future research is recommended to design and fabricate the proposed adapter with mechanism that can place and clamp the coconut shell automatically before machining. The material used can be improved with more lightening and anti-corrosion because the proposed adapter will be used in food industry. Higher number of spring's ring can be used to characterize the spring as a damper.

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REFERENCES

1. Hedge, A. Examples : Vibrating Hand Tools Segmental Vibration. *Hand, The*, 2008 (August), 1–4.
2. Hand-Arm Vibration - Fact Sheet, September 2012, pp1-3
3. Journal, I., & Engineering, O. F. International journal of engineering sciences & research technology Review Paper on Vibration Reduction in Hand Held Power Machinery, 2014 *3*(11), 501–503.
4. M.J. Griffin, Foundations of hand-transmitted vibration standards, Nagoya J. Med. Sci. 57, 1994 147–164.
5. Wu, J. Z., Krajnak, K., Welcome, D. E., & Dong, R. G. Analysis of the dynamic strains in a fingertip exposed to vibrations: Correlation to the mechanical stimuli on mechanoreceptors. *Journal of Biomechanics*, 2006 *39*(13), 2445–2456. http://doi.org/10.1016/j.jbiomech.2005.07.027
6. ISO 2631-5, Mechanical Vibration and Shock—Evaluation of Human Exposure to Whole-body Vibration — Part 5: Methods for Evaluation of Vibration Containing Multiple Shocks, 2004
7. Thomas, M., & Beauchamp, Y. Development of a new frequency weighting filter for the assessment of grinder exposure to wrist-transmitted vibration. *Computers & Industrial Engineering*, 1998 *35*(3-4), 651–654. http://doi.org/10.1016/S0360-8352(98)00181-8
8. Gurram, R., Rakheja, S., & J. Gouw, G. Vibration transmission characteristics of the human hand-arm and gloves. *International Journal of Industrial Ergonomics*, 1994 *13*(3), 217–234. http://doi.org/10.1016/0169-8141(94)90069-8
9. ISO 8727, Mechanical Vibration and Shock – Human Exposure – Biodynamic Coordinate Systems, 1997.
10. M.J. Griffin, Handbook of Human Vibration, Academic Press, London, 1990.
11. Freivalds, A. Biomechanics of the Upper Limbs: Mechanics, Modelling and Musculoskeletal Injuries (p. 624). 2004. Retrieved from https://books.google.com/books?id=fxAC9T3x-pEC&pgis=1
12. ISO 5349-1, Mechanical Vibration – Measurement and Evaluation of Human Exposure to Hand-transmitted Vibration – Part 1: General Requirements, 2001.
13. Adewusi, S. a., Rakheja, S., Marcotte, P., & Boutin, J. Vibration transmissibility characteristics of the human hand-arm system under different postures, hand forces and excitation levels. *Journal of Sound and Vibration*, 2010 *329*(14),2953–2971. http://doi.org/10.1016/j.jsv.2010.02.001
14. Scalise, L., Rossetti, F., & Paone, N. Hand vibration: non-contact measurement of local transmissibility. *International Archives of Occupational and Environmental Health*, 2007 *81*(1), 31–40. http://doi.org/10.1007/s00420-007-0190-3

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