UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE USE OF PADDY STRAW FIBER AS AN ADDITIONAL DAMPER TO REDUCE VIBRATION TRANSMISSIBILITY FROM HAND-HELD POWER TOOLS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Maintenance Technology) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) (Hons.). The member of the supervisory is as follow:

……

(MR. AHMAD YUSUF BIN ISMAIL)

ABSTRAK

Kajian ini dijalankan untuk melaksanakan penggunaan serat jerami padi sebagai peredam tambahan untuk mengurangkan kebolehpindahan getaran dari alat kuasa tangan. Tangan Lengan Getaran (HAV) menyumbang akibat kerosakan saraf seperti menggigil berpanjangan ke arah bahagian badan yang telah terdedah kepada kebolehpindahan getaran. Dalam kajian ini, pembikinan sarung tangan dengan peredam tambahan padi serat jerami dan span dihasilkan untuk menyekat getaran daripada memasuki tapak tangan dengan cara-cara inovasi. Penyediaan bahan dijalankan pada komposisi yang berlainan bagi ujian perbezaan diantara komposisi-komposisi yang ditambahkan kedalam sarung tangan-sarung tangan tersebut. Tujuan kaedah penyediaan adalah untuk menguji dan menganalisis keberkesanan menggunakan gentian jerami padi sebagai redaman tambahan dalam mengurangkan kebolehpindahan getaran dari alat kuasa tangan. Satu reka bentuk konsep telah dibuat untuk membantu proses pembuatan dari segi jahitan dan keselesaan menggunakan prototaip ini. Data yang dikumpul dianalisis menggunakan Perisian Pro-Photon Analisis Spektrum Getaran untuk mencapai objektif dimana membandingkan tingkah laku kebolehpindahan getaran itu. Getaran kebolehpindahan dikira menggunakan persamaan indeks pengurangan getaran. Antaranya yang mempunyai kebolehpindahan paling rendah getaran adalah komposisi yang terbaik untuk mewajarkan penggunaan serat jerami padi sebagai peredam tambahan daripada alat kuasa tangan. Oleh itu, penggunaan gentian jerami padi adalah lebih berkesan diantara 40% hingga 80% komposisi mengikut jisim gentian jerami padi.

ABSTRACT

This study is conducted to perform the use of paddy straw fiber as an additional damper to reduce vibration transmissibility from hand-held power tools. Hand Arm Vibration (HAV) contributes the consequences of neurological damages such as prolonged shiver towards the part of body that has been exposed to that vibration transmissibility. In this study, fabrication of the gloves with additional damper of paddy straw fiber and sponge is developed as to suppress the vibration from transmit palm of the hand with the means of innovation. Material preparation is conducted at different composition for the test of such differences between those compositions added on these gloves. The purpose of the preparation method is to test and analyze the effectiveness of using paddy straw fiber as an additional damping in reducing the vibration transmissibility from hand-held power tools. A conceptual design was made to aid the manufacturing process in terms of sewing and comfort of using this prototype. Data collected is analyzed using Pro-Photon Vibration Spectrum Analyzer Software to achieve the objectives on comparing its vibration transmissibility behaviour. Vibration transmissibility is calculated using vibration reduction index equation. Of which has its lowest transmissibility of vibration is the best composition on justifying the use of paddy straw fiber as an additional damper from hand-held power tools. Therefore, the use of paddy straw fiber is more effective in a range of 40% to 80% composition by mass of paddy straw fiber.

DEDICATION

The hardship on executing this project is dedicated to my beloved parents, family, my supervisor, Mr Ahmad Yusuf Bin Ismail, and my best friends for the support and indulgence of easing till the completion of this project. This project also is dedicated to my beloved teammates in Futsal Wanita Utem which give me a full support to finish this project in time no matter how hard it could be.

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I would also like to thank my parents and family members for the support they provided me through my entire life and in particular. Words cannot express how grateful I am to my mother and father for all of the sacrifices and prayer that they have made on my behalf. Lastly to my best friends who have shared their experience and difficulties together on behalf of sacrificing the time with me to fullfill the requirement of this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

HAV	-	Hand Arm Vibration
HAVS	-	Hand Arm Vibration Syndrome
ISO	-	International Standard Organization
VRI	-	Vibration Reduction Index
VWF	-	Vibration-induced White Finger
m	-	Mass
t	-	Time
k	-	Spring Stiffness Coefficient
x	-	Displacement
X	-	Displacement of the Function
$\dot{X}$	-	Velocity of the Function
$\ddot{X}$	-	Acceleration of the Function
ω	-	Frequency of the system
ω_n	-	Natural Frequency
T	-	Vibration Transmissibility
c	-	Damping Loss Factor
ξ	-	Damping Coefficient
K_{ij}	-	Vibration Reduction Index
a	-	Equivalent Absorption Lenght
a_i	-	Equivalent Absorption Lenght of the Element i
a_j	-	Equivalent Absorption Lenght of the Element j
c_0	-	Sound Velocity in Air
l_{ij}	-	Common Lenght of the Junction i-j
f_{ref}	-	Reference Frequency
f	-	Frequency of the Band
T_s	-	Structural Reverberation Time of the Element i or j
S	-	Area in Square Meters of the Element i or j

CHAPTER 1
INTRODUCTION

1.1 Human Vibration

Human being is exposed to vibrations of one or other sort during the normal day lives such as in buses, train and cars. A large number of people are also exposed to other vibrations during their working day, for example vibrations produced by hand-tools, machinery, or heavy vehicles. Human vibration can be divided into two main vibration which is a whole-body vibration and hand-arm vibration. Both types of human vibration may be either temporary or permanent physical system damage in the case of long term exposure to excessive vibration.

The whole-body vibration is defined as vibration that occurred when a greater part of the body weight is supported on a vibrating surface where at this state the vibration transmission take place (Ismail et al., 2010).Most common case that may give effect regarding the whole-body vibration is a bad sitting position where the vibration transmitted through the seat pan or back rest (Ismail et al., 2010). Factors that affect the body to vibrate are pointed toward the contact area between the body surface and the area of the vibration is produced or having excitation. When the body are in contact with the vibration surface, the transmission of vibration will take place in between this two contact surface. Therefore, the vibration will then being transmitted to the whole body.

The hand-arm vibration is one of the specific and common types of exposure that focus only on vibration transmissibility at the palm of the human hand. This vibration transmissibility exposure will give a result in severe symptoms such as

tingling, numbness, and loss of feeling and control in those fingers which are affected (Welcome et al., 2014). This type of vibration exposure is due to a long exposure condition while using the machine that is in contact with the hand. So that the vibration will be transmit from the tools to the palm of the hand where it can give an effect on human nervous system.

1.2 Hand-transmitted Vibration and It's Effects

Hand-Transmitted Vibration (HTV) is one of the mechanical vibrations arising from powered tools and entering the body at the fingers or at the palm of the hands.Prolonged exposure to the vibration frequency will be harmful and can lead to hand-arm vibration syndrome (HAVS) when using hand-held power tools (Griffin, 1994). A frequently exposure to hand-arm vibration throughout the years can cause permanent physical damage known as "white-finger syndrome" or "Hand-Arm Vibration Syndrome (HAVS)" as shown in Figure 1.1, which can damage nerve of the wrist and/or elbow (Govindaraju et al., 2008). In addition it also can cause non-vascular diseases such as Carpal Tunnel Syndrome (CTS) (National Institute for Occupational Safety and Health, 1988).

Reducing the magnitude of the vibration transmitted from a tool to the hand has been viewed as a potential effective approach to prevent HAVS (Singh and Khan, 2014). In this study, the use of natural fiber coating is one of the approaches to reduce vibration transmissibility from hand-held power tools. Eliminating or minimizing exposure to HAV usually involves isolating or cushioning methods. A few studies reported that some of these syndromes can be reduce by using anti-vibration glove when working with hand-held power tools. The testing and assessment of such gloves has been performed in accordance with the International Organization for Standardization (ISO) (ISO 10819, 1996).

Figure 1.1: Hand-arm vibration syndrome

1.3 Natural Fibers as an Additional Damper

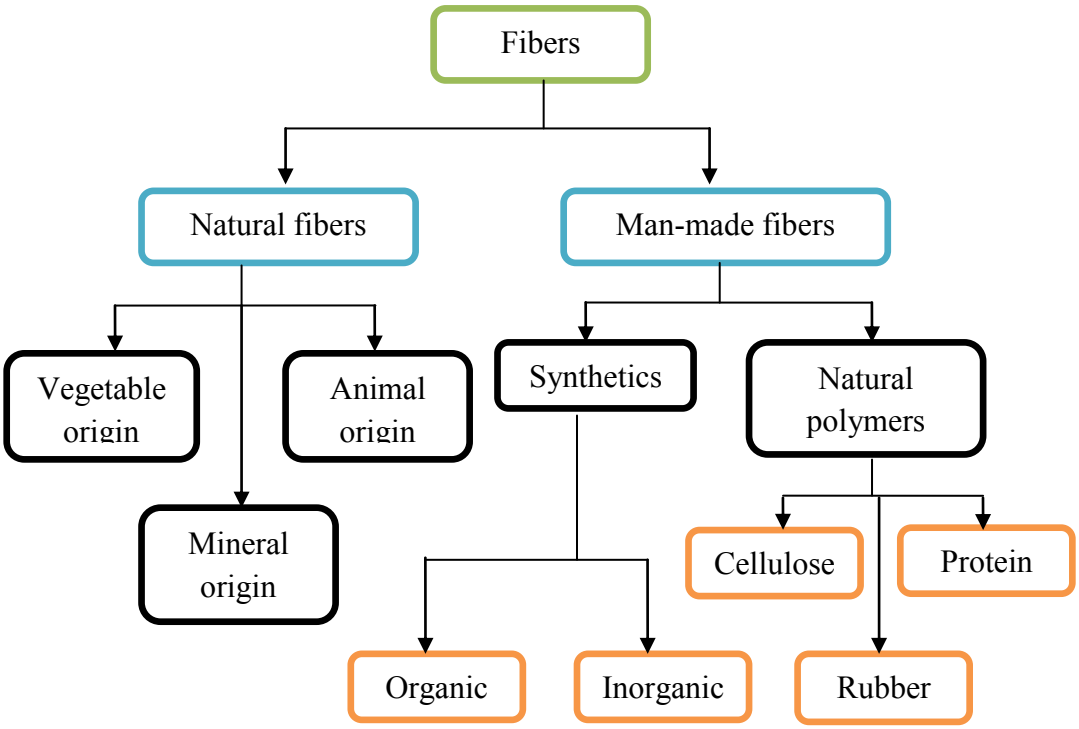

Figure 1.2: Classification of fibers

Damping can be defined as the energy dissipation properties of a material or system under continues stress that applied. It is the conversion of mechanical energy into thermal energy. The amount of energy dissipated is a measure of the material's damping level. The damping system is important in industrial application as it can reduce or suppress the vibration transmission from one part to another part of the body system. Choosing suitable materials for certain system should be considered as an important step in producing a good quality product according to their functions. In this study, natural fiber is selected as vibration damping materials for producing a new vibration damping gloves as an approach for industrial application.

Natural fibers can be divided into three main classifications which are vegetable origin, animal origin and mineral origin. Natural fibers from vegetable fibers are obtained from the various parts of the plants. In this research, paddy straw fibers will be use as a raw material and additional damper in reducing vibration transmissibility. Paddy straw fibers have features such as it is bio-degradable,

nonabrasive, abundance and having less health andsafety risk while handling and processing (Abdullah et al., 2011). It is also sustainable, lightweight and environmental friendly to use without affecting the future needs.

The use of natural fibers may improve the quality of damping system on anti-vibration gloves compared with the use of synthetic material which is now widely used in industrial sector. Different types of working activities will need different types of glove used in order to prevent the workers from injuries. Good materials used in producing anti-vibration gloves will give a better performance as it is comfortable and meets the requirements standard.

The man-made fibers are mainly undergoes several chemical process. Most of it is produce by addition of chemical composition for some application in industrial sector. Man-made fibers are divided into two categories which is synthetics and natural polymers. Synthetic fiber are also known as artificial fibers and whereas the natural polymers whose structure that are composed of multiple repeating units. Both synthetic fibers and natural polymers are also widely use in industrial sector where they undergoes additional chemical properties to produce a unique physical properties such as toughness, viscoelasticity, and a tendency to form a better structure according to their application needs in industry.

1.4 Problem Statement

Apart from any interest in protecting the hand from abrasion, extreme temperature, chemicals, and wetness, gloves might also assumed to reduce the vibration transmissibility to the hand.The use of gloves has been shown to have both positive and negative influences on hand exertion (Singh and Khan, 2014). Different types of material used for anti-vibration gloves have different level of effectiveness or ability to suppress vibration from transmitted to the human hand.

Most of manufacturers today produced anti-vibration gloves which are made of synthetic material that is not really suitable for human health and environment. In order to find an anti-vibration glove which has a high tendency to suppress the vibration transmissibility, many researchers take their responsibility to do some research regarding the anti-vibration gloves. One of the studies shows the performance of two typical models of vibration-reducing gloves which is a gel-filled glove and an air bladder-filled glove (Welcome et al., 2014).Grip and push forces that applied during working with the hand-held power tools could be one of the cause that affect vibration transmissibility and give a different result of gloves performance (McDowell et al., 2007).

In this study, the idea is to use the paddy straw fiber as a mechanical compound materials which have a characteristic of an eco-friendly and sustainable material (Abdullah et al., 2011) to reduce vibration transmissibility to the hand. With the combination of this natural fiber and the commercial absorber material, the best mix composition to optimally suppress the vibration as well as to reduce material cost in the production process will be achieved.Therefore, by using a method of modifying existing glove to either minimize the vibration or prevent the vibration from moving into the handle of the tool (Kowalski, 2011, Welcome et al., 2014). This approach will give some new findings in improving the effectiveness of using the natural fibers as a damping material on anti-vibration gloves.

1.5 Objective of Research

The objectives of the project:

i. To fabricate the gloves with additional damper of paddy straw fiber and sponge as to suppress the vibration from entering palm of the hand.
ii. To test and analyze the effectiveness of using paddy straw fiber as an additional damping in reducing the vibration transmissibility from hand-held power tools.

1.6 Scope of Research

The scope of the project:

i. Preparation of paddy straw fiber and sponge in different quantities in the form of percentages by mass are used to fabricate the additional damping materials at the palm of the existing gloves in order to modify the gloves.
ii. A test is conducted by using the electric hand saw machine that is experimented with only single axis (z-axis) to avoid variety of result that is unnecessary from the vibration transmissibility in the laboratory monitored with accelerometer and signal analyser.
iii. Analyzing the effectiveness of paddy straw fiber as an additional damping to reduce the vibration transmissibility to the hand from hand-held power tools is conducted by using vibration analysis software.

CHAPTER 2
LITERATURE REVIEW

2.1 Vibration Damping Body

Vibration can be defined as the study of the repetitive motion of objects relative to a stationary frame of reference or nominal position (usually equilibrium). Vibration can be reduced by adding some type of damping. In this case study, the use of vibration damping materials is applied. According to Jones (2001), damping is defined as any mean of dissipating some fraction of each increment of energy which is otherwise added to the system at resonance, by the exciting forces, during each cycle of response. There are two types of damping. One method is active damping, using appropriate sensors to measure the response at each instant and actuators to automatically apply forces which oppose the measured vibration response in a prescribed manner. The other is by passive damping, using materials or devices which, as a result of deformation, apply forces which oppose the velocity motion. The passive damping will be implemented in this study of vibration transmissibility.

Tool manufacturers continue to incorporate new designs to the internal mechanism of tools in order to decrease the vibration that is delivered to the hand during operation. Modification of some tools to minimize tool vibration is not easily resolved through internal tool design. For this reason, vibration damping materials applied between the tool and the hand are a simple alternative. The damping materials may be applied to the area of the tool directly contacted by the operator or in a glove containing a vibration absorbing pad. These interventions are developed specifically to damp vibration but are not necessarily produced and tested under the

same work conditions that a company may expose their workers. Therefore, it is important to test the value of the proposed interventions for the specific applications.

The physical explanation of the phenomena of vibration transmission from tools to the hand can be illustrated as shown in the figure below.

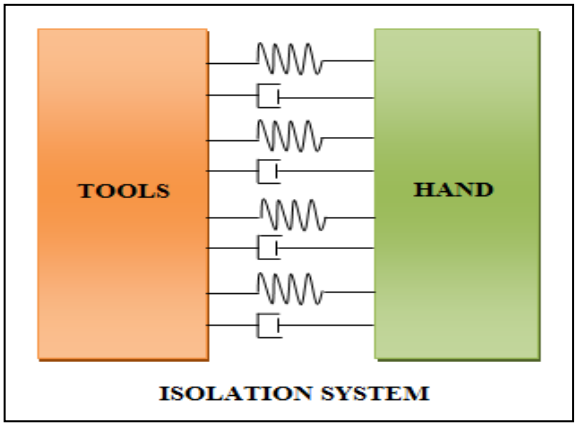

Figure 2.1: Isolation system

The vibration is transmitted from power tools to the human hand. It is important to know about hand systems response with respect to exposure to vibration. From Figure 2.1, the tools and hand will be separated with the existence of vibration damping materials. This isolation system will be implemented in this study.

2.1.1 Gloves

Gloves are used in many settings for many purposes. For example like rubber gloves protect the hands and forearms from chemicals, anti-vibration gloves reduce the transmission of vibration while latex examination and surgical gloves give a function on prevention in transmission of pathogens. A glove must perform its prime function of protection, but considering the effects of gloves on manual work can improve the selection of the most appropriate glove. Maximizing the capability of gloved workers is possible by choosing the most appropriate glove for a job. However, the very properties of gloves that help to protect our hands, may affect our ability to perform manual work effectively.

There are several types of gloves with a specific applications used in different sectors. They included chemical resistant gloves, surgical gloves, cold exposure and anti-vibration gloves. The several important considerations about glove characteristics should we look for, which is (1) the gloves offer barrier protection both for the health care worker and the patient to guard against contact with blood, other body fluids, and microorganisms, (2) the glove needs to be comfortable, and (3) the glove cost.

2.1.2 Coating on the Handle

Most of the hand-held power tools that available in market are base on rubber-coated handled. According to Chaturvedi et al. (2012), rubber was also found suitable in reducing vibrations in power tillers out of various interventions of different materials used in the study. There are some examples of hand-held power tools which coated with rubber at the handle as shown in the following Figure 2.2 to Figure 2.4:

Figure 2.2: Jigsaw (White's Agri, 2012)