

**OBJECTIVE AND SUBJECTIVE ASSESSMENTS OF  
VIBRATING TOOLS**

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# ABSTRACT

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(keywords: Hand Arm Vibration, power tools, vibration attenuation)

Vibration among hand held power tools are commonly blamed for the causation of upper limb musculoskeletal disorders among industrial workers. Hand arm vibration is a serious problem in the workplace. Workers are mostly exposed to hand arm vibration through the usage of power tools. The study is about the objective and subjective measurements hand arm vibration levels during power tool usage. Objective measurements of vibration have been set forth by certain standards; however the implementation of the vibration measurement becomes a challenge with the addition of vibration attenuation gloves. Therefore the effectiveness of vibration attenuation gloves must be measured. In this study, the effectiveness of vibration attenuation gloves and vibration values for two types of power tools were measured, Bosch and Makita hand grinders. Results indicated that the both Bosch and Makita grinders do not have a difference in terms of vibration values. The anti vibration gloves were found to be cumbersome to use, a burden while operating power tools, but the gloves were easy to use by the participants.

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# **CHAPTER 1**

## **INTRODUCTION**

This chapter signifies the beginning of this research report. As the first chapter in this report, the relevant headings that will be covered are the research background, objectives and the scope of this study. The report will be revolving around the measurements of vibrating hand tools, which were measured objectively and subjectively using established methods and techniques.

### **1.1 Background of study**

In today's world, vibration is a common phenomenon. Vibration often occurs as a result of operating machinery. Vibration, as defined by The Free Dictionary is "A rapid oscillation of a particle, particles, or elastic solid or surface, back and forth across a central position." The rapid oscillations can be induced by anything; more often than not

it is the byproduct of a machinery operation. Machineries often have electric motors running in them, and electric motors are the major component in hand tools such as drills and grinders. With the assistance of powered hand tools, work had been made to be more efficient and effective in accomplishing tasks that could not have been done before.

As the prevalence of powered hand tools continue, the number of problems associated with powered hand tools are on the increase as well. Disorders such as Raynaud's Syndrome, Vibration White Fingers are common for those workers exposed to hand arm vibration for a long time. Guidelines such as the European Directive *2002/44/EC* places the responsibility of the managing the risk of vibration on the employers. The same guideline states the permissible exposure limits for vibration exposure.

Vibration can occur as result of a single cause or in combination. Most of the vibrations coming from machineries are as a result of the electric motors running in them. However, vibrations can also occur from somewhere else, outside the machines. Things such as imbalance, misalignment, wear and looseness can also contribute to vibration in the workplace, apart from the machineries.

## 1.2 Problem Statement

Many tools in the workplaces are powered; hence vibration is inevitable. Tools such as the hand grinders, drills, jackhammers, sanding machines, and many others. These tools are used almost on a daily basis by workers in many manufacturing jobs. Without the assistance of powered tools, it would be impossible to complete tasks effectively and efficiently. The National Research Council in the USA stated that in 1999, between USD 45 to USD 54 billion dollars were spent due to musculoskeletal disorders. Out of these figures, the disorders relating to vibration is also significant. Since the use of power tools are unavoidable, certain efforts needs to be made in order to reduce the vibration hazard in the workplace. Vibration attenuation gloves are one of the personal protective equipments used in reducing the exposure to vibration caused by power tools. It is unknown if the vibration attenuation gloves are capable in reducing the vibration hazards in the workplace. Therefore one of the aims of this research is to look at the ability of the available vibration attenuation gloves in reducing vibration hazard.

### **1.3 Objective of Study**

The main objective of this study is:

To evaluate the level of vibrations in selected power tools using objective and subjective methods.

### **1.4 Potentials benefits**

The results of this study will determine the efficacy of the available methods such as the vibration attenuation gloves in reducing the vibration hazards. Industries will definitely benefit from the knowledge gained from this study as most manufacturing industries are heavily dependent on power tools. Workers will then be protected from the exposure of vibration hazard in the workplace, thus creating a healthy and safe working environment.

## **CHAPTER 2**

### **LITERATURE REVIEW**

This chapter contains the literature review concerning the research on vibration and vibration hazards. It may also look at the how vibration is caused, and the effects of vibration on human health. Whole Body Vibration (WBV) and Hand Arm Vibration (HAV) will be discussed in this chapter. European guidelines on vibration will be referred to in this chapter as well.

#### **2.1 Introduction**

Ergonomics is the study of optimizing the interaction between humans and their tools, technology and environment. Powered hand tools are one of the commonly used tools in



workplaces especially the manufacturing industry. The word “Ergonomics” comes from the Greek word, “ergos” which means work and “nomos” which means law. The fields of biomechanics, physiology, psychology, environmental sciences are often encountered when implementing ergonomics in the workplace. The popular approach in ergonomics is to fit the task to the worker, and not the other way around. Typically, an ergonomics assessment in a workplace is being carried out by an ergonomist. An ergonomist will have some background in engineering, physiology, psychology and biomechanics to determine the fit between the worker and the task. The task of using power tools is inherently hazardous to humans as it exposes the workers to unacceptable levels of vibration.

Vibration is defined as the mechanical oscillations occurring from the equilibrium point. As vibration is closely related to sound, these two are often studied together and certain musical instruments depend on the mechanical oscillations to produce music. Sounds are produced when pressure waves travel through the air. In the case of vibration, a solid body is oscillating at certain frequencies. Vibration usually occurs in either in the x-axis, y-axis, and the z-axis. It can also rotate around these three axes. The phenomena of vibration can be caused by an external source or an internal source. Frequency and the magnitude of the vibration will be a function of the energy generated by the source of vibrating energy.

## 2.2 Effects of vibration exposure on workers

There are many related tasks and one of them happens to be grinding. Grinding involves the usage of power tools such as a grinder. Grinders can expose workers to excessive levels of vibration depending on the type of work involved. The effect of vibrations caused in the human body related to the preservation of working efficiency, conservation and protection of the health or safety of relief. The high levels of vibration or long-term exposure has a negative impact on human health and can cause long term problems.

Power tools can promote tingling and numbness of the hands if used too long. Studies have shown that the operators of power tools can be exposed to Hand Arm Vibration Syndrome (HAVS). Other things that might happen is the Raynaud's Syndrome. Both of these conditions are dangerous for the workers and can cause disability in the long term. Symptoms of these conditions include numbness, tingling, white discolorations on the hands, reduced dexterity. Workers should seek the treatment of professionals if any of these symptoms are detected on their bodies.

HAVS is a term that is often used for symptoms associated with prolonged exposure to vibration. (Aldien et al, 2006). From the signs, there are some adverse effects faced by workers and the impact this may affect workers and job performance. HAVS is frequently reported by workers exposed to hand-arm vibration which is produced from using the tool hand-held devices (Barregard et al., 2003). They can also reduce the ability when working in cold or humid conditions such as doing outside work. Because it

involves their grip strength muscle disorders might also happen. In addition, they also lose the ability to do work such as the installation of small components or daily tasks. They also can not hold a perfect machine and the performance is reduced.

Apart from that awkward posture can also give problems for workers using hand held power tools. Awkward postures are things where the body is not at the correct position when doing work. Neutral positions are the best for working and it promotes good health and safety. Generally, the more awkward the posture the more bad the effect is on the human body. Become more tired easily and more stress on the worker and this will result in bad condition for the worker and employees.

### **2.3 Ergonomic related injuries**

As a result of excessive vibration many injuries can happen and one of them turns out to be ergonomics injuries. Ergonomic injuries can happen as a result of repeated motions and exposure to things like vibration. The cause for ergonomic injuries can include many things like awkward postures, and vibration and excessive work demands. The combination of these factors will make the problem of ergonomic injuries even worse.. When assessing ergonomic problems we must also consider many things such as design of tool, workstation, job rotation, job demand and many more. The concept of ergonomic injuries can also be referring to same tasks performed again and again. Ergonomic injuries can be considered by several physical work load factor, associated with symptoms and injuries of the musculoskeletal system. Other important factors are static loading of the muscle system. This happens a lot when using tools and power tools and muscles have to remain quiet for a long time that is why bad for the worker and get fatigued easily. Body posture influence using the hand tools because prevention from the awkward posture, wrist posture and effected to the musculoskeletal injuries and repetitive motion injuries.

## 2.4 Methods for vibration assessment

There are many methods for vibration checking, one of them is survey and the other one is using the vibration meter. The usage of vibration meter is more objective involves more accurate and precise measurement of values and data. Data captured by the vibration meter is quantified in certain unit . Vibration meters are using accelerometer as the main component. Accelerometer is a device that measures acceleration in x,y,z directions. The device is placed either to the axis at worker's finger or at the tools itself. The value of measurement is measure in  $m/s^2$ . Data analysis is performed by the VI 400 Pro software QuestSuite Professional II. EAV and ELV values are measured by the vibration meter. The exposure action value (EAV) is the value. The exposure action value for a worker in a day is  $2.5m/s^2$ . A higher EAV value would indicate a higher risk for HAV. Meanwhile the exposure limit value (ELV) is the maximum value of vibration. The ELV limit in a day is  $5 m/s^2$ . Actions to reduce the exposure should be taken immediately if the exposure is close or exceed the value.

## **CHAPTER 3**

### **METHODOLOGY**

This chapter will discuss about the technique used in this study. The various vibration measurement methods used would be explained and discussed in this chapter.

#### **3.1 Experimental procedure**

In this experiment, several types of test were carried out to determine level vibration that generated by power tools. Bosch and Makita grinders were used in this study. Participants were all right handed, healthy individuals with no symptoms of disease of upper limbs.

Participants were instructed to grind a piece of mild steel plate with a length of 120mm. The surface of the mild steel was determined to be of a uniform thickness before it was selected for the grinding process. The x, y, z axis sensor of the vibration meter is attach to the index finger neatly according to the ISO 5349 standard. This is to ensure that the readings obtained will be consistent throughout the experiment. As the grinding process takes place, the vibration readings will be appearing at the vibration meter.

The length of a single grinding task was set to be at 5 minutes. Four grinding tasks were to be done. The set up of the grinding task is as follows:

	Gloved hands	Non Gloved Hands
Bosch Grinder		
Makita Grinder		

Figure: Grinding task set up

For each one of the grinding task conditions, participants had to perform the task for 5 minutes. A 5 minute rest was given for the participants between each grinding task to prevent exhaustion and fatigue.

### 3.2 Data Analysis

Data was collected by using the vibration meter, which is later analyzed by the software called Powerful QuestSuite Professional Software. The results were generated in the form of root means square (RMS), vibration level exposure A(8) and time to Exposure Limit

Value(ELV) and Exposure Action Value(EAV ). A(8) is the value used to indicate the level of vibration affected by the user over 8 hour (workday) timeframe with certain time of tool usage. RMS is the mean value of the acceleration produced by the grinding tool. The value of RMS is affect the value of A(8). In the experiment, the participants would grind a piece of metal in the standing posture such as below.



Figure : Standing working posture

The x, y, z axis sensor of the vibration meter was attach to the fingers properly. As the grinding process takes place, the vibration readings would be recorded by the meter.



### **3.3 Subjective vibration measurement**

Apart from the objective vibration measurement using meters, an alternative method was used to capture the vibration sensation perceived by the participants. The method intends to evaluate the levels of fatigue perceived by the vibration devices. The survey that will be conducted is about the ergonomics and the effectiveness of using gloves while doing the experiment. The purpose of this survey is to determine the effectiveness of the gloves and to evaluate the usability of the gloves to the user. The questions that would be asked to the participants were based on usability and comfort. The usability is measured by the various factors such as the easiness of using the equipment, how the participants feel when they are using the equipment as well as the expected result by the participants. The questions about the comfort ability of the gloves would also be asked.

## **CHAPTER 4**

### **RESULT AND DISCUSSION**

This chapter contains the findings obtained from the study of grinding task using Bosch and Makita grinding tools. The purpose was to evaluate the level of vibration and the subjective perception of vibration during grinding task. Final discussion in this chapter shall include some explanation on the effectiveness of hand gloves during hand grinding task.

#### 4.1 Objective vibration level measurement

The results for the objective vibration measurement were shown below. The differences between different grinding conditions seem to be very minimal. The RMS value difference between grinding and non grinding condition is only 4.6%. The biggest difference seems to come from the vibration level exposure A (8), which is 28.2%. However, all the values indicated in the table below were a bit high since the RMS values exceeded the recommended threshold value of  $2.5 \text{ m/s}^2$ . Care should be taken in grinding tasks in order to prevent ergonomic injuries.

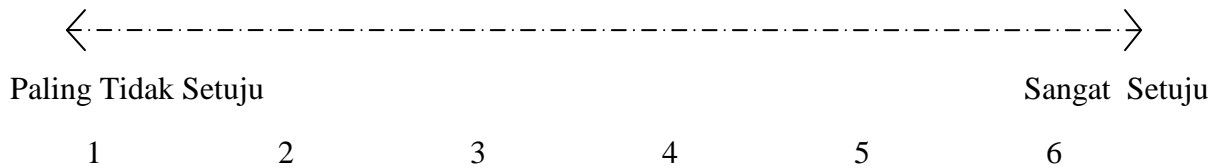
Table 4.1: Vibration level data

Type of task	RMS ( $\text{m/s}^2$ )	Vibration level exposure A(8)	Time to reach EAV (hours)	Time to reach ELV (hours)
Vibration readings from grinder alone	8.78186	1.093185	0.3995	1.59375
Vibration readings from grinding a flat surface	8.373605	0.785188	0.4335	1.7425
<i>Difference</i>	4.6%	28.2%	-8.5%	-9.3%

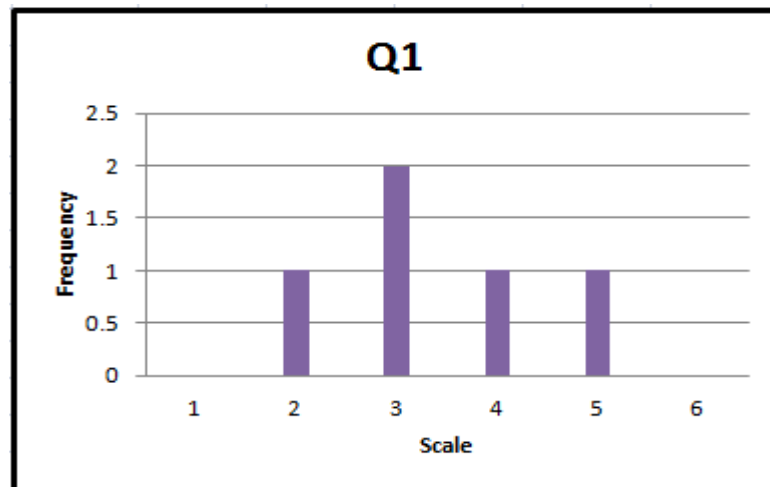
Under the current health and safety laws, employers are required to provide a healthy and safe work environment. If vibration values exceeds the EAV value ( $2.5 \text{ m/s}^2$ ), the employer must find ways to reduce vibration hazards.

## 4.2 Subjective vibration level measurement

There are 14 questions that were asked to each of the participants. The questions are using the scale in order to determine the levels of agreement of the participants to the question asked. The scale is shown below:

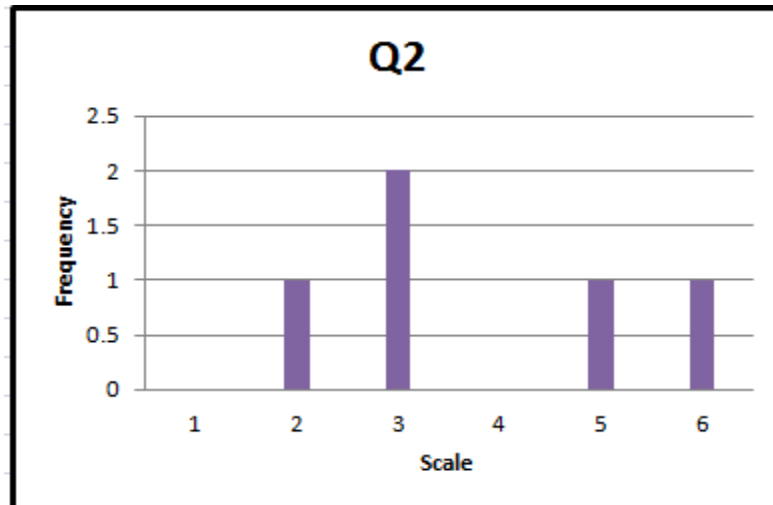


1. Dengan menggunakan sarung tangan ini, saya boleh menjalankan tugas saya dengan lebih cepat.



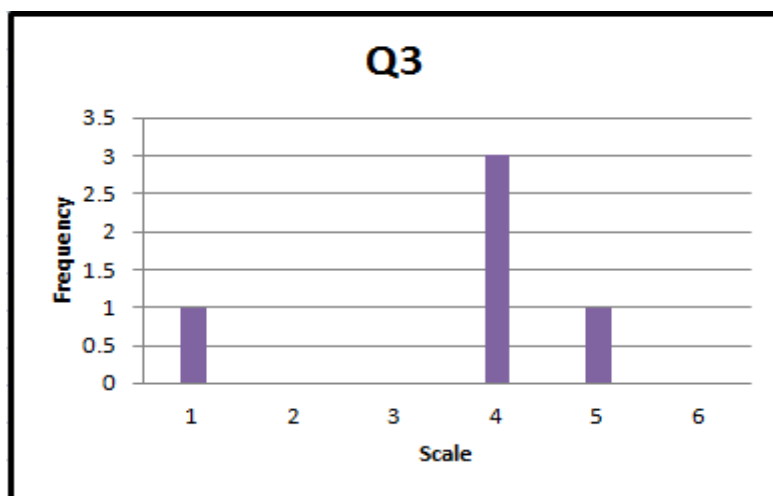
From the graph mostly participant does not agree with the question where the task can be done quickly by wearing the glove. This is because the glove is thick and the participant have problem to grab the tool easily.

2. Produktiviti saya dalam kerja ini akan meningkat sekiranya saya menggunakan sarung tangan ini



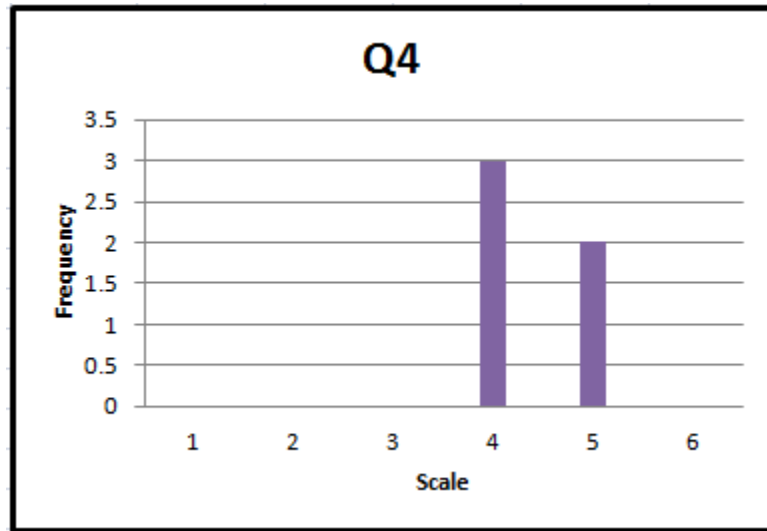
Three participants are not agreeing that productivity can be increased by wearing this glove in doing the task. The reason is they need to take time to adjust their hand with the glove as they had problem to grab the tool as well as they have limited movement while wearing the glove. In the other hand the rest of the participant thought the productivity will increase because of the vibration is reduce and they can do the task in long time.

3. Sarung tangan ini akan menyebabkan tangan saya merasa kebas



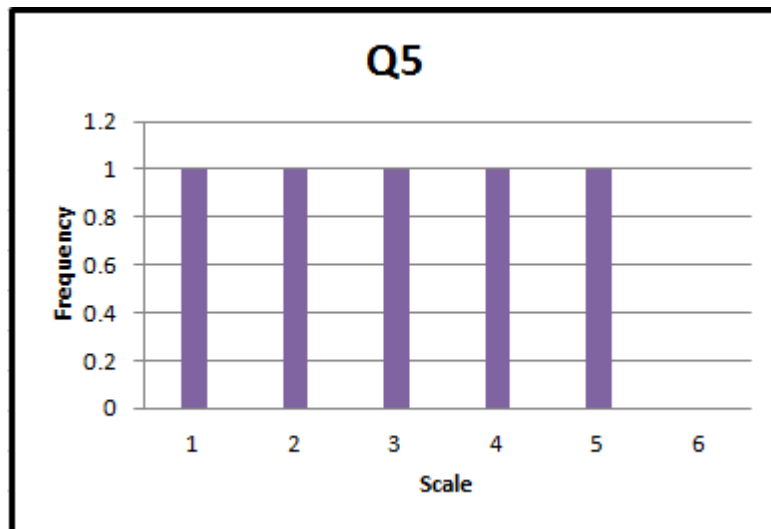
Most of the participant felt that by wearing the anti vibration glove their hand turn numb. The numbness may because of the thickness of the glove; their hand does not felt the tool that they are grabbing.

4. Saya dapat belajar menggunakan sarung tangan ini dengan senang



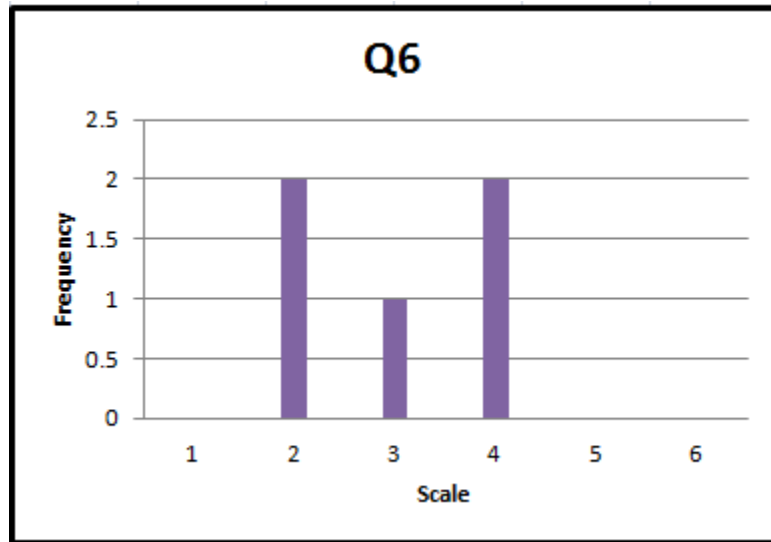
All the participants find the anti vibration glove is easy to use as the glove does not have any different with the normal gloves.

5. Sarung tangan ini akan menyebabkan postur tangan yang selesa



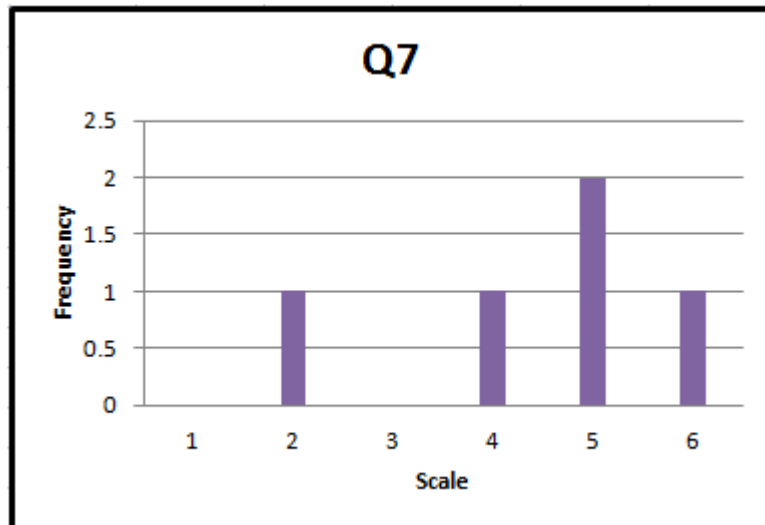
Posture of the hand is also asked in this questionnaire, but the respond from the participant is different from one another. There is participant that really disagrees with this anti vibration glove but there is also the participant that agrees with the usage of the glove give the good posture to hand.

6. Sarung tangan ini membantu saya memegang alat ini.



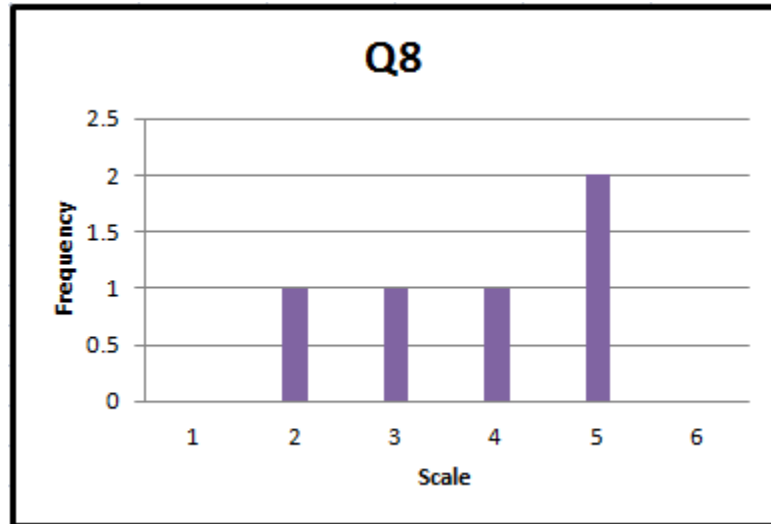
The participants believed that this glove does not help to easily grab the tool while performing the experiment. This is related to the previous question where the participant is asked whether the glove can help the participant to increase the productivity as the answer is not.

7. Sarung tangan ini membantu dalam mengurangkan grip force semasa memegang alatan



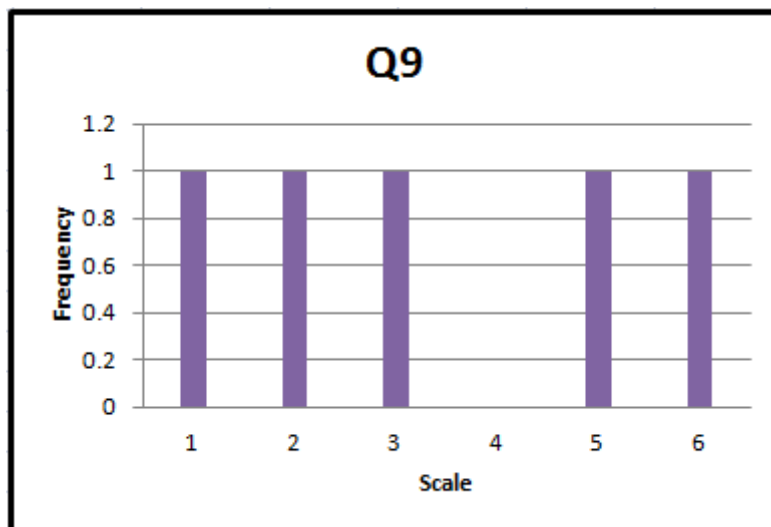
The participants agree that the gloves reduced the grip force while performing the task as the anti vibration glove is thick. The glove contained the materials to absorb the vibration in it.

8. Sarung tangan ini membantu saya dalam mengendalikan alatan tangan dengan baik



The most of participants agree that by wearing the anti vibration glove, they can handle the tools better than without wearing the glove.

9. Sarung tangan ini akan menyebabkan tangan saya berpeluh



Most of participants agree by wearing the glove, their hand are sweating. The thickness of the glove prevents the skin of their hand to perspire well so that it is sweating.

10. Sarung tangan ini senang digunakan.