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Method of Selecting Gloves Based on Pressure on The Palms Using A Measuring Instrument with A Force Sensing Resistor

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Abstract. *Assembly is a common activity in manufacturing companies. The use of handtools during assembly creates pressure on the palms surface which can lead to injury. To reduce the risk of injury, operators need to use gloves as personal protective equipment. Regardless of the general function of the glove, the type of glove tends to be chosen specifically for each task. But there is no specific method to determine the right gloves for certain activities. It is important to know the effect of using gloves on the palms surface during work activities. So this study aims to design a measuring instrument that can determine the pressure on the palm surface during activities by wearing gloves. This is done in order to be able to choose the right gloves for assembly. The result shown that during assembly the areas on the palms receive different pressure. Areas of the palms that receive the greatest pressure are the distal phalanx, and proximal phalanx on the index, middle, ring and little fingers. Pressure on the palms surface differs depending on the type of glove used. This may be due to the thickness of the glove, the thinner the glove, the greater the pressure on the palms surface. Assembling the chair using leather gloves has the lowest pressure value compared to other gloves. The pressure value on the palms surface when wearing leather gloves during the assembly of the chair is 262.15 N, 40% lower than the assembly without using gloves.*

Keywords: *pressure, force sensing resistor, glove, palm surface*

I. INTRODUCTION

Assembly is a common activity in manufacturing companies. The assembly includes operator accuracy (Wartenberg et al. 2004), repetitive movements of arms, hands and fingers (Fernandez et al. 1999), application of grip strength (Armstrong et al. 1986, Kong et al. 2007), operators may need to lift and support heavy objects when assembling large components (Hakkanen et al. 1997).

The use of handtools during assembly creates pressure on the palms surface. This happens because when using a hand tool, you need to grip the handle of the hand tool tightly, causing a force on the palm of your hand. Pressure is a force distributed over a surface (Aldien et al, 2005). Handtools requiring high grip, which is known to be one of the main factors that increase the risk of cumulative trauma disorder. (Radwin et al., 1987; Rempel et al., 1992; Reidel, 1995). Many studies have investigated the contact of the palms surface with handtools causing pressure on the palms surface and affect the severity of exposure to the hand transmitted vibration and hand–wrist cumulative trauma disorders. (Fransson and Winkel, 1993; Pyykko¨ et al., 1976; Radwin et al., 1987).

To reduce the risk of injury, operators need to use gloves as personal protective equipment. Theoretically, reducing the risk of CTS can be done by reducing exposure to pressure on the palms surface and using appropriate postures during activities. Gloves can help spread the pressure on the palm, so it is not concentrated at several points (Muralidhar & Bishu, 2000).

Regardless of the general function of the glove, the type of glove tends to be chosen specifically for each task. But there is no specific method to determine the right gloves for certain activities. Several studies have shown that wearing gloves can reduce maximal levels of grip strength (Bishu et al., 1987; Bishu & Klute, 1995; Cochran et al., 1986; Kovacs et al., 2002; Rock et al., 2001). However, most studies use short

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assessments using dynamometers, which may not provide realistic information about conditions on the job (Dianat et al., 2012). It is important to know the effect of using gloves on the palms surface during work activities.

Few studies have shown the specific effect of gloves on the palms surface during long periods of activity. So this study aims to design a measuring instrument that can determine the pressure on the palm surface during activities by wearing gloves. This is done in order to be able to choose the right gloves, in this context, gloves that can minimize the pressure on the palms surface.

There have been studies on tools to measure pressure in the palms. Lee et al., (2008) used the Force sensing resistor (FSR) which was assembled into a smart glove (I-Force Glove) which was used to measure the pressure force on the palm. But I-Force Glove cannot be used to measure the pressure force on the palm when using other gloves. It is necessary to measure the pressure on the palms surface that can be used when wearing various types of gloves, so the effect of gloves can be evaluated.

II. RESEARCH METHOD

Measuring instrument system

To measure the pressure on the palms surface during work activities, a measuring instrument system was developed by overlaying flexible and thin conductive polymer pressure sensors (Force Sensing Resistor Sensor) on the palm.

The definition of FSR (Force Sensing Resistor) is a polymer film, which when the force on the sensor surface is increasing, the decreasing resistance emits. Compared with rubber conductibility, it has no electronic hysterics and reasonable price. Compared with piezoelectric film, FSR has a little influence on vibration and heat than piezoelectric film. The FSR sensor can be applied to various fields such as industry, medical science, robotics, and body pressure equipment. Figure 1 show the composition of a typical FSR sensor.

The components in the measuring instrument are Arduino Uno, FSR, capacitors, resistors, and

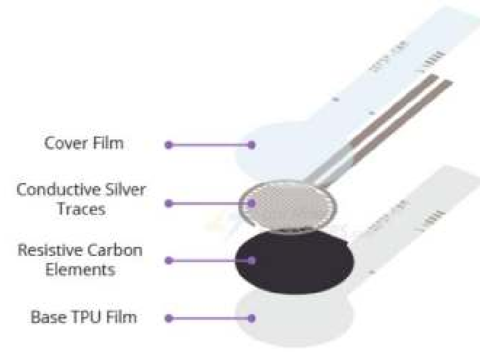

Figure 1. Force Sensing Resistor

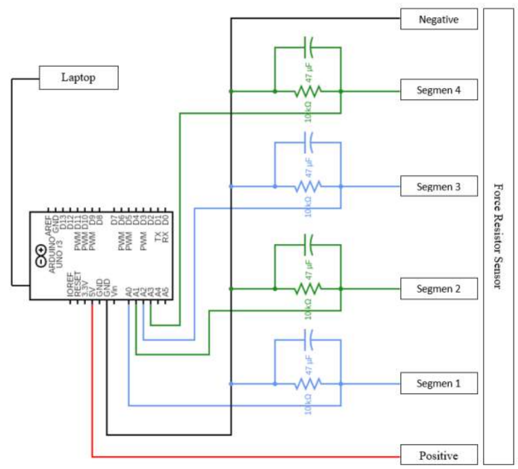

Figure 2. Circuit Diagram

laptops. The FSR is connected to the Arduino Uno. Pressure force is detected using FSR, the results of analog values from FSR are then processed by Arduino Uno into digital values with a range of 0 to 1023. Results are recorded on a laptop via PLX-DAQ which is connected to Microsoft Excel. Figure 2 show circuit diagram of measuring instrument.

FSR used in the study had 20 pressure reading points divided into 4 segments that shown at figure 3. First Segment consists of 1 sensor on the thumb distal phalanx. Second Segment consists of 2 sensors on the thenar area. Third segment consists of 9 sensors, 6 pieces on the palm area and 3 pieces on the hypothenar area. Fourth Segment consists of 8 sensors, 1 on the distal phalanx, and 1 on the proximal phalanx on the each index, middle, ring and little fingers.

When multiple points in same segment receive pressure at the same time, the recorded result is the point with the highest value. So the final result is a pressure on 4 different segments which are then added together to get the total pressure. Each point has a diameter of 12.5 mm, a thickness of 0.55 mm, as well as a maximum weight reading of 6 kg.

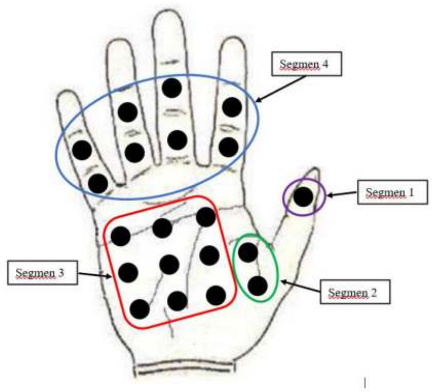

Figure 2. Placement of the single sensors

Table 1. Calibration Result

No	Weights (kg)	Result		Error (%)
		Bit	kg	
1	0.5	88	0.51	3.23
2	0.5	86	0.50	0.88
3	0.5	84	0.49	1.47
4	0.5	83	0.48	2.64
5	0.5	91	0.53	6.74
6	1	165	0.96	3.23
7	1	168	0.98	1.47
8	1	172	1.00	0.88
9	1	176	1.03	3.23
10	1	175	1.02	2.64
11	2	345	2.02	1.17
12	2	339	1.98	0.59
13	2	336	1.97	1.47
14	2	351	2.05	2.93
15	2	349	2.04	2.35
16	3	501	2.93	2.05
17	3	503	2.95	1.66
18	3	499	2.92	2.44
19	3	521	3.05	1.86
20	3	515	3.02	0.68
Mean error				2.18

Table 2. Subjects hand size

Operator	Palm width	Palm length	Palm thickness	Length for palm to thumb
M1	8.0	17.5	2.0	10.2
M2	8.3	18.0	2.2	10.8
M3	8.1	17.8	2.0	10.3
M4	8.3	18.3	2.1	10.5
M5	8.2	18.5	2.2	10.3

Calibration

Calibration is carried out using standardized weights. The variations of the weights are 0.5 kg, 1 kg, 2 kg, and 3 kg. Calibration is done by placing the weights on the FSR so that the results of the received pressure values can be obtained. Result shown at Table 1 shown that the largest error value is 6.74%, the smallest error value is 0.59%, and the average error value is 2.18%.

Participants

Subjects participated in the experiment are 5 males. Subjects were 22-23 years old, right-handed oriented, and had similar hand sizes. Each participant had no prior history of right hand and arm injuries. The hand size of the subject was represented by the palm width, length, thickness and length from palm to thumb as shown in Table 2.

Experiment Design

Experiments were carried out on the case of chair assembly at the Industrial Engineering practicum at the Sebelas Maret University. The chair which is the object of assembly in the practicum has 12 components shown in Figure 3.

Figure 3. Practicum chair

The chair assembly consists of 1 sub assembly and 12 assemblies. Assembly of the front backrest on the main frame (A1), backrest cover assembly (A2), H-frame assembly (A3) union jack assembly (A4), round connector assembly (A5), leg frame assembly (A6), L shaped frame assembly (A7), seat assembly (A8), Bottom shelf assembly (A9), end cap assembly (A10) Table arm assembly (A11), sub assemly table plate with table board (SA1), and table assembly on the main frame (A12).

The types of gloves used are nylon nitrile gloves, cotton gloves, PVC gloves, cut resistant gloves, leather gloves, and the condition of the

Figure 4. (a) Cut resistant glove (b) leather glove (c) pvc glove (d) cotton glove (e) nylon nitrile glove

Figure 5. Measuring instrument placement

gloves. Nylon nitrile gloves are 25.5 cm long, 9.5 cm wide, and 0.14 cm thick. PVC gloves are 26.5 cm long, 9 cm wide and 0.12 cm thick. Cotton gloves are 22 cm long, 9.5 cm wide, and 0.23 cm thick. Cut resistant gloves are 23 cm long, 10 cm wide, and 0.29 cm thick. Leather gloves are 23 cm long, 10 cm wide and 0.26 cm thick. The type of glove shown at Figure 3.

The experiment was carried with 5 repetitions, in each repetition the participants did the full chair assembly and were given a 30 minute break so that the participants did not experience fatigue. Chair assembly consists of 12 assemblies and 1 sub assembly. The maximum pressure values for each of the 12 assemblies and 1 sub-assembly are added up to determine the total pressure value during chair assembly.

The measuring instrument is placed to the upper arm in the right hand and FSR is placed on the palm of the hand using a plaster, so that the FSR is located between the surface of the palm and the inside of the glove. Placement of the measuring instrument is shown in Figure 5.

III. Result and Discussion

The average pressure on the palms surface during assembly of the chair is shown in Figure 5. The backrest cover assembly (A2) is an assembly element that has the highest pressure on the palm of the hand, which is 49.2 N. The arm of the table assembly (A11) is an assembly element that has the lowest pressure on the palm of the hand, which is 1.3 N. The round connector assembly (A5), assembly the table arm (A11), and the table assembly on the main frame (A12) have a fairly low pressure on the palm surface, this is because these parts do not use bolts, so there is no need to tighten the bolts using a handtool.

Figure 6 shows that during assembly, segment 4 is the area with the greatest pressure. Pressure in segment 4 is 41%, pressure in segment 3 is 34%, pressure in segment 1 is 15%, and pressure in segment 2 is 10%. Pressure distribution in the palm of the hand is closely related to the type of handle on the handtool. In this experiment the type of handtool used is an electric screwdriver with a shape like a handgun. Segments 4 and 3 have high pressure, probably because these are the main areas that come into contact when gripping the handtool.

Figure 7 shows that pressure on the palms surface during assembly without using gloves is 437.77 N, when using nylon nitrile gloves the

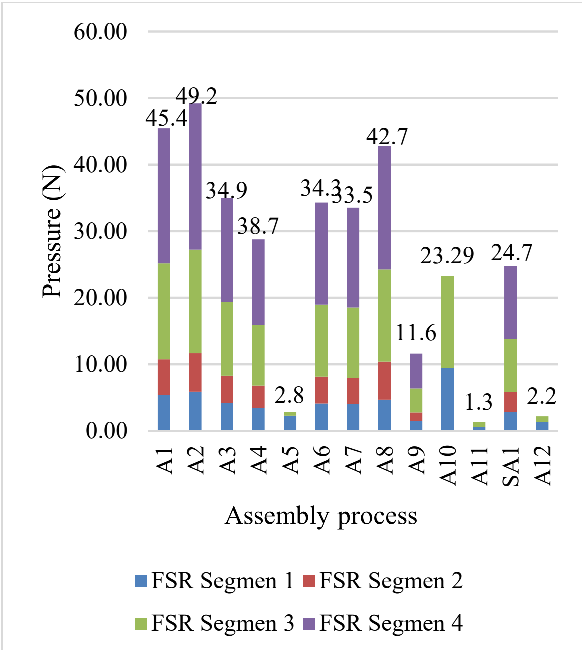

Figure 6. Pressure on the palms surface

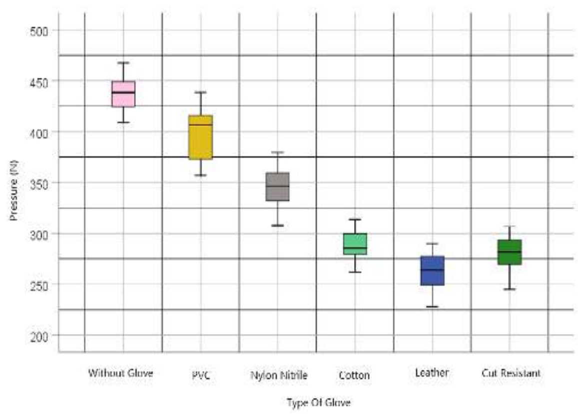

Figure 7. Pressure on the different glove type

average pressure is 345.31 N, when using cotton gloves the average pressure is 287.60 N, when using cut resistant gloves the pressure is obtained the average is 279.70 N, when using PVC gloves the average pressure is 399.52 N, and when using leather gloves the average pressure is 262.15 N.

Pressure on the palms surface differs depending on the type of glove used. This may be due to the thickness of the glove. PVC gloves are gloves with the smallest thickness (0.12 cm), producing the greatest pressure on the palmar surface compared to other gloves. This is in line with research by Kovacs (2002) which states that the thinner the glove, the greater the pressure on the palms surface. In addition to thickness, the level of stiffness of the glove material also affects the pressure on the palms surface. According to Wimer (2010) stiff gloves can increase grip effort. Cut resistant gloves with a thickness of 0.29 cm produce a higher pressure on the palm surface compared to leather gloves with a thickness of 0.23 cm. This is because cut resistant gloves have higher stiffness than leather gloves.

IV. CONCLUSION

The measuring instrument with FSR has an error rate of 2.18%, and is able to measure the pressure on the palms surface during chair assembly either by wearing gloves or without wearing gloves, making it possible to choose the right type of glove based on the pressure on the palms surface.

During chair assembly, the areas of the palms that receive the greatest pressure are the distal phalanx, and proximal phalanx on the index, middle, ring and little fingers as well as the thenar and hypothenar areas. this can be a reference in making a glove design in which certain parts can be given different thicknesses.

Assembling the chair using leather gloves has the lowest pressure value compared to other gloves. The pressure value on the palms surface when wearing leather gloves during the assembly of the chair is 262.15 N, 40% lower than the assembly without using gloves.

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