

ANALYSIS OF SIMULTANEOUS WRIST TORQUE AND
ELECTROMYOGRAPHY OF THE DOMINANT HAND:
THE EFFECTS OF WRIST POSITION, EXERTION
DIRECTION AND GENDER



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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022



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ELECTROMYOGRAPHY OF THE DOMINANT HAND: THE
EFFECTS OF WRIST POSITION, EXERTION DIRECTION AND
GENDER**

**This report is submitted in accordance with requirement of the Universiti Teknikal
Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)**



by

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970614-26-5036

FACULTY OF MANUFACTURING ENGINEERING

2022

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **MECHANICAL AND PHYSICAL ANALYSIS ON THE EFFECT OF COMMERCIAL ALUMINUM MESH IN FIBRE REINFORCED LAMINATE STRUCTURES**

Sesi Pengajian: **2021/2022 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Bachelor Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:



ABSTRAK

Dalam bidang pembuatan, banyak operasi manual memerlukan tork pergelangan tangan, seperti penggunaan alatan tangan. Oleh itu, data tork pergelangan tangan dan hubungannya dengan elektromiografi (EMG) adalah penting untuk merekabentuk alatan tangan seperti pemutar skru mengikut keupayaan tork individu. Masalah untuk merekabentuk alatan tangan akan berlaku jika tiada data tentang tork pergelangan tangan dan hubungannya dengan EMG. Objektif kajian ini adalah untuk mengukur tork pergelangan tangan dan EMG dalam otot brachioradialis tangan dominan, menganalisis korelasi antara tork dan elektromiografi brachioradialis untuk kedudukan pergelangan tangan dan arah kerja yang berbeza, dan mencipta prototaip pemutar skru. Terdapat 30 lelaki dan 30 wanita dewasa di Malaysia menyertai eksperimen data tork dan EMG ini. Pembolehubah eksperimen termasuk kedudukan pergelangan tangan, arah kerja, dimensi antropometrik dan jantina. Meter tork (Mark 10, USA) dan peranti EMG (NeuroTrac® MyoPlus Pro) digunakan untuk mengukur tork dan EMG. Analisis kejuruteraan telah dilakukan pada pemutar skru sedia ada untuk menentukan keperluan rekabentuk prototaip. Reka bentuk dan pemilihan konsep rekabentuk terbaik ditentukan menggunakan "Quality Function Deployment" (QFD) dan matriks pemilihan konsep Pugh. Perisian Fusion 360 digunakan untuk melakar konsep rekabentuk pemegang pemutar skru sebelum prototaip pemegang pemutar skru dihasilkan. Hasil analisis menunjukkan lelaki menghasilkan tork pergelangan tangan dan EMG yang lebih tinggi berbanding wanita. Lelaki menggunakan 481 Ncm tork dan wanita menggunakan 299 Ncm tork pergelangan tangan. Nilai EMG maksimum peserta lelaki dan perempuan ialah 1999 volt RMS. Kajian ini merumuskan bahawa tork pergelangan tangan dan EMG berkaitan dengan kedudukan pergelangan tangan, arah tenaga, dan dimensi antropometrik. Statistik dan maklumat ini membantu merekabentuk alatan tangan yang memenuhi keperluan pengguna, keperluan tugas dan kemudahan penggunaan. Ia akan mengurangkan kecederaan di pergelangan tangan dan menggalakkan amalan kerja yang ergonomik.

ABSTRACT

In manufacturing, many manual operations need wrist torque, such as operating lathe and milling machines, and screwing tasks. Thus, the data of wrist torque and its relationship with hand electromyography (EMG) are crucial to design hand tools such as screwdrivers within individuals' torque capabilities. Engineers and product designers facing constraint to design hand tools like screwdrivers without any data on wrist torque and its relationship to EMG for the Malaysian population. The objectives of this study are to measure the wrist torque and EMG in the brachioradialis muscle of the dominant hand, to analyse the correlation between the wrist torque and electromyography of brachioradialis muscle with different wrist positions and exertion directions, and to develop a prototype of screwdriver handle. There were 30 males and 30 females of Malaysia young adults recruited for the wrist torque and EMG experiments. The experiment variables include wrist positions, exertion directions, anthropometric dimensions, and gender. A torque gauge (Mark 10, USA) and EMG device (NeuroTrac® MyoPlus Pro) were utilised to measure wrist torque and EMG data. Engineering analysis was performed on existing screwdrivers to determine the prototype's design requirements. Design and selection of the best design concept were developed by using Quality Function Deployment (QFD) and Pugh Concept Selection Matrix. The best screwdriver handle concept was sketched using Fusion 360 software. Lastly, a screwdriver handle prototype was fabricated. The result showed males generate higher wrist torque and EMG than females. Males exert 481 Ncm and females exert 299 Ncm of wrist torque. Male and female participants' maximum voluntary EMG contraction is 1999 Volt RMS. This study concluded that the wrist torque and EMG of the brachioradialis muscle are related to the wrist position, the direction of exertion, and the anthropometric dimensions. These statistics and information help design a hand tool that meets user needs, task requirements, and functionality. It will decrease wrist injuries and promote ergonomic work practices.

DEDICATION

Special dedication to my beloved family and friends
for giving me support, encouragement, and understandings
Thank You So Much & Love You All Forever



ACKNOWLEDGEMENT

First, I would like to thank the committee of bachelor's degree Project, PSM UTeM for conducting and coordinating this project for all final year students. It provides me the opportunity to learn, understand and implement the syllabus and knowledge gained throughout the four years of study. I would also like to thank my supervisor, Dr. Isa bin Halim who guided me patiently throughout the project and given me advice and ideas to improve my project. Without the supervisor, my Final Year Project would not go this well and smoothly. Besides, I would also like to convey my thanks to all the staffs and assistant engineers and students that I had asked for assistance, because they always being patient in giving me advice and guidance that helps me a lot throughout my data collection and fabrication of prototype. Finally, a special appreciation to my family as they always show their greatest support in every way and my friends who always give me supports and assistance whenever I need them.

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LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
CAD	-	Computer-Aided Design
CAM	-	Computer-Aided Manufacturing
EMG	-	Electromyography
MVC	-	Maximum Voluntary Contraction
NIST	-	National Institute of Standards and Technology
RT	-	Real Time
QFD	-	Quality Function Deployment
SOP	-	Standard Operating Procedures
WMSD	-	Work-Related Musculoskeletal Disorder

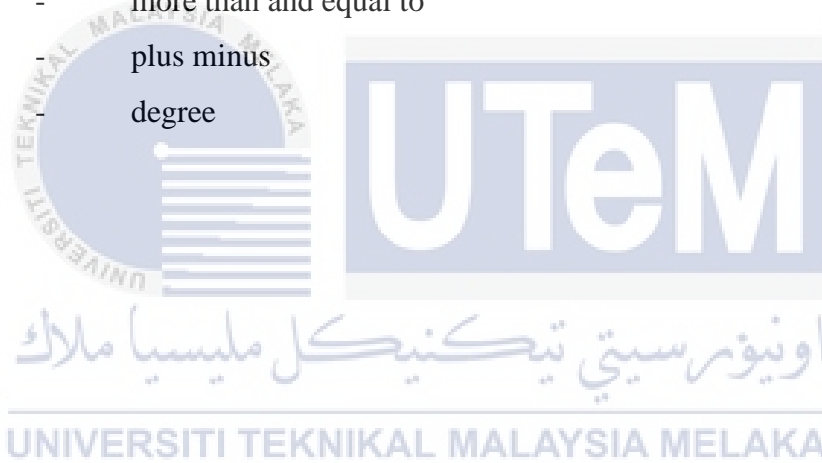


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LIST OF SYMBOLS

mm	-	millimetre
cm	-	centimetre
%	-	metre
Ncm	-	Newton centimetre
Nm	-	Newton metre
N	-	Newton
mHz	-	millihertz
s	-	second
\geq	-	more than and equal to
\pm	-	plus minus
$^{\circ}$	-	degree



CHAPTER 1

INTRODUCTION

This chapter introduces the background of study which related to the design of hand-held tool used in the industry to comply to ergonomics requirements. Besides, it includes problem statements related to ergonomics issues encountered during gripping and turning the existing hand-held tools or devices such as screwdriver, torque wrench and hand-operated valve. The objectives, scope and significance of study will be shown followed by a summary that summarises the whole chapter.

1.1 Background Of Study

Manufacturing industries are those that convert goods, materials, or substances into new products. Physical, chemical, or mechanical transformations are all possible. Manufacturers frequently have facilities, mills, or factories that make things for the public. Machines and equipment are commonly utilised in the production process. In the manufacturing industry, handling machinery and equipment has become commonplace and necessary. There are a variety of jobs that require workers' strength when operating machines and equipment including screwdriving. Non-powered screwdriver is manually operated tool used for screw installation and tightening. A non-powered screwdriver consists of a head or tip that engages with a screw, a handle to apply torque for rotating the tip, and to positioning and supporting the screwdriver. This type of tool has features; a handle and a shaft that allow it to be positioned and maintained while also applying torque when twisted. A screw has a head with a contour that allows proper screwdriver tips to engage it in such a way that applying enough torque to the screwdriver causes the screw to revolve with the force of one hand.

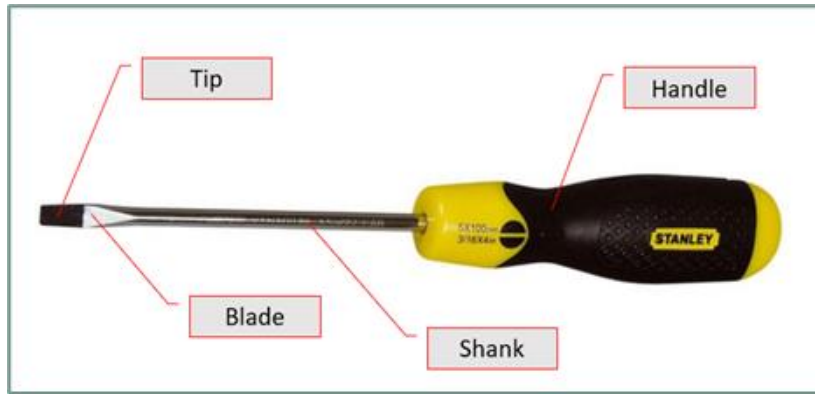


Figure 1.1: Part of screwdriver

A screwdriver is one of the most important hand tools in every toolbox. Many situations and industries require the use of a screwdriver to perform a specific task involving the loosening or tightening of fasteners. However, non-powered screwdriver requires force exertion from human muscle strength. This physically demanding job activity would expose the operators or users to ergonomic risk factors. The ergonomics risk factors are frequently seen together. Repetitive force exertion in difficult positions, and so on are examples. Users who were exposed to these ergonomics risk factors are at a higher risk of developing work-related musculoskeletal disorders (WMSD). The WMSDs are a group of painful muscle, tendon, and nerve problems. Tendonitis, carpal tunnel syndrome, thoracic outlet syndrome, and tension neck syndrome are just a few examples (2019). In the workplace, ergonomics is a main concern and should be a priority in the workplace so that WMSD can be avoided rather than treated (n.d.). Ergonomics is described as the study of work, and it is founded on the concept that the job should be adapted to fit the individual rather than the person being forced to fit the job. Ergonomics refers to the process of restructuring or changing working settings to make the job easier, as well as minimising stressors that cause musculoskeletal illnesses (n.d.).

There is a various type of screwdrivers used in the industry. However, on-going research on ergonomics gives a great effort to determine the optimum type of screwdriver to use to avoid the discomfort and health risks in manual screwdriving. It is well understood that humans have muscles and nerves that allow them to move their bodies. Manual screwdriving also puts a huge strain on the forearm muscles. Selecting a suitable screwdriver is essential to ensure workers are not exposed to ergonomic risks. In the manufacturing industry, operational efficiency has a significant impact on the tools used and how the task

is completed. As a result, this study is focuses into the effect of screwdriver type and size have on forearm muscle activity and wrist motion while using a screwdriver. The main objective of this study is to measure the wrist torque and electromyography in the brachioradialis of dominant hand and to design and develop a prototype of screwdriver handle that apply data wrist torque and electromyography of brachioradialis. Figure 1.2 shows the different types of screwdrivers in current market.



Figure 1.2: The different types of screwdrivers in current market (Chris, 2021)

1.2 Problem Statement

There are a few difficulties that have been discovered with the use of screwdrivers in the manufacturing industry.

Each finger's ideal diameter was determined by adjusting the diameter of the cylindrical handle with varied diameters. The diameter of screwdriver handle should be suitable to size of user's hand. If the size of handle is more way bigger than the user's hand, then it is not an ergonomic design since the grip size is smaller than the handle's size. If the handle's size is more way smaller than the grip size, then user will need more strength to fully grip the handle. Thus, users will quickly feel more fatigue if doing screwdriving work repeatedly or continuously. It is crucial for hand tool design to avoid compressive stress

concentrations. The ergonomic design of manual hand tools, such as screwdrivers, is especially significant since it minimises workers' physical demands and may avoid musculoskeletal diseases. As a result, from the aspect of ergonomic design, screwdriver handle optimization is essential. Figure 1.3 shows the hand holding the small size of screwdriver handle.



Figure 1.3: Hand holding the small size of screwdriver

Contact stress occurs when the body's soft tissues are constantly in contact with and rubbing against a hard item or surface. Tissue injury develops because of repeated mechanical stress or pressure exposure over time. Several designs of screwdrivers made of hard material especially the cheaper one. Contact stress can arise during the action when the palm applies force to the screwdriver handle. The fundamental ergonomics principle is that contact stress should be reduced to avoid exposure to ergonomics risk factors that would affect the human body in the long term. If the workers or users must grip screwdrivers with hard material handle repeated and continuously, their hand will be in pain and redness occur. Figure shows screwdriver with hard material handle.



Figure 1.4: Contact stress occur after gripping hard material handle



Figure 1.5: Screwdriver with hard material handle

1.3 Objectives

The objectives are as follows:

- (a) To measure the wrist torque and electromyography in the brachioradialis of dominant hand with different wrist positions and exertion directions among male and female Malaysian young adults
- (b) To analyze the correlation between the wrist torque and electromyography of brachioradialis with different wrist positions and exertion directions
- (c) To design and develop a prototype of screwdriver handle that apply data wrist torque and electromyography of brachioradialis.

1.3.1 Relationship Between Problem Statement and Objectives

To predict the result, have a clear of understanding of problem statements and objectives is a must. The study hypothesis is depending on the problem statements and objectives. Table 1.1 shows the relationship between problem statement and objectives.