**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

# Ergonomic Investigation of Hand Tools
# (Case Study: Bottle Opener)

Thesis submitted in accordance with the partial requirements of the
Universiti Teknikal Malaysia Melaka for the
Bachelor of Manufacturing Engineering (Manufacturing Design)

By

**Noor Rahimi binti Idiris**

Faculty of Manufacturing Engineering
May 2007

# APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The members of the supervisory committee are as follows:

…………………………………………

Main supervisor

Faculty of Manufacturing Engineering

………………………………………….

Co-supervisor

Faculty of Manufacturing Engineering

# DECLARATION

I hereby, declare this thesis entitled "Analysis of Plastic Flow inside the Three Plate Mould" is the result of my own research except as cited in the references.

| | |
|---|---|
| Signature | :.............................................................................. |
| Author's Name | :……………………………………………………. |
| Date | :……………………………………………………. |

# ABSTRACT

Hand and finger force data are used in many settings, including industrial design and indicating progress during rehabilitation. Forceful exertion of the hand is considerable stress endured by users of hand tools that may also be one of the factors that lead to the development of work-related musculoskeletal disorders (WRMSDs). The application of appropriate work design principles, during the design of tools and workstations that involve the use of the hand and fingers, may minimize upper extremity injuries within the workplace. Whether ergonomics is handled by plant teams, safety professionals, or trained ergonomists, there is often a need for systematic assessments to identify and quantify injury risk and opportunity potential. Ergonomic analysis tools are designed to meet these needs. This study is about ergonomic investigation of hand tools which focusing on bottle opener. The investigation concentrates on ergonomic analysis tools that are RULA analysis, ACGIH TLV and Strain Index. This study examined whether exerted finger force could be analyze using the ergonomic analysis tools. Following the methodology, firstly ergonomic analysis tools were investigated by analyzing the activity of opening bottle. The data of pinching and gripping strength were taken among Malaysian population. Data of grip strength and pinch strength are crucial in designing hand tools. Hand tools design that properly fit the user will help reduce cumulative trauma disorders (CTDs) and carpal tunnel syndrome in tasks that involve gripping and pinching. Hopefully in the future there will be ergonomic analysis tools to analyze finger force and prevent any injuries.

# ABSTRAK

Data untuk kekuatan daya tangan dan jari digunakan dalam banyak perkara, termasuk dalam rekabentuk industi dan dalam menetukan perkembangan sesuatu pemulihan. Daya yang dikeluakan oleh tangan boleh dianggap tekanan yg ditahan oleh pengguna peralatan tangan yang boleh membawa kepada berlakunya penyakit work-related musculoskeletal disorders (WRMSDs). Penggunaan prinsip rekabentuk kerja yang sesuai ketika merekabentuk peralatan dan tempat kerja yang melibatkan penggunaan tangan dan jari boleh mengurangkan kecederaan bahagian atas badan dalam tempat kerja. Sama ada ergonomik dikendalikan oleh kumpulan perancang, pekerja keselamatan yang professional atau pelatih ergonomik, selalunya akan terdapat keperluan untuk penilaian sistematik bagi mengenalpasti dan menjumlahkan potensi serta risiko kecederaan. Alat-alat analisis ergonomik direka untuk memenuhi keperluan ini. Kajian ini adalah berkaitan dengan penyiasatan peralatan tangan yang ergonomik yang memfokuskan kepada pembuka botol. Penyiasatan bertumpu kepada peralatan analisis ergonomik iaitu analisis RULA, ACGIH TLV dan Strain Index. Kajian ini memeriksa cara alat-alat ergonomik digunakan. Berpandukan kepada kaedah kajian, peralatan analisis ergonomik disiasat dengan menganalisis aktiviti membuka botol. Data kekuatan mencubit dan menggenggam diambil di kalangan orang Malaysia. Data kekuatan mencubit dan menggenggam sangat penting dalam merekabentuk peralatan tangan. Rekabentuk peralatan tangan yang sesuai dengan tangan pengguna akan menolong mengurangkan Cumulative Trauma Disorders (CTDs) dan Carpal Tunnel Syndrome (CTS) dalam melakukan aktiviti mencubit dan menggenggam. Semoga pada masa hadapan terdapat peralatan analisis ergonomik bagi menganalisis daya jari dan mengelakkan sebarang kecederaan.

# DEDICATION

**To my lovely parents:**

**Idiris bin Abdullah**

**Siti Aeshah binti Yusoff**

For your love and demonstration the values of education since I’m still a kid.

**To my siblings:**

**Siti Norzuraini binti Idiris**

**Mohd Sobri bin Idiris**

**Zulkifli Bin Idiris**

**Afuza Abdullah bin Idiris**

For your love, encouragement, and support on this project was absolutely invaluable.

**To my special Lecturer:**

**Puan Seri Rahayu binti Kamat**

**Mr. Norakramin bin Mohamad**

For your guidance and helping in finishing this project.

# ACKNOWLEDGEMENT

In the name of Allah, Most Gracious, Most Merciful.

All praises to the Almighty Allah for giving me the strength, patience and guidance throughout the process of completing this research study. I am grateful to have the support and motivation from many people throughout completing this study and I would love to take this opportunity to thank those who are either directly or indirectly involved during this study is conducted.

Most immediately, a special gratitude goes to my respective supervisor, Puan Seri Rahayu binti Kamat for her precious advices, time, contributions, comments, and guidance in every stage of this study. Mt utmost gratitude also goes out to all lecturers From the Faculty of Manufacturing Engineering for being a very nice and effective lecturer to me and thus, making this study easier to be completed.

My token of appreciation also goes to my beloved family members who never failed to be there for their love, supports and prayers. Last but not least, I would like to thank to all my friends, especially my classmates for their never ending supports.
May Allah bless to all of you.

# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| PSM | - | Projek Sarjana Muda |
| CTDs | - | Cumulative Trauma Disorders |
| WRMSDs | - | Work-Related Musculoskeletal Disorders |
| CTS | - | Carpal Tunnel Syndrome |
| RH | - | Right Hand |
| LH | - | Left Hand |
| SPSS | - | Statistical Package for the Social Science |
| TLVs | - | Threshold limit values |
| AL | - | Action Limit |
| ACGIH | - | American Conference of Governmental Industrial Hygienists |
| HAL | - | Hand Activity Level |
| NPF | - | Normalized Peak Force |
| RULA | - | Rapid Upper Limb Analysis |
| REBA | - | Rapid Entire Body Assessment) |
| MVC | - | Maximum Voluntary Contraction |

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

One issue facing many safety professionals and ergonomics is selecting ergonomic analysis tools. Selecting ergonomic tools warrants careful study and consideration. Choosing inappropriate tools can frustrate teams, confuse managers, and yield data that do not adequately assess risk. This can compromise the entire ergonomics process and its credibility. For these reason, the investigation of ergonomics analysis tools is really essential in order to identify and quantify injury risk and opportunity potential.

Every year more people are injured between the ages of 18-64 from repetitive motion injuries to the human musculoskeletal system than any other category of disorder. The average employee loses nearly two days of work each year as a result of these disorders (Putz-Anderson, 1988). Work-related musculoskeletal disorders occur when there is an interface problem between the physical environment of a job and the physical capacity of the human body (OSHA, 2002). Unfortunately, workers often overlook ergonomic illnesses until symptoms become permanent or chronic due to the fact that usually are not a result of a single incident.

This study investigate an ergonomic analysis tools which focusing on hand tools that is bottle opener. In this research, the data of pinching and gripping strength were taken among Malaysian population. The data of pinching and gripping are really important in designing properly hand tools. There are few past research about pinching and gripping strength, but there is no research in investigate Malaysian hand strength.

## 1.2 Objectives

1) To study the ergonomic hands tools analysis software available in Malaysia's market.
2) To gain knowledge of human limitation of their strength of pinching and gripping for Malaysian population.
3) To find out the distribution of Malaysian population capability in pinching and gripping for the left and right hand based on age, gender and races.

## 1.3 Project Scope

1) Investigate the suitable ergonomic hands tools analysis software to analysis hand activity level which focusing on opening bottle activity in everyday task which are RULA analysis, ACGIH Hand Activity Level Threshold Limit Value (HALTLV) and Strain Index that are available in Universiti Teknikal Malaysia Melaka (UTeM).
2) This project involves ergonomics assessment on strength/power in gripping and pinching in Malaysian populations from various of aspect :
    a) Age (Years)
        i. Child ( 7 - 12 )
        ii. Teenagers ( 17 - 19 )
        iii. Adult ( 20 - 40)
        iv. Older People (40 - 70).
    b) Race
        i. Malay
        ii. Chinese
        iii. Indian

c) Gender
    i. Male
    ii. Female
d) Left and right hand

3) Analysis the data from the survey to find out the human limitation in pinching and gripping activity.

## 1.4 Problem Statement

The goal of this study is to investigate ergonomic hand tools analysis software that available in Malaysia's market which focusing on hand activity level such as opening bottle activity. Ergonomic hand tools analysis software involves in this research are RULA analysis, ACGIH Hand Activity Level Threshold Limit Value (HALTLV) and Strain Index. Many ergonomic analysis tools are available today which can analyze many parts of body but there are no tools that can evaluate finger force. This research also provides the data of pinching and gripping strength for Malaysian population. Data of grip strength and pinch strength are crucial in designing hand tools. Hand tools design that properly fit the user will help reduce cumulative trauma disorders (CTDs) and Carpal Tunnel Syndrome (CTS) in tasks that involve gripping and pinching. The design of safe and comfortable hand tools is critical to avoid any injuries. In Malaysian industries, many hand tools are not designed for Malaysian dimensions both in terms of strength and physical dimensions.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Introduction

This chapter discuss about the relevant literature with the title of project. The literature review highlight past studies related to the subject of this project. It contains a literature review about the investigations of ergonomics analysis of hand tools and other information about gripping and pinching strength that are related with the title of thesis. There were many studies about ergonomics analysis tools. This present study is to investigate ergonomic hands tool analysis tools during opening bottle activity which involve of pinching and gripping strength. The ergonomic hands tool analysis involves in this research are RULA analysis from CATIA software, ACGIH Hand Activity Level Threshold Limit Value (HALTLV) and Strain Index from Ergoweb software. This study also provides the data of pinching and gripping strength for Malaysian population. The purpose of literature review is to be as guidance in writing thesis with related subject. Source of information were obtained from journals, handbooks, reports and electronics media publications.

### 2.2 Common Ergonomics Analysis Tools

Whether ergonomics is handled by plant teams, safety professionals, or trained ergonomists, there is often a need for systematic assessments to identify and quantify injury risk and opportunity potential. Ergonomic analysis tools are designed to meet these needs. Selecting ergonomic analysis tools requires an understanding of the users or analysts, the types of tasks being analyzed, the characteristics of the tools themselves, and the intended use of collected data. Table 2.1 is several of the most commonly used ergonomic hand tools analysis.

Table 2.1: The most commonly used ergonomic hand tools analysis

| Analysis tool | Risk factors evaluated | Areas of body addressed | Sample applications |
|---|---|---|---|
| **RULA**<br>(Rapid Upper Limb Analysis) | - Repetition<br>- Force<br>- Awkward postures | - Wrists<br>- Forearms<br>- Elbows<br>- Shoulders<br>- Neck<br>- Trunk | - Assembly work<br>- Sewing<br>- Meatpacking<br>- Grocery cashier<br>- Dentists and dental technicians |
| **REBA**<br>(Rapid Entire Body Assessment) | - Repetition<br>- Force<br>- Awkward postures | - Wrists<br>- Forearms<br>- Elbows<br>- Neck<br>- Trunk<br>- Back<br>- Legs<br>- Knees | - Patient lifting & transfer<br>- Nurses<br>- Janitors<br>- Grocery warehouse<br>- Telephone operators<br>- Dentists and dental technicians<br>- Ultrasound technicians<br>- Production workers |
| **Strain Index** | - Repetition<br>- Force<br>- Awkward postures | - Hands<br>- Wrists | - Small parts assembly<br>- Meatpacking<br>- Sewing<br>- Packaging<br>- Keyboarding<br>- Jobs involving highly repetitive hand motions |
| **Hand Activity Level**<br>(Hand Activity Level) | - Repetition<br>- Force | - Hands<br>- Wrists | - Small parts assembly<br>- Meatpacking<br>- Sewing<br>- Packaging<br>- Keyboarding<br>- Jobs involving repetitive or frequent hand motions |
| **ACGIH Hand/Arm Vibration TLV** | - Vibration | - Hands<br>- Arms<br>- Shoulders | - Grinding<br>- Chipping<br>- Drilling<br>- Sawing<br>- Chainsaw operation<br>- Production work using vibrating |

The design of safe and comfortable hand tools is critical to avoid CTDs such as carpal tunnel syndrome. In Malaysian industries, many hand tools are not designed for Malaysian dimensions both in terms of strength and physical dimensions.

## 2.3 RULA (Rapid Upper Limb Assessment)

RULA is an ergonomic tool that is used to evaluate exposure to postures, repetition, force, and muscle activity that contribute to CTDs. This tool is not designed to be a comprehensive analysis, but rather a quick and easy screening instrument. The focus of RULA is to help in determining the root cause of cumulative trauma injuries in the hands, neck, arms, and shoulders. A RULA analysis can be broken up into three steps that include observation, scoring and recording, and determining an action level. The observation process of RULA includes determining the part of a task that poses the highest risk of postural loading. Some factors that may be taken into consideration include duration of the posture and degree of deviation. Also, while observing, it is possible to score each side of the body independently if desired. The second step of a RULA analysis is scoring the posture. In this step, scores are assigned to movements associated with different parts of the upper extremity. Tables are provided on the RULA work sheet that allows calculation of a grand score. The final step includes comparing the grand score to the four action levels in order to determine the degree of risk. The four action levels include:

a) Action level 1
    - Scores of 1 or 2 indicate acceptable postures if not repeated for long periods.
b) Action level 2
    - Scores of 3 or 4 indicate a need for further investigation and possible changes.
c) Action level 3
    - Scores of 5 or 6 indicate changes are required soon.
d) Action level 4

- A score of 7 indicates investigation and changes are required immediately.

## 2.4 ACGIH Hand Activity Level Threshold Limit Value (HALTLV)

Authored by the American Conference of Governmental Industrial Hygienists (ACGIH), the Hand Activity Level is a semi-quantitative analysis that identifies injury risk of the forearm/wrist/hand in cyclical-short cycle, hand intensive tasks. The tool assesses two variables hand activity level (HAL) and hand normalized peak force (NPF) and compares the outcome to a threshold limit value (an exposure level up to which nearly all workers may be repeatedly exposed without adverse health effects) and action limit (level of intermediate risk). HAL analysis is intended for mono-task jobs performed for four or more hours per day. A mono-task job may be defined as a job that requires performing the same set of motions and/or exertions repeatedly (ACGIH 2003). Examples include assembly line work or data entry on a keyboard. This method is applicable to determine the risk of forearm/wrist/hand injury for repetitive short-cycle tasks performed for four or more hours per day. This analysis primarily evaluates repetition and force. Other risk factors such as awkward posture, contact stress, temperature, vibration, and job duration are not directly addressed.

ACGIH is a professional, scientific society composed of industrial hygienists and other occupational health professionals dedicated to the development and improvement of worker health protection. Among other activities, they establish threshold limit values for chemical substances and physical agents. Threshold limit values (TLVs) are guideline criteria set after review of significant, published, peer-reviewed scientific literature by ACGIH committees composed of experts in public health and related sciences. TLVs are health-based values that are established without consideration of economic factors and technical feasibility.

TLVs are not standards. They have not been generated by a consensus of various stakeholders such as what occurs with government regulations or standards from organizations like the American National Standards Institute. However, ACGIH feels TLVs are valuable scientific opinion that regulatory bodies should consider in the risk characterization process of physical agents and chemical substances.

### 2.4.1 Assessment of Hand Activity Level

The ACGIH TLV addresses mono-task jobs that take place longer than 4 hours a day. A monotask job may be defined as a job that requires performing the same set of motions and/or exertions repeatedly (ACGIH 2003). The two independent variables used in the ACGIH TLV are the Hand Activity Level and the Normalized Peak Force.

The Hand Activity Level (HAL) characterizes repetition on a scale from 0 to 10. Where 0 is completely idle and 10 is the greatest level of repetition imaginable. This scale was proposed by Latko et al. (Latko 1997; Latko, Armstrong et al. 1997) HAL is a function of both frequency and speed of work. It can be determined by assessment from a trained observer or through direct time measurement. This software allows inputting only considering the trained observer method. Table 2.2 shows the relationship in determining the Hand Activity Level.

Table 2.2: Table for determining Hand Activity Level (www.ergoweb.com)

| **Tool Menu Choice (also the trained observer method)** | **Calculated Method** | | **HAL Numeric Level** |
|---|---|---|---|
| | **Frequency (exertions/second)** | **Duty Cycle (% of work cycle where force is greater than 5% of maximum)** | |
| | 0.125 | 40 to 100 | -- |
| | 0.25 | 60 to 100 | |
| Hand idle most of the time; no regular exertions | 0.125 | 0 to 40 | 1 |

| | | | |
|---|---|---|---|
| Consistent conspicuous, long pauses; or very slow motions | 0.25 | 0 to 40 | 2 |
| | 0.25 | 40 to 60 | 3 |
| | 0.5 | 0 to 20 | |
| Slow, steady motion/exertions; frequent brief pauses | 0.5 | 20 to 40 | 4 |
| | 1.0 | 0 to 20 | |
| | 0.5 | 40 to 80 | 5 |
| | 1.0 | 20 to 60 | |
| | 2.0 | 20 to 40 | |
| Steady motion/exertions; infrequent pause | 0.5 | 80 to 100 | 6 |
| | 1.0 | 60 to 80 | |
| | 2.0 | 40 to 60 | |
| | 1.0 | 80 to 100 | 7 |
| | 2.0 | 60 to 80 | |
| Rapid, steady motion/exertions; no regular pauses | 2.0 | 80 to 100 | 8 |
| | -- | -- | 9 |
| Rapid, steady motion/difficulty keeping up or continuous exertion | -- | - | 10 |