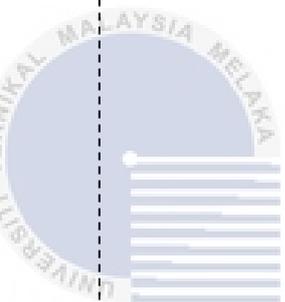
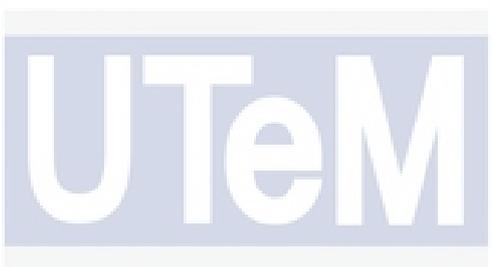


DESIGN AND EVALUATION OF ERGONOMIC GRIP
HANDLE FOR MANUAL CARRYING OF LONG METAL BAR



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021



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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

B051710100

BACHELOR OF MANUFACTURING ENGINEERING (Hons.)

2021 UTeM



DESIGN AND EVALUATION OF ERGONOMIC GRIP HANDLE FOR MANUAL CARRYING OF LONG METAL BAR

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



LIEW JEE SENG

B051710100

960922-13-5437

FACULTY OF MANUFACTURING ENGINEERING

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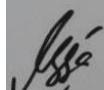
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Disahkan oleh:



DR. ISA BIN HALIM
Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka

LIEW JEE SENG

Alamat Tetap:
No 23, Pasar Siburan Batu 17,
Jalan Kuching Serian,
94200, Kuching, Sarawak

Tarikh: 15/07/2021

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DECLARATION

I hereby, declared this report entitled “Design and Evaluation of Ergonomic Grip Handle for Manual Carrying of Long Metal Bar” is the result of my own research except as cited in references.

Signature

: *LIEW JEE SENG*

Author's Name

: LIEW JEE SENG

Date

: 15 July 2021



APPROVAL

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



ABSTRAK

Aktiviti pengendalian bahan secara manual biasanya dilakukan oleh pekerja di pelbagai industri seperti pembinaan, pembuatan, pertanian, dan automotif. Biasanya, pengendalian bahan manual seperti pemindahan logam panjang akan dilakukan secara manual oleh dua pekerja kerana kos buruh yang rendah. Sekiranya permintaan logam panjang tinggi, pekerja mungkin mengalami 'gangguan otot-berangka disebabkan kerja' kerana proses pemindahan yang berulang-ulang. Dalam keadaan terburuk, logam panjang bergoyang dan berayun semasa proses pemindahan. Oleh itu, ini akan menyebabkan pergerakan tidak stabil pada logam panjang semasa proses pemindahan dan mempengaruhi kekuatan gengaman tangan pekerja. Objektif kajian ini bertujuan menentukan keperluan reka bentuk dan kehendak pengguna bagi pemegang cengkaman ergonomik untuk membawa bar logam panjang secara manual, merancang pemegang cengkaman ergonomik berdasarkan keperluan reka bentuk dan kehendak pengguna serta membuat dan menilai prestasi prototaip ketika membawa bar logam panjang secara manual. Terdapat 50 peserta terlibat dalam pengukuran data antropometrik untuk merancang pemegang cengkaman ergonomik. Tinjauan soal selidik dilakukan untuk menentukan keperluan pengguna. Setelah itu, "*Quality Function Deployment*" diaplikasikan untuk menganalisis hubungan antara keperluan pengguna dan spesifikasi kejuruteraan pemegang cengkaman. Beberapa lakaran dilukis berdasarkan hasil yang diperolehi dari QFD. "*Pugh Conceptual Selection*" digunakan untuk memilih konsep yang terbaik bagi menghasilkan lukisan kejuruteraan dan prototaip. "*System Usability Scale*" digunakan untuk menilai kebolegunaan prototaip. Hasil pengujian kebolegunaan adalah 77.08 dari 100 telah ditakrifkan prototaip sebagai "baik". Tambahan pula, "*Carry Analysis*" disimulasikan dengan menggunakan perisian "*CATIA*" dan hasil membawa bar logam panjang menggunakan tangan berbanding menggunakan prototaip ialah 231.831 N dan 283.718 N. Oleh itu, membawa logam panjang dengan pemegang cengkaman ergonomik tidak melebihi jarak menegak tangan dan disimpulkan prototaip dapat membantu pengguna atau pekerja semasa proses pemindahan logam panjang secara manual serta memenuhi keperluan ergonomik.

ABSTRACT

Manual materials handling (MMH) activities are typically performed by workers in various industries such as construction, manufacturing, agricultural, and automotive. Usually, MMH associated with transferring of long metal bar will be carried out manually by two workers due to relative low labour cost. If the demand for metal bar is high, worker might be suffered from the Work-Related Musculoskeletal Disorder due to repetitive transferring process. In worst case scenario, long metal bar may be wobble and swing during the carrying process. Hence, it may lead to unstable motion on the metal bar while transferring process and affect the hand grip strength of workers. The objectives of this study were to identify the design requirements and user's requirements of an ergonomic grip handle for manual carrying long metal bar, design an ergonomic grip handle based on the design requirements and user's requirements as well as to fabricate and evaluate the performance of the grip handle prototype in manual carrying of long metal bar. There were 50 participants involved in anthropometric data measurement for designing the grip handle. A questionnaire survey was performed to determine users' requirements. Subsequently, Quality Function Deployment (QFD) was applied to analyze the correlation between users' requirements and engineering specification of the grip handle. Few sketches were created based on the result obtained from the QFD. Pugh Conceptual Selection was developed to choose the best design. The best selected conceptual design was converted into engineering drawing and a prototype was fabricated. The System Usability Scale was applied to evaluate the usability of the prototype. The result on usability testing is 77.08 out of 100 which defined the prototype as "Good". Additionally, carrying analysis was simulated by using CATIA software, the results of carrying a long metal bar using bare hand versus using the prototype are 231.831 N and 283.718 N, respectively. Hence, carrying long metal bar with the ergonomic grip handle will not exceed the standard of hand vertical distance. Therefore, this study concluded that the grip handle prototype was able to assist users or workers to perform manual carrying of long metal bar that fulfil to ergonomics requirements.

DEDICATION

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



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LIST OF ABBREVIATIONS

| | | |
|--------|---|----------------------------------------|
| CAD | - | Computer-Aided Design |
| EMG | - | Electromyography |
| FEA | - | Finite Element Analysis |
| FKP | - | Faculty of Manufacturing Engineering |
| MMH | - | Manual Material Handling |
| MSD | - | Musculoskeletal Disorder |
| QFD | - | Quality Functional Deployment |
| SOCISO | - | Society Security Organisation Malaysia |
| SUS | - | System Usability Scale |
| UTeM | - | Universiti Teknikal Malaysia Melaka |
| WRMSD | - | Work-Related Musculoskeletal Disorder |



LIST OF SYMBOLS

| | | |
|----------------------|---|------------------------------|
| mm | - | millimetre |
| cm | - | centimetre |
| kg | - | kilogram |
| m | - | meter |
| MPa | - | Megapascal |
| GPa | - | Gigapascal |
| N | - | Newton |
| MPa.m ^{0.5} | - | Megapascal square root meter |



CHAPTER 1

INTRODUCTION

This chapter introduces the background of the study which is related to manual materials handling such as transferring the long metal bar. It has been recognized as one of the common tasks in manufacturing industries and construction sites. Besides, the problem statements of the study are the safety and ergonomic issues during the process of transferring the long metal bar. The objective of the study is to design and evaluate an ergonomic grip handle for manual transferring the long metal bar. The scope and significance of the study will be shown followed by a summary that summarizes the whole chapter.

1.1 Background of Study

Material handling is an invariable part of any manufacturing or service operation' (Rajesh, 2016). For instance, material handling tasks take place in almost all the field including manufacturing, construction, agriculture, workshop, hardware store, etc. Among the example above, material handling tasks is the most frequently occurred at manufacturing industries and construction sites such as transferring the long metal bar, steel plate, etc.

Manual material handling (MMH) can be defined as transfers an object or material either by lifting, lowering, carrying, pushing, or pulling. According to (Rajesh, 2016), Two out of every five workplace injuries reported to the Health and Safety Executive are due to manual handling. Hence, the manual handling handbook is very important to training the workers to follow the standard operating procedure while manual handling an object or material. Even though the safe manual handling method would not make people stronger or able to lift a greater load, but it can provide the safe and standard procedure for manual

handling an object or material instead to prevent accidents and injuries happen. Figure 1.1 shows the manual handling object.



Figure 1.1: Manual handling object

The metal bar also known as blank, slug, or billet which is a common material used for manufacturing industries and construction sites. There are several sizes of metal bars which are round, square, hexagon, etc. In manufacturing industries, the metal bars can be fabricated to become a part of the product while in construction sites it is used to develop good bond strengths with concrete on the building. In manufacturing industries, the long metal bar will be manufactured by the traditional manufacturing process to become a part of the product. The traditional manufacturing process involves cutting, milling, drilling, turning, etc. Normally, the long metal bar is stored at the warehouse before sending it to the traditional manufacturing process. If the requirement of the long metal bar to fabricate the product, not a huge portion, generally the long metal bar will be transferred to the machine for the process manually. Hence, the workers manually carrying the long metal bar with a bare hand. Without the dedicated tool support when carrying, can result in strain and fatigue in the hand and arm muscle.

At the construction site, the unloading of the long metal bar from the lorry will be done manually by workers. Due to the huge capacity of the long metal used at the construction site, so the worker must repeat the transferring process of the long metal bar until fully unload. When workers transferring the long metal bar by hand without supportive tools which have the probability to occur safety issues such as the long metal slip and fall from the hand. Besides, the prolonged manual carrying the long metal bar without dedicated tools to risk the factor related to Work-Related Musculoskeletal Disorder (WRMSD).

Work-related musculoskeletal disorders (WRMSDs), defined as a subset of musculoskeletal disorders (MSDs) that arise out of occupational exposures, may lead to work restriction, work-time loss, or consequently cause work leave (Kathy Cheng et al., 2013). ‘WRMSD pain is related to the muscles, nerves, tendons, joints, cartilages, and spinal discs associated with exposure to risk factors in the workplace’ (Irruhe et al., 2013). Hence, ergonomics play an important role in the workplace to prevent injuries to occur. According to the workplace safety and health report 2019 from the Ministry of Manpower Singapore, the total cases of MSDs are 326 and 293 in the year 2018 and 2019, respectively. The major cause is due to the forceful exertions by manual handling activities. The cases of MSDs mostly took place in industries of manufacturing and construction. Also, according to the report at Great Britain showed the average prevalence rate of WRMSD across all industries was 1,130 cases per 100,000 workers and construction with a rate of 2,020 cases per 100,000 workers averaged over the period 2017/18-2019/20. The main cause of MSDs due to manual handling activities such as lifting a heavy load and improper manual handling method.

Nowadays, there are many types of equipment and hand tools have been designed and fabricated in the market instead to assist industrial practitioners to minimize occupational health risk and work efficiency in lifting and transferring the long metal bar. However, the equipment and hand tools designed which lack ergonomic cause the users’ risk to MSDs while manual material handling activities. Hence, ergonomic studies must be conducted to design the grip handle based on Malaysia anthropometric data and strength. This study aims to design and fabricate a high-fidelity prototype of a grip handle for lifting and carrying a long metal bar to improve grip performance, usability, and work efficiency.

1.2 Problem Statement

The long metal bar is a common material used at construction site and manufacturing industries. Normally, all the carrying and transferring of the long metal bar process conduct manually by the workers. Hence, there are many problems and issues that occur if manual carrying and transferring the long metal bar without a proper assist device. Figure 1.2 shows the workers manually carrying the long metal bar.



Figure 1.2: Manual handling long metal bar

From the annual report of the Social Security Organization (SOCSO) in Malaysia, the accident of over-exertion in lifting objects had been analysed in figure 1.3. From the trend, the accident occurs in the gender of male involved more than female because handling the long metal bar is heavy duty. From year 2014 to year 2017, the number of accidents increase steadily and decrease slightly from year 2017 to year 2018.

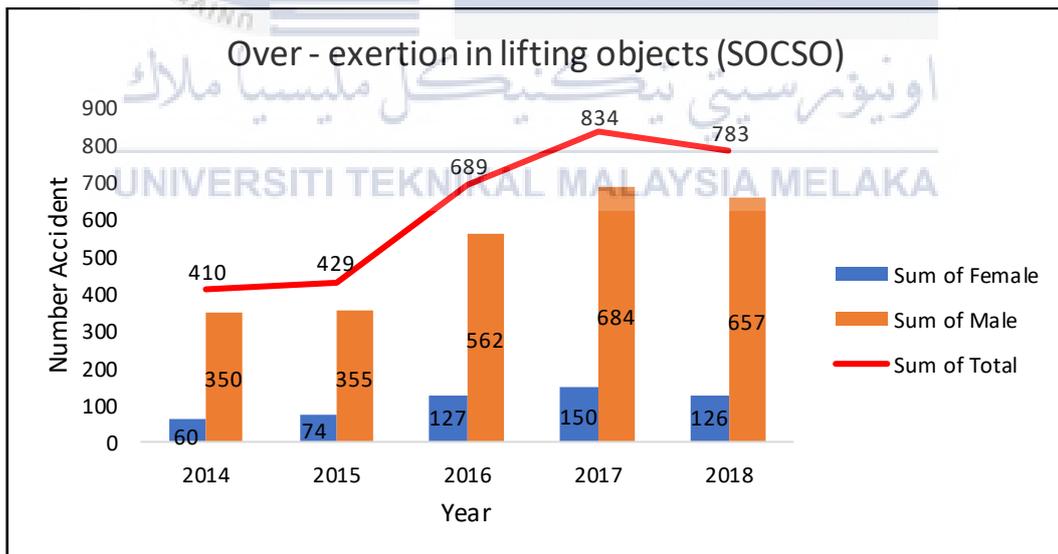


Figure 1.3: Trend of over – exertion in lifting object