SPACE MAPPING OF HIP AND HAND WRISTS MOTIONS FOR MANUAL MATERIAL HANDLING (MMH) WORKSTATION DESIGN (A MALAYSIAN CASE STUDY)

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

by

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ABSTRAK

Projek ini merupakan kajian awal yang menyiasat keperluan ruang untuk reka bentuk stesen kerja bagi aktiviti pengendalian bahan secara manual (MMH). MMH adalah kegiatan memindahkan bahan secara manual dari satu lokasi ke lokasi yang lain, yang dilakkukan secara meluas di syarikat-syarikat pembuatan. Jika stesen kerja tidak direka dengan betul, pekerja berisiko mengalami gangguan muskuloskeletal (MSDS) jika melakukan tugas yang berulang-ulang untuk tempoh yang lama. Di sesetengah negara, garis panduan untuk mereka bentuk stesen kerja telah diwujudkan. Walau bagaimanapun, tidak ada bukti bahawa garis panduan yang sama telah diwujudkan bagi konteks populasi negara Malaysia. Oleh itu, satu kajian yang boleh menyumbang kepada garis panduan tersebut diperlukan. Satu eksperimen pemindahan barang telah dijalankan untuk melihat corak pinggul dan pergelangan tangan dari pandangan atas, bagi tujuan pemetaan ruang stesen kerja untuk aktiviti MMH.

Seramai 15 sukarelawan lelaki telah mengambil bahagian dalam eksperimen ini. Dalam kajian ini, parameter yang ditetapkan adalah ketinggian stesen asal dan stesen destinasi, dan berat kotak yang hendak dipindahkan. Sementara itu, parameter yang berubah adalah jarak pemindahan sisi iaitu 0.5m, 0.75m, 1.0m, dan 1.25m. Sistem menangkap dan merekod gerakan badan yang digunakan ialah set X-Sens. Sementara itu perisian yang terlibat untuk menganalisis data adalah MVN Studio, Cinema 4D, Microsoft Excel 2013, dan Solidworks 2013. Hasil daripada kajian ini menunjukkan bahawa jarak pemindahan terpendek memberikan corak pemetaan pinggul dan pergelangan tangan yang paling statik dan lengkung apabila dilihat dari pandangan atas. Corak lengkung semakin berubah menjadi kurang lengkung apabila jarak pemindahan semakin bertambah. Dari pemetaan pinggul dan pergelangan tangan itu, dapat diperhatikan bahawa ruang yang lebih kecil menyebabkan badan sukarelawan lebih berpusing dan kurang membongkok, manakala ruang yang lebih besar menghasilkan postur badan yang kurang berpusing dan lebih membongkok ketika aktiviti pemindahan barang.

ABSTRACT

This project is a preliminary study that investigates the space requirements for manual material handling (MMH) workstation design. MMH is the activity of transferring material manually from one location to another, which is widely applied in manufacturing companies. If workstation is not designed correctly, there is a higher risk for workers to experience musculoskeletal disorders (MSDs) when performing repetitive task for long hours. In some countries, guidelines for designing workstation has already been established. However, there is no evidence in Malaysian context that the same guidelines have been established for Malaysian populations. Therefore, a study that may contribute to that guidelines is needed. An MMH experiment has been conducted to see the patterns of hip and hand wrists motions from top view, in order to map the space requirement for MMH workstation design.

A total of 15 male volunteers participated in this experiment. In this study, the constant parameters were the heights of the origin and destination stations and the weight of box to be transferred. Meanwhile, the manipulative parameter was the lateral transfer distance which was set to 0.5m, 0.75m, 1.0m, and 1.25m. The motion capture system used was X-Sens set. Meanwhile the software involved for data analysis were MVN Studio, Cinema 4D, Microsoft Excel 2013, and Solidworks 2013. The results from this study show that the patterns of participants' hip and hand wrists motions are most static and curve in shape for shortest lateral distance, when mapped from top view. The pattern slightly changes into a more stretched-curve shape as the lateral distance increases. From the mapping of the hip and hand wrists motions, it was observed that smaller space requirement causes participants to possess more twisting and less bending postures, while bigger space requirement results in more bending and less twisting postures during MMH.

DEDICATION

Dedicated to my beloved family

Honorable lecturers

Supportive friends

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LIST OF ABREVIATIONS, SYMBOLS AND NOMANCLATURE

ASOII	-	Annual Survey of Occupational Injuries and Illness
BLS	-	Bureau of Labor Statistics
DOSH	-	Department of Occupational Safety and Health
L5-S1	-	Lumbosacral
MMH	-	Manual Material Handling
MSDs	-	Musculoskeletal Disorders
MSI	-	Musculoskeletal Injury
NIOSH	-	National Institute for Occupational Safety and Health
WMSDs	-	Work-Related Musculoskeletal Disorders

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Musculoskeletal disorders (MSDs) are injuries that affect human's body movements or musculoskeletal system such as muscles, tendons, ligaments, nerves, discs, blood vessels, and etc. A design of a workstation may affect how a human body will move, turn, twist, or bend. Thus it is important to identify the limitations of suitable postures of human body in order to map a good and suitable workstation design for general workers in manufacturing industries. These limitations can help determine the suitable space requirement for average Malaysians.

The awareness of the importance of having convenient and ergonomic workstations has been rising in Malaysia, including in manufacturing industries. A suitable space requirement of workstation may avoid a worker from having musculoskeletal disorders after performing a same repetitive task for some times. According to an article titled The Definition and Causes of Musculoskeletal Disorders (MSDs) (Middlesworth & Matt, 2016), in United States, almost 30% of all workers' compensation costs is a contribution from workplace injuries which is due to MSDs.

In Malaysia, Social Security Organization (SOCSO), under the Ministry of Human Resources reported that musculoskeletal disease among employees have been increasing since

2003 to 2009. This report can be obtained from their official website of Department of Occupational Safety and Health, www.dosh.gov.my. The statistics is shown in Figure 1.1.

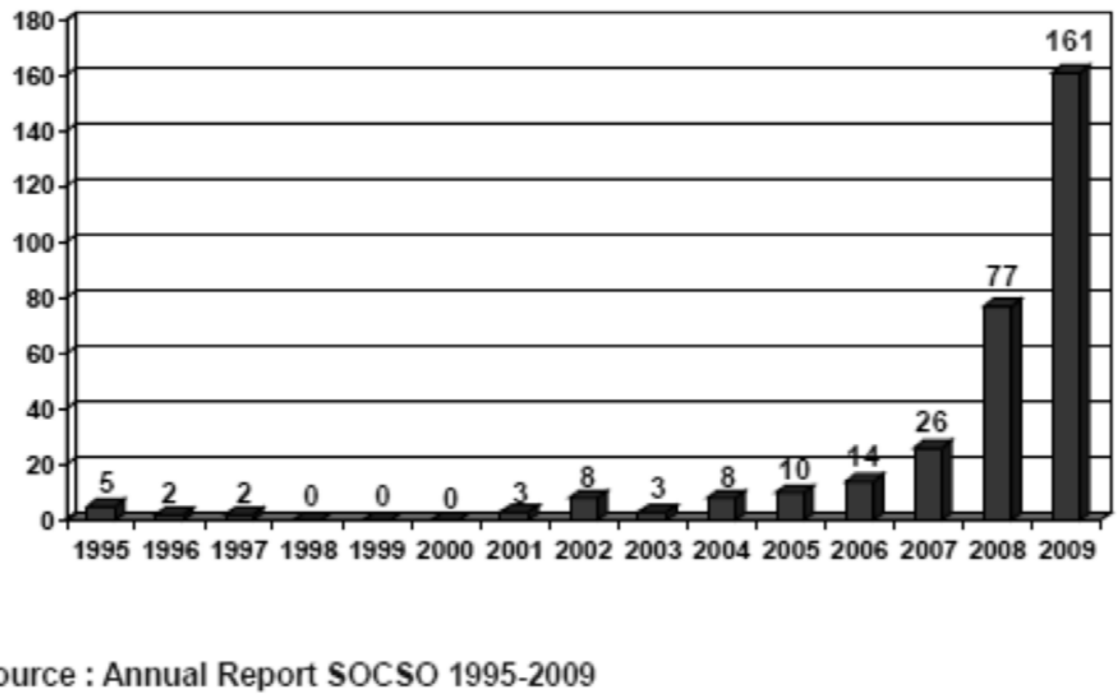

Figure 1.1: Occupational Musculoskeletal Disorder Statistics among Malaysians (Department of Occupational Safety and Health, Ministry of Human Resources, 2016)

The graph shows that musculoskeletal injuries reported among Malaysian workers has been increasing drastically from 2003. The number of workers having MSDs kept on shooting up from three in 2003 to 161 in 2009. According to The Star Online dated 3 December 2012, reposted by the official website of Department of Occupational Safety and Health, the chairman of the National Institute of Occupational Safety and Health, Tan Sri Lee Lam Thye stated that "In 2006, 14 people were reported such cases and the numbers jumped to 238 in 2010 while last year (2011), a total of 286 people were recorder of such disorder".

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To avoid the graph from further increasing in the future, the development of a suitable space requirement for every particular task may be one of the helpful tools. In order to do that, a study should be done on the limitations of human spine from performing awkward postures such as over twisting and forward bending. MSDs do not only cause pain to employees, it can also reduce their work performance. Figure 1.2 shows the relationship between the space requirement of a workstation, MSDs, and worker’s performance.

Figure 1.2: Relationship between space requirement of a workstation, MSDs, and worker’s performance.

Work performance of an employee may be caused by many factors. From Figure 1.2, MSDs in one of the factors that affect work performance. Meanwhile, the severity of MSDs experienced by workers may be influenced by the space requirement of the workstation the workers are working at. If the space requirement is not suitable for a particular task, the risk of having musculoskeletal injury will be higher.

1.2 Problem Statement

In Malaysia, a specific space requirement of workstation design for manual material handling activity in manufacturing company has yet to be identified. Layout of a workstation design may influence workers' movements and postures during manual handling. Bad movements and awkward postures if done repetitively may create pain called musculoskeletal disorders, to workers' body parts. Mapping of hip and hand wrists motions during manual material handling can be a guideline for engineers and designers to plan space requirements for manual material handling workstation design.

1.3 Objectives

The Objectives of this study are:

- To understand the relationships between lateral transfer distances in workstation design in manufacturing line, with bending and twisting postures during manual material handling.
- To explore how differences in lateral distance affect the top view pattern of hip and hand wrists motions during manual material handling and consequently affect the space mapping requirement.
- To map and calculate the space requirements for Malaysian's manual material handling workstation design for four lateral distances.

1.4 Scope

This is a preliminary study on the space requirements for workstation design for manual material handling activity at manufacturing companies. This study is focusing on Malaysian citizens of male gender and is restricted to healthy subjects only. The manipulative parameter in this study is the distance of the lateral transfer stations that were set to 0.5m, 0.75m, 1.0m, and 1.25m.

1.5 Significance of Study

After the completion of this study, there are some potential benefits that can be obtained. The mapping of hip and hand wrists motions during manual material handling helps to show the lateral bending and twisting of workers, as well as the space required for manual handling activity. Over-bending and over-twisting are bad postures since they may cause musculoskeletal disorders to workers. Hence, this study may help designers or engineers to decide on the space required for manual handling activity that has minimal bending and twisting impacts in order to minimize musculoskeletal injuries from workers, which consequently will not reduce their work performance.

1.6 Organization of Report

Chapter 1: Introduction

This chapter discusses the background of the study, report of MSDs disease among workers in manufacturing industries in Malaysia, and the relationship between space requirement of manual material handling workstation design, MSDs, and worker performance. The problem statement is highlighted and the objectives of the study have been listed, followed by the scope of the study which narrows down the area of focus.

Chapter 2: Literature Review

This chapter outlines the previous studies done related to the area of study, through journals, books, and internet references. The causes of MSDs are identified. The current workstation design for manual handling is also explored.

Chapter 3: Methodology

This chapter explains the methods used to complete the study. The methods on how to conduct the experiment and mapping the required space of the workstation design are also discussed in this chapter.

Chapter 4: Results and Discussions

This chapter shows the results from the conducted experiment. The discussions of the results are also included in this chapter.

Chapter 5: Conclusion and Recommendations

This chapter concludes the project based on the stated objectives. The relationship between this project and sustainability is also included. Lastly, some recommendations for future improvements are also suggested in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Front End Ergonomics Consideration in Workstation Design

The term ergonomics or human factors is defined as interactions between humans and other elements of a system involving tasks, jobs, environment, and products, that is compatible with the needs, limitations, and abilities of people (International Ergonomics Association (IEA), 2016). IEA divides ergonomics into three domains namely physical ergonomics, cognitive ergonomics, and organizational ergonomics. As in manufacturing industry, all of these domains are related with this work field. Going in deeper, physical ergonomics domain is associated with general workers especially from production lines as this domain involves working postures, repetitive movements, material handling, workplace layout, safety and health, and musculoskeletal disorders (MSDs). However in Malaysia, it is reported that the awareness on the importance of ergonomics implementation is still very low among industries, despite its benefits (Mohd et. al., 2016).

Middlesworth & Mark (2013) highlighted five benefits of ergonomics implementation in workplace. They are reducing MSDs cost, improving productivity through efficient workstation design, improving quality of work when workers health and emotions are in good conditions, improving employee engagement, and developing a better safety culture. The practice of effective ergonomics in industry can minimize the manual material handling activities, which may help reduce possible musculoskeletal injuries to workers. When possible injuries of workers are reduced, medical treatment cost and insurance compensation can be cut down. Less of injuries also can lead to the enhancement of product quality, company's productivity, and entire business competitiveness (Division of Occupational Safety and Health, 2007). Due to these benefits, Ann

& Mikael (2012) believe that the bonding between assembly ergonomics and quality needs to be a proactive attention at initial design stage. They also believe that by adopting ergonomics practice proactively, besides medical cost, there is a huge impact on product development and product design processes.

In a similar research scope, White & Catherine (2015) briefly explained that proactive ergonomics is a concern on determining possible problems before they occur. She elaborated that creating a job that can allow neutral postures of human body, fewer movements, and smaller force exertion can increase the efficiency of the workers and the work area. Besides that, she also highlighted that proactive ergonomics implementation can treat MSDs issues at initial stage thus reducing the medical and compensation costs directly.

It is important for engineers or designers to consider developing the suitable space requirement for manual material handling at early stage to adopt the implementation of proactive ergonomics, so that the risk of workers having MSDs can be minimized, hence minimizing the cost of medical treatment of this injury, as well as maintaining good performance of workers and maximum productivity.

2.2 Space Requirement of Manual Material Handling Workstation Design

Kuorinka & Ilkka (1994) believes that lack in space does not permit correct handling. In Malaysia, there is no evidence showing that a fixed space requirement for manual material handling workstation that fits Malaysian population has ever been studied on. In order to avoid awkward postures for safe manual material handling, the required space of workstation must be designed appropriate to safe bending, safe twisting, and safe-over-reaching (University of California, n. d.). When designing a workstation for manual material handling, the transfer distance from the lifting station to the placing station must be ergonomics for workers' movements within those stations. In this case, ergonomics stand for the suitability and convenience between lifting station and placing station for workers to pick material, turn, walk, place material, and turn back, without having severe fatigue on their back after performing the task, especially if it is done repetitively.

Mehta et. al. (2014) outlined in his journal that seperating the origin of the lift station and the destination may nurture workers to step and turn their whole body, which may help reduce lateral bending and twisting during manual handling activity. It was suggested that making lifting station and placing station distant can limit the degree of lateral transfer and twisting of body. In a similar study, Lavender et. al. (2009) revealed that bending and twisting of spine were minimized when a seperation distance of 1 meter was created betweent the lift's origin and the destination.

In another study, Backstrand & Gnner (2007) wrote about Volvo Powertrain Sweden company whom used a methodology called BUMS to map and evaluate workplace and workstation designs in their company, before the design is approved. They found that this tool helpful to identify design faults at the beginning of the development process, thus helped them to improve the efficiency of the workplace and workstation.

In a study on the effects of transfer distance on spine kinematics for de-palletizing tasks, Mehta et. al. (2014) determined how the degree of bending and twisting of a perosn change the distance of transfer and initial height of lift. The experiment was conducted for American population specifically to study the raltaionship of height of conveyor and distance of origin and destination conveyors with the degree of twisting and bending during MMH, and this study did not mention about mapping of space requirement of MMH activity. A number of 18 male participants participated in this experiment. The parameters set constant in this experiment were weight of box, 10.9 kg, and the height of destination conveyor, 0.9 meter. The manipulative parametes were the heights of lift origin which were 0.5 m, 0.9 m,and 1.3 m from the floor, and transfer distance that were set to 0.5 m, 0.75 m, 1.0 m, 1.25 m, 1.5 m, and 1.75 m. Figure 2.1 shows the design of the workstation.