UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ERGONOMIC DESIGN OF COMPUTER NUMERICAL CONTROL LATHE MACHINE WORKSTATION

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

by

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DECLARATION

I hereby, declared this report entitled “Ergonomics Design of Computer Numerical Control Lathe Machine workstation” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons.). The member of the supervisory is as follow:

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(Dr. Isa bin Halim)

DEDICATION

Special dedication to my parents, lecturers, siblings and friends for giving me knowledge and moral support to complete the project and reports

ABSTRACT

In manufacturing industry, the CNC lathe machine is widely used to improve productivity, repeatability and precision in machining process. However, the existing workstation of CNC lathe machine has contributed to unsafe working practices such as awkward postures, prolonged standing, repetitive movements and handling heavy loads which can lead to the muscle fatigue. In recognition the importance of these issues, the aim of this study is to improve the workstation design of CNC lathe machine. This can be achieved by redesigning the workstation according to ergonomics features required by the machinists. The ergonomics features were obtained through a questionnaire survey among 30 machinists. The machinists' requirements were transferred into technical specifications by using House of Quality (HoQ). Then, the morphological chart was used to generate three conceptual designs of new workstation of CNC lathe machine. The final design of the workstation was drawn using CATIA software. The Rapid Upper Limb Assessment (RULA) was applied to analyze the working postures of machinists at the existing workstation and the redesigned workstation of CNC lathe machine. Based on the RULA analysis, the redesigned workstation of CNC lathe machine has improved the working postures of machinists. Hence, this study concluded that considering ergonomics features in the workstation design of CNC lathe machine contribute to safe working posture for the machinists.

ABSTRAK

Di dalam industri pembuatan, penggunaan teknologi mesin larik berkomputer (CNC lathe machine) telah digunakan secara meluas untuk meningkatkan ketepatan, kejituan dan produktiviti di dalam proses memesin. Walaubagaimanapun, penggunaan mesin larik berkomputer ini mewujudkan suasana kerja yang tidak selamat seperti postur kekok, berdiri untuk tempoh masa yang lama, pergerakan yang berulang-ulang serta mengangkat beban melebihi kemampuan jurumesin yang akan membawa kepada kelesuan otot kepada jurumesin. Setelah mengenalpasti isu ini, kajian ini dijalankan untuk melakukan penambahbaikan semula kawasan kerja mesin larik berkomputer. Ini boleh dicapai dengan merekabentuk semula kawasan kerja mengikut ciri-ciri ergonomik yang diperlukan oleh jurumesin. Ciri-ciri ergonomik yang diperlukan jurumesin diperolehi melalui kaji selidik daripada 30 orang jurumesin. Keperluan jurumesin akan diterjemahkan ke dalam spesifikasi teknikal dengan menggunakan 'House of Quality' (HoQ). Selepas itu, carta morfologikal digunakan untuk menghasilkan tiga konsep rekabentuk yang baharu untuk ruang kerja mesin larik berkomputer. Konsep terakhir dilukis dengan menggunakan perisian 'CATIA'. Analisa 'RULA' akan dilakukan untuk mengkaji postur kerja jurumesin di mesin larik berkomputer yang sedia ada dan di mesin larik berkomputer yang diperbaharui. Berdasarkan analisis RULA tersebut, rekabentuk semula kawasan kerja mesin larik berkomputer (CNC lathe machine) dapat memperbaiki postur kerja jurumesin. Oleh itu, kajian ini membuat bahawa kawasan kerja mesin larik berkomputer yang diperbaharui dengan mengambil kira ciri-ciri ergonomik dapat menghasilkan postur kerja yang selamat kepada jurumesin.

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CHAPTER 1
INTRODUCTION

This chapter contains of background of study, the problem statement, objectives of study, and scope and limitation of study.

1.1 Background of Study

In industrial sectors and educational institutions nowadays, Computer Numerical Control (CNC) machines are commonly used to produce parts from the simplest to complex shape. There are different types of CNC machines such as lathe, milling, and grinding. The CNC lathe machine is usually use to make boring or drilling holes, cylindrical, conical and flat shape machining operation. To perform machining operation in CNC lathe machine, a machinist has to program the machine using unique software and G-code language setup. The advantages of applying CNC lathe machine in machining operation are high productivity, precision and accuracy.

Even though the CNC lathe machine can contribute to enormous profits to industry practitioners; however the machine can lead to occupational injuries due to lifting of heavy or large workpieces, accidents while starting the machine, and unclean mating surface causing the object to slip (Rey Y, Dec 2009). In addition, the machinists might be exposed to low back pain, shoulder pain, and neck pain due to improper design of control panel of CNC lathe machine (Krishnamoorthy et al., 2012). Other factors that contribute to the injuries are handling heavy workpieces, repetitive motions, and awkward working posture (Imtiaz Ali khan, 2012). A previous study reported that the

machinists experienced muscle fatigue in the legs due to standing in a long period of time.

There are several tools that can be utilized to improve the design of CNC lathe machine. One of the popular tools that commonly used is the Quality Function Development or known as QFD (Akao, 1990). The QFD is an approach to determine the technical and ergonomic design requirement characteristics of new or innovated product to meet the users' requirements. This method translates the Voice of Customer (VoC) obtained from questionnaire to fulfil the customer satisfaction (Adila Md Hashim et al., 2012). To generate the result, users' requirements will be summarized in the House of Quality (HOQ).

By realizing these needs, the aim of this study is to improve CNC lathe machine workstation by redesigning it according to the ergonomic features and customer's requirements by focusing to the common risk of factor occurred. To do so, the QFD tools are needed for this study.

1.2 Problem Statement

Based on on-site observation, the existing design of CNC lathe machine requires further improvement in terms of ergonomics as it leads to muscle fatigue that can be summarized as follow:

1. Awkward posture: The machinists adopted awkward postures associated with trunk flexion while loading the workpiece into the machine chuck. This is due to the machinists that have to bend forward to reach and manually lift the material from the buffer area. This may cause the machinists to feel pain especially in their arms, shoulder and neck (Imtiaz Ali khan, 2012).

2. Prolonged standing: The machinists are exposed to prolong standing while performing monitoring, observation, programming and editing process. This happens as a result of not having a chair and floor fatigue mat at the workstation. This process will lead to muscle fatigue to the machinists. They tend to sense this

muscle fatigue especially on their lower back, knees and legs (Isa Halim et al., 2012).

3. Repetitive movements: The machinists operations in repetitive movements were during the machining and observation. Others than that, the improper position of control panel also leads to the repetitive movements. Nowadays, there are too many designs build out there which do not fulfil the anthropometry standard for Asians. This may exposed the machinists to serious injuries and illness. They may experience musculoskeletal disorder such as neck pain, shoulder pain and back pain if there is no improvement occurred (Krishnamoorthy et al., 2012).

4. Heavy load: The machinists need to carry heavy load of the raw material manually during the workpiece loading. Until now, there is no mechanical device being provided. This may exposed the machinists to experience pain in their arms due to this activity (Imtiaz Ali Khan, 2012).

As a consequence of this ergonomic risk factor, this working condition may reduce the productivity, accuracy and efficiency of the industry. By referring to Figure 1.1, the relationship between the main effect and causation can be found through the Ishikawa Diagram.

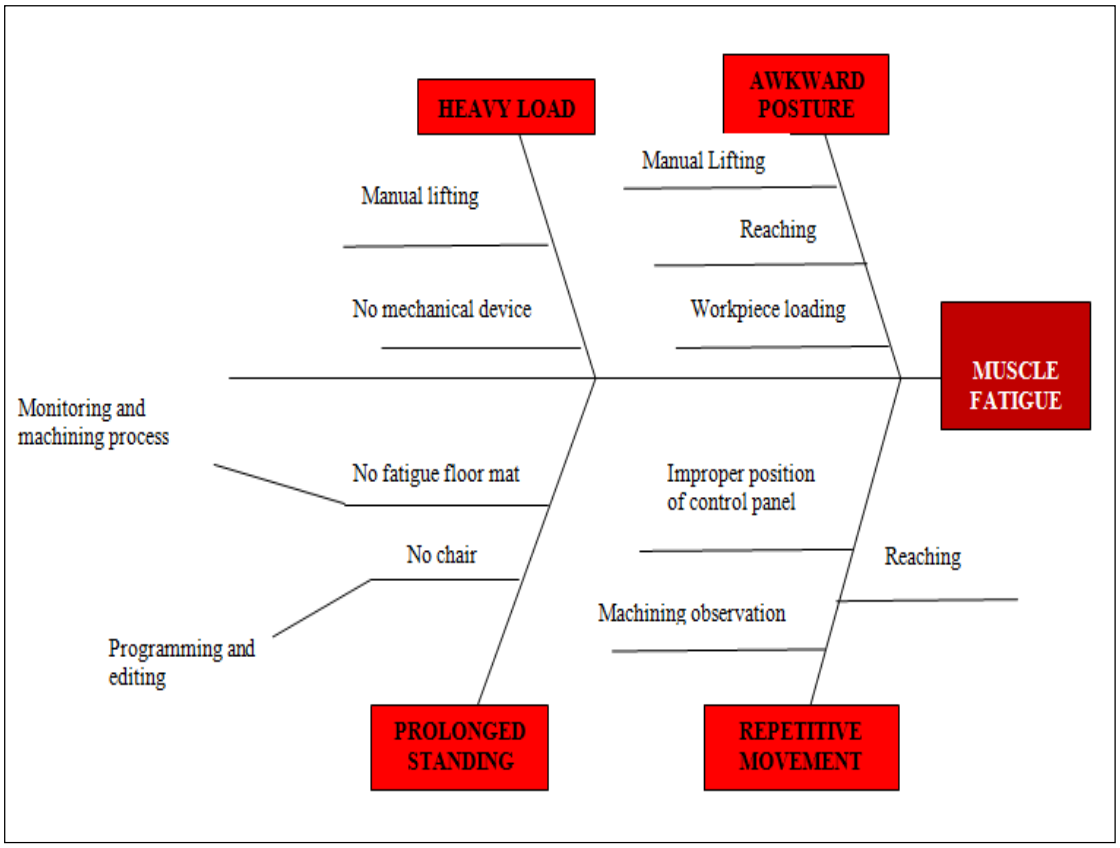

Figure 1.1: Relationship between the main effect and causation through an Ishikawa Diagram

1.3 Objectives of Study

To provide solution for the above mentioned problems, this study is carried out to achieve the following objectives:

1. To determine ergonomics features required by the machinists to improve the existing CNC lathe machine workstation design.
2. To redesign the existing workstation design of CNC lathe machine by taking into account ergonomics features required by the CNC lathe machinists.
3. To validate the working postures of machinists while performing jobs at the redesigned CNC lathe workstation.

1.4 Scope and Limitation of Study

This study performs ergonomics improvement on a Haas CNC lathe machine manufactured at York Country, Virginia that is available in CNC laboratory in Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM). In the design of the CNC lathe machine, the following ergonomics risk factors were critically studied: unsafe working postures adopted by the machinists while inserting the workpieces into the machine chuck, prolonged standing while the machinists monitors the machining process, and unsafe working posture while the machinists editing and programming the G codes in the control panel of machine.

As a limitation of the study, the ergonomics design applied in the CNC lathe machine focus on workpieces loading mechanism, standing platform, and control panel. These improvements were applied in the existing CNC lathe machine workstation through computer aided design, and their effectiveness was validated based on simulation study. In other words, there was no actual fabrication and assessment done for the redesigned workstation.

1.5 Report outline

In chapter one, it provides an introduction of the study, the problem statements of the study, objectives, scope and limitation of the study and also the report outlines. The main objectives of the project are: to determine ergonomic features required by the machinists to improve the workstation design of the existing CNC lathe machine; to redesign the existing workstation design of CNC lathe machine by taking into account ergonomics features required by the machinists; and to validate the working posture of machinists while performing jobs at redesigned CNC lathe workstation. The scope and limitations of the project explain the range of the project that will be done and the limits of the project itself.

In chapter two, the literature review is provided in order to support the discussion and the methodology of study. The literature review was performed by online search through journals and other reliable resources.

Chapter three discusses the method applied to redesign the CNC lathe machine workstation. The questionnaire survey was used to obtain the machinists requirements. Next, the Kano model was used to evaluate the satisfaction-dissatisfaction of the machinists. Then, the machinists' requirements were translated from Voice of Customer (VoC) into the Voice of Engineer (VoE). Next, the conceptual design of the CNC lathe machine workstation was determined by using morphological chart, screening and scoring method. The final design of the workstation draws by using the CATIA software. Lastly, the working postures of the machinists were validated by using RULA analysis.

Chapter four presents the data and results obtained through the questionnaire survey, House of quality (HoQ), morphological chart, scoring and screening method and RULA analysis.

Last but not least, chapter five concludes the findings of study and it provides recommendations for future works. Figure 1.2 illustrates the report outline.

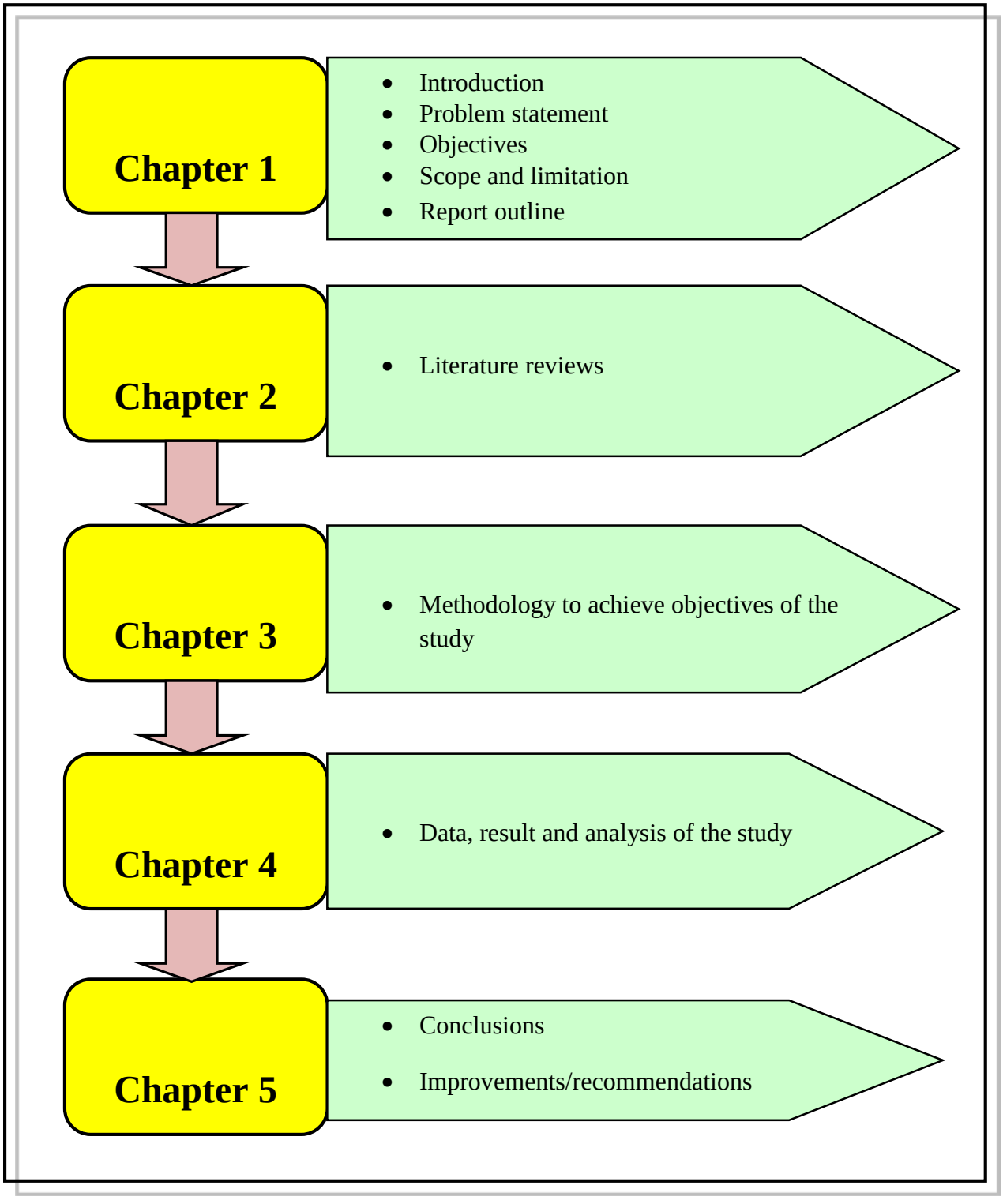

Figure 1.2: The report outline

CHAPTER 2
LITERATURE REVIEW

While the previous chapter introduces the background of the study, this chapter continues with the literature review on the following subjects: features and ergonomic requirements regarding CNC lathe machine; and validate the working postures in terms of ergonomics features. The information and knowledge are obtained through hardbound and online journals, relevant articles and reference texts.

2.1 Ergonomics Features in CNC Lathe Machine Design

2.1.1 Workstation Design of CNC Lathe Machine

Nowadays, the CNC lathe machine is widely used in the manufacturing industry and metalworking industry because it can increase productivity and reduce downtime (Tufan and Erhanbozdag, 2006). The CNC lathe tools are usually controlled by a computer program. It is used to produce parts from the simplest to the most complex shapes either in small or large batch sizes. Generally, the CNC lathe machine can be classified into two types; vertical (VTL) and horizontal orientations as shown in Figure 2.1.

Figure 2.1: VTL CNC lathe machine (left) and horizontal CNC lathe machine (right) (Amtechmachine, 2008)

The VTL machine consists of a spindle that can move along the z-axis. On top of that, it provides the headstock that place in the floor and the potter wheel to handle a heavy and large workpieces. Due to this element, it can complete the machining process by single setup; and at the same time, the time and cost will be saved. For the horizontal CNC lathe machine, it consists of a variety of cutters that can easily change. Generally, it performs a face cutting by using spindle and allows side, face and form machining in only one operation. Besides that, the horizontal spindle make the workpiece to spin and the cutting tools are moved across it in the z-axis and x-axis.

Basically, the CNC lathe machine has its own workstation design. Commonly, a workstation contains of one or two workers to perform a job. In the workstation, the workers need to prepare the materials and equipment to perform a job. Therefore, this workstation needs to be design according to the worker's convenience. On top of that, the workstation has to be built according to worker anthropometry to minimize the