ERGONOMIC DESIGN OF ADJUSTABLE HEIGHT STANDING PLATFORM FOR MANUAL MILLING OPERATION

Submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering (Hons)

by

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2019

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DECLARATION

I hereby, declared this report entitled "Ergonomic Design of Adjustable Height Standing Platform for Manual Milling Machine" is the results of my own research except as cited in reference.

Signature: …………………………

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Date: 3-6-2019

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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 requirements for the degree of Bachelor of Manufacturing Engineering (Hons).

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(Principle Supervisor)-Signature and Stamp

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ABSTRAK

Pengguna mesin pengisar manual mengalami kecederaan berkaitan ergonomik disebabkan oleh ketidaksepadanan saiz fizikal mereka dan spesifikasi mesin. Tujuan utama kajian ini adalah untuk menghasilkan satu prototaip platform berdiri yang mempunyai ciri ketinggian boleh laras.

Di samping itu, kajian ini juga mengukur kekuatan maksimum daya kilas tangan dan pergelangan tangan pengguna mesin pengisar pada tiga ketinggian yang berbeza. Daya kilas tangan diukur pada ketinggian bahu, ketinggian mata dan ketinggian atas kepala. Manakala daya kilas pergelangan tangan diukur pada ketinggian pinggang, ketinggian siku dan ketinggian bahu. Kekuatan maksimum daya kilas tangan dan pergelangan tangan telah diukur dengan menggunakan Mark 10 Series R52 Model M3i yang dipasang pada pelantar ujian. Pengukuran tork tangan diukur pada ketinggian bahu, ketinggian mata dan ketinggian overhead di kedua arah jam manakala pengukuran tork pergelangan tangan diukur pada ketinggian pinggang, ketinggian siku dan ketinggian bahu pada kedua arah jam. Borang wawancara dan pemerhatian dijalankan untuk menentukan keperluan pengguna mesin pengisar sebelum ianya diterjemahkan kepada beberapa lakaran konsep.. Kaedah ‘House of Quality’ telah digunakan untuk mengubah keperluan pengguna mesin pengisar kepada keperluan kejuruteraan. Manakala kaedah pemeriksaan ‘Pugh Method’ telah diaplikasi utk menentukan konsep platform berdiri yang terbaik. Untuk menentukan kelayakan ekonomi dan kos yang mungkin, Pulangan Pelaburan (ROI) dinilai. Keputusan kajian menunjukkan bahawa kekuatan maksima daya kilas tangan (905.6667 Ncm) dan kekuatan maksima daya kilas pergelangan tangan (514.666667 Ncm) adalah pada ketinggian bahu. Kajian ini membuat kesimpulan bahawa prototaip platform berdiri boleh laras mampu memberikan ketinggian yang sesuai kepada pengguna untuk mendapatkan kekuatan maksimum semasa operasi pengisaran secara manual.

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ABSTRACT

Users of manual grinding machines suffer from ergonomic-related injuries due to their physical size mismatches and machine specifications. The main purpose of this study is to produce a standing platform prototype that has an adjustable height feature.

In addition, this study also measures the maximum strength of the hand torque and the wrist of the user of the blender machine at three different heights. Hand torque is measured at shoulder height, eye height and heights above the head. While the torque is measured at the waist height, elbows and shoulder height. The maximum strength of hand torque and wrists was measured using the Mark 10 Series R52 M3i Model installed on the test rig. Hand torque measurements are measured at shoulder height, eye height and overhead height in both directions while wrist torque measurements are measured at waist height, elbow height and shoulder height in both clockwise. An interview and observation form is conducted to determine the needs of the blender machine user before it is translated into some concept sketches. The 'House of Quality' method has been used to transform the user's requirements of the blender machine into engineering requirements. Whereas the 'Pugh Method' check method has been applied to determine the concept of the best stand platform. To determine the economic feasibility and possible costs, the Return on Investment (ROI) is assessed. The results showed that the maximum strength of hand torque (905.6667 Ncm) and the maximum strength of the wrist torque (514.666667 Ncm) was at shoulder height. This study concludes that the prototype adjustable stand platform is able to provide the user with the appropriate height to gain maximum strength during manual grinding operations.

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DEDICATION

Only

My beloved father, Lee Song Chong

My appreciated mother, Beh Lee Lee

My adored brother and sister, Lee Ren Hua and Lee Ren Yan

For giving me moral support, cooperation, encouragement and understandings

Thank you so much and Love you all forever

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ACKNOWLEDGEMENT

Firstly, I would like to express my gratitude and thanks to my supervisor, Dr. Isa bin Halim. He always provides me guidance and comments throughout conduct this study. He guided me with a vast amount of information when I faced some problem.

Besides that, I also would like to thank to Dr. Nadiah binti Ahmad, Dr. Nor Akramin bin Mohammad and PM Dr Seri Rahayu Kamat for giving me tons of fruitful comments on my project which greatly helps me improve the accuracy and the outcome of the results.

Furthermore, I would like to thank to every assistant engineer and students that involved in this project. Commitment and help from them facilitate me to finish the project smoothly.

Lastly, I would like to express my gratitude to my parents, who gave me moral support since from the start of the project. They always encourage me and cheer me up.

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Chapter 1

Introduction

This chapter represents the background of study, problem statements, objectives, scope and the significant of the studies. The background of the studies is to focus on ergonomic design of adjustable height standing platform for manual milling operation. The problem statement will be mainly delivered what is the problem faced by user when using current existing standing platform during milling operation. The objective of the study is to design and fabricate a high functional prototype of adjustable height standing platform for manual milling operation while the scope will be mainly describing the focus and limitation of the study.

1.0 Background of study

Milling is a very common machining process. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to a platform inside the milling machine. The cutter is a cutting tool with sharp teeth that is also secured in the milling machine and rotates at high speeds. By feeding the workpiece into the rotating cutter,

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material is cut away from this work piece in the form of small chips to create the desired shape.

Milling operation is a very physically demanding work where it involving repetitive movements and tasks, hand gripping, forceful manual-exertion, heavy lifting, and exposure to whole body or segmental vibration that are known to lead people to Work-related musculoskeletal disorders (WMSD). According to the Social Security Organisation's (SOCSO) statistics, National Institute of Occupational Safety and Health (NIOSH) chairman Tan Sri Lee Lam Thye noted in 2013 alone, there were 694 ergonomics related cases out of 2,630 cases of disease, which means for every four cases reported to SOCSO, one was related to musculoskeletal disorders. Apart from the incident happened, there are few imperfection on the milling machine platform, which is the design of the standing platform for milling operation is not ergonomically designed, which will lead to unproductive output.

Moreover, most of the design of the milling machine that imported from the Europe countries are generally not feasible for the Asian height due to its size. According to the Nurul Izzah Abdullah Rahman et al (2016) studies, they found out that Malaysian shortest female is around143.9 cm while tallest guy is around 181.5cm while the range of 6 tons milling machine are around 250 cm to 400 cm height. The workers that working on inflexible standing platform will force to work them to work in awkward posture which will lead to work-related disorder (WMSD). The force exerted by the user unable to optimize if their working posture is not neutral and this might lead to various work-related injuries such as Carpal Tunnel Syndrome.

Due to overall consideration, the purpose of this study is to redesign the standing platform for the milling machine to solve all the following problem related to reach the draw bar and awkward posture in operating manual milling operation.

1.1 Problem Statement

Based on the investigation through interview form and immersion, we found out the current non-adjustable standing platform unable to match height of users .This issue greatly affected the whole milling operation productivity as users unable to work in ergonomic

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friendly environment. Based on Newton 2nd Law, maximum torque able to achieve if the force is perpendicular to center of rotation. However, since the user unable to reach same height level with the draw bar, user need to exert more force to generate torque to loosen the draw bar. Some user might try to climb and stand on the milling beam just to loosen then draw bar that might slip and fall to the floor which pose another serious safety issues. Figure 1.1 shows a manual milling machine.

Figure 1.1 Vertical milling machine in UTeM

(a) Draw bar is too high to reach.

The current location for draw bar of milling machine is too high and unable to reach by some users. The maximum torque can be obtained when the force is perpendicular to the handle. However, due to the height of the draw bar, most users unable to exert maximum torque because their arm unable to reach same level as the handle. The muscle in the arm forced to stretch and might cause muscle strain. Figure 1.2 shows an average male exert torque draw bar with fully stretch arm. This study observed that his wrist are bend and arm is not perpendicular with the spanner handle.

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Figure 1.2 User trying tighten or loosen the draw bar with a spanner

(b) Awkward posture while performing operation.

Due to the stationary design of the milling standing platform, tall users have to bend their back while shorter user need to lift up their ankle to adjust their vision so they know where to positioning their work piece. Figure 1.3 shows an average male users is bending his back to have a better vision of the work piece. This is due to the vertical knee transverse crank and the cross feed handle are located at the lower position of the milling machine. As a consequences causes the tall users need to bend down their back to turn them and will induce lower back pain and can causes other Work-related musculoskeletal disorder (WMSD).

Figure 1.3 User bends his back to have a clearer view on the work piece.

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1.2 Objective

The objectives of this study are:

a) Measure the maximum hand and wrist torque strength of dominant hand of Malaysian in neutral posture with different heights which are waist height, eye height and shoulder height during standing position.

b) Determine user requirements regarding the design of adjustable height standing platform for manual milling operation.

c) Design a high fidelity prototype of adjustable height standing platform which considering the maximum hand and wrist torque and the user requirement.

1.3 Scope of Study

This study is to discuss about the redesign of milling standing platform that enable FKP students and staff to standing and operating at comfortable and ergonomic healthy condition. This study only limited to conventional standing vertical milling machine.

Based on the first objective, data collection for maximum hand torque and wrist torque are only focus on Malaysian aged around 20-40 years old free from disabilities or injuries on wrist or arm. These data collection only limited to standing Malaysian users' hand and wrist torque strength with neutral wrist and pronation arm posture while apply force in clockwise and anticlockwise direction at eye height, shoulder height and waist height.

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The second objective mainly emphasize on the parameters that determine the user requirement needed for the adjustable height standing platform. The users only limited to University Technical Malaysia Melaka (UTeM) students and staff.

The third objective is focus on redesign the current standing platform. In order to design a high fidelity of adjustable height standing platform, we will need to consideration on Malaysian anthropometry. The new design of the adjustable standing platform will enable users to have more better ergonomic working posture during operating milling machine which generally will increase productivity and comfort level of users. However there are some limitation on this study. We only focus on design and fabricate the prototype version of the adjustable height standing platform. We only produce high fidelity of prototype version of the adjustable height standing platform. Any limitation will investigate in future for further improvement.

1.4 Framework structure of the study

The summary of the study is shown in Figure 1.4.

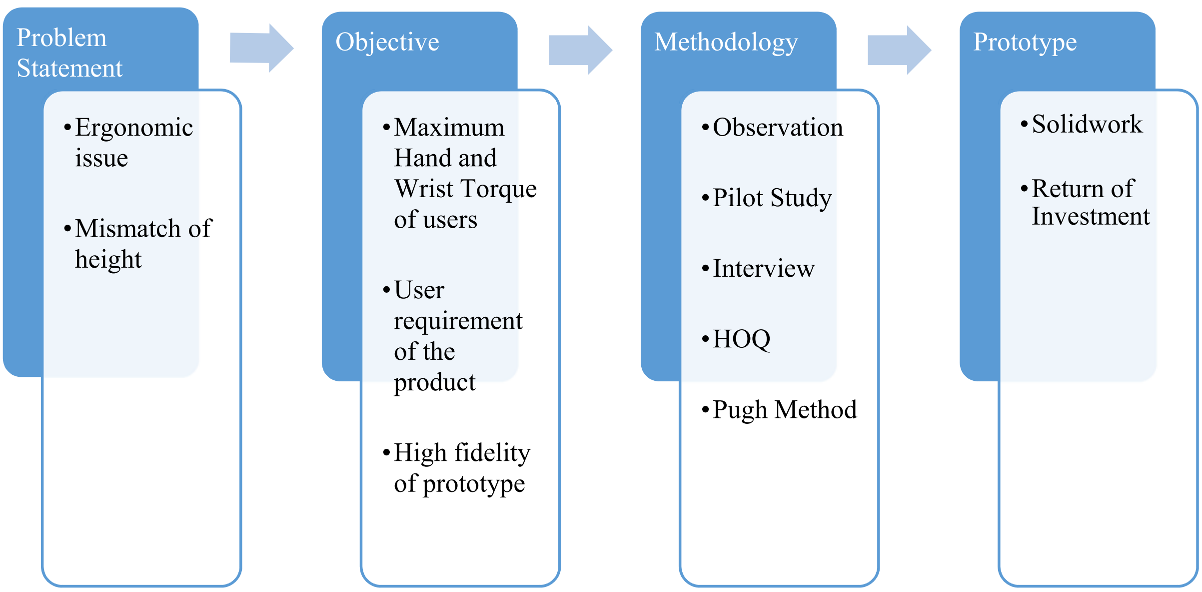

Figure 1.4 shows the framework of the study

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Chapter 2

Literature Review

This chapter describes the literature review that related to the study that made by the past researcher. In this chapter the study will be focus on the related information to our objectives. All information are obtained from relevant journal, articles, books and online resources.

2.1 An Overview on Hand and Wrist Torque Strength

Our hand torque strength is always needed to handle objects and tools or to operate controls, knobs and valves in most daily and occupational activities (Shih and Wang, 1996; Imrhan and Jenkins, 1999; Dianat et al., 2012b).

2.1.1 Factors Affecting the Hand Torque and Wrist Torque Strength

There are various factors that affect the hand torque or wrist torque strength such as gender, surface finish, types of muscle contraction and dominant of hand.

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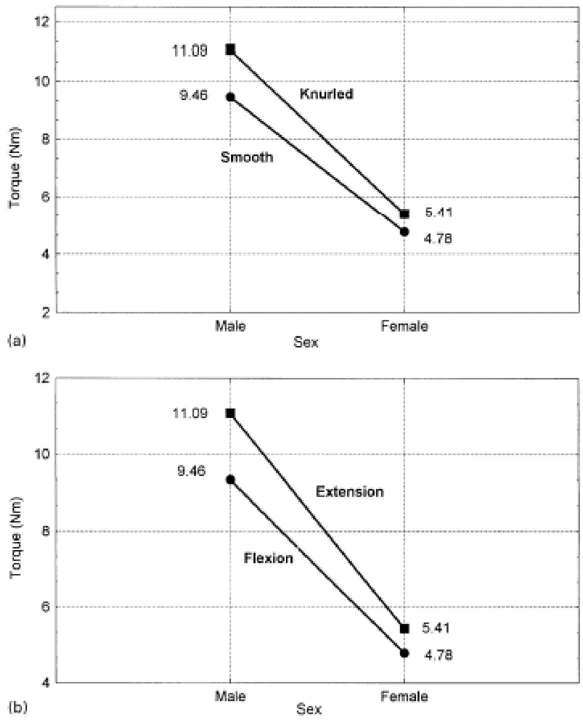
2.1.1.1 Genders and Surface Finish

Based on forearm torque and lifting strength study (Peter et al,.July 2018) , it shows that male have approximately 70% higher forearm torque and lifting strength compare to female. A researcher also proven that the female participants are weaker in upper limb about 40-60% and in lower limb about 25-30% compared to male participants (Shephard, 2000).

S.N. Imrhan, G.D. Jenkins / International Journal of Industrial Ergonomics 23 (1999) 359–371



Interaction effects between (a) sex and handle surface and (b) sex and wrist action on wrist turning strength.

Figure 2.1 Interaction between torque with gender and type surface finish.

Based on results as shown figure 2.1 below from Imrhan and Jenkins1999 studies, the hand turning torque by male are generally higher than female regardless degree of shoulder flexion, type of shoulder muscle contraction, dominant hand and type of handle surface.

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Table 2.1 Mean hand turning torques (N m) on 21 4 in diameter cylinders for males and females over 24 different test conditions.

Arm Position			Males (*n* = 10)		Females (*n* = 10)	
Type surface	(Deg shoulder flexion)	Type of contraction	Right hand	Left hand	Right hand	Left hand
Knurled	30	Flexion	10.48 (0.46)	8.74 (0.40)	4.69 (0.43)	4.50 (0.37)
		Extension	12.83 (0.61)	12.02 (0.84)	6.12 (0.52)	5.66 (0.49)
	90	Flexion	10.52 (0.48)	9.82 (0.54)	5.27 (0.42)	4.70 (0.36)
		Extension	12.09 (0.70)	11.90 (0.69)	6.19 (0.56)	5.47 (0.52)
	130	Flexion	10.91 (0.78)	8.98 (0.63)	5.16 (0.35)	4.68 (0.33)
		Extension	11.78 (0.62)	12.07 (0.59)	6.02 (0.52)	5.59 (0.49)
Smooth	30	Flexion	8.75 (0.65)	8.22 (0.56)	4.47 (0.39)	4.21 (0.38)
		Extension	10.59 (0.59)	9.90 (0.75)	5.63 (0.51)	4.90 (0.48)
	90	Flexion	9.11 (0.72)	8.54 (0.69)	4.68 (0.39)	4.52 (0.35)
		Extension	10.59 (0.78)	9.61 (0.84)	5.28 (0.49)	4.65 (0.52)
	130	Flexion	9.52 (0.61)	8.46 (0.66)	4.53 (0.35)	4.35 (0.32)
		Extension	10.31 (0.73)	9.56 (0.80)	5.25 (0.46)	4.89 (0.59)

Meanwhile for wrist torque on the past studies made by Imrhan and Jenkins, 1999, it shows that the arm position doesn't bring much significant effect on wrist torque strength. Based on the table 2.1, it shows that extension torque are generally larger in both sexes compare to flexion torque.

2.1.1.2 Types of muscle contraction

Hazelton et al (1975) found that the strongest total finger flexion force was achieved in wrist ulnar deviation, followed by the wrist positions of neutral, radial deviation, extension, and flexion. According to Loren et al 1996, length-tension relationship of the active contractile elements within a muscle affects wrist torque. It may be that when the wrist is positioned at 20 ° of extension and 5 ° of ulnar deviation the muscular compartments for individual fingers are at optimal length for maximum active force production.

Next friction force within the carpal tunnel may interpret as wrist deviation. As the wrist deviates, extrinsic finger flexors are bent against the structures within the carpal

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