



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DESIGN OF MANUAL MILLING OPERATION  
WORKSTATION FOR PRODUCT DIMENSIONAL ACCURACY  
AND SAFE POSTURE**

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

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2016

**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

**TAJUK: Design of Manual Milling Operation Workstation for Product Dimensional Accuracy and Safe Posture**

**SESI PENGAJIAN: 2015/16 Semester 2**

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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)

## **ABSTRAK**

Dalam krisis ekonomi semasa, syarikat-syarikat di bawah Perusahaan Kecil dan Sederhana (PKS) lebih mengutamakan keuntungan berbanding keselamatan, kesihatan dan kebajikan pekerja. Operasi mengisar secara manual merupakan kerja yang memerlukan ketepatan tinggi dan operator mestilah lebih teliti untuk menghasilkan produk yang berkualiti. Walau bagaimanapun, operator terdedah kepada pelbagai faktor risiko seperti getaran dan bunyi bising, paparan mesin yang tidak jelas, ketinggian bekerja yang tidak sesuai, waktu kerja yang panjang, pengudaraan tempat kerja yang tidak baik dan tahap pencahayaan yang tidak mencukupi semasa menjalankan operasi mengisar. Tujuan kajian ini adalah untuk membentuk semula stesen kerja mengisar manual. Kajian ini menggunakan kaedah temu bual, pemerhatian di tempat kerja, kajian literatur dan kajian soal selidik melibatkan 20 pekerja industri untuk menentukan faktor risiko yang terdapat di stesen kerja mengisar manual. Faktor risiko yang berkaitan dengan postur kerja dianalisa menggunakan Rapid Upper Limb Assessment (RULA). Untuk membangunkan stesen kerja yang optimum, kajian ini melakukan eksperimen secara faktorial penuh dalam Design of Experiment (DoE). Selain itu keperluan operator mengenai reka bentuk stesen kerja didapati melalui soal selidik dan dipindah ke House of Quality (HOQ). Lima konsep reka bentuk telah dilakar dan disaring melalui kaedah pemilihan Pugh berdasarkan kesesuaian dan keberkesanan kos. Analisa kos dan faedah telah digunakan untuk menilai kesesuaian kos supaya dapat memenuhi keperluan keusahawanan. Kajian ini menyimpulkan bahawa reka bentuk baru stesen kerja telah meningkatkan postur kerja dan kualiti produk. Kajian ini mencadangkan bahawa siasatan lanjut mengenai bunyi bising yang melampau dan getaran perlu dipertimbangkan dalam kajian akan datang.

## **ABSTRACT**

In the economic crisis, the small and medium enterprises (SMEs) is trying to drive their business to profit based rather than safety, health and welfare of workers. Manual milling operation is widely applied in manufacturing industries under the SMEs. This operation is a precise task that requires the operators to pay high concentration to ensure the work piece being milled is accurate. However, the operators are exposed to various risk factors such as excessive vibration and noise, unclear machine gauge display, inappropriate working height, prolonged working hours, poor workplace ventilation and inadequate lighting level at the workstation while performing manual milling operation. The aim of this study is to redesign the existing manual milling operation workstation. This study applied interview, workplace observation, literature review and questionnaires survey among 20 workers in a medium sized machining company to determine risk factors associated with the manual milling operation. The risk factor which relate to non-neutral work posture was analysed by Rapid Upper Limb Assessment (RULA). This study explored the optimum manual milling workstation design through an experimental work using full factorial design of Design of Experiment (DoE). Additionally the operators' requirements regarding manual milling workstation were captured using questionnaire survey and then transform to House of Quality (HOQ). Furthermore, five concepts of improved design of the workstation were sketched. They were screened through Pugh selection method based on practicability and cost effectiveness. Cost and benefit analysis (CBA) was used to evaluate the cost effectiveness of the screened concepts so that the final design also able to meet the entrepreneurial requirement. This study concluded that the new design of the workstation has improved the work posture and products quality. This study suggested that further investigation on excessive noise and vibration should be considered in the future research.

## **DEDICATION**

For my beloved family, academic supervisor, industrial supervisors, lecturers and friends that always believe in me to complete this project and report.



## **ACKNOWLEDGEMENT**

This report inevitably involves many Good Samaritan. Firstly, I am extremely thankful to my supervisor, Dr Isa bin Halim for all guidance, advices and critics that given to me during this project and also his scarification in time to coach and explain to me without a word of complaint. He had dedicated to provide me useful information and comments in completing the presentations and the reports.

Furthermore, I am also grateful and thanks to Associate Professor Dr. Lukman Sukarma for all the information in data analysis and Madam Indra Devi a/p M. Subramaniam in guiding me to improve my report in terms of language.

Thank and deeply indebted to all my friends whose involve in this project directly and indirectly. Their perpetual support keeps me going well when I were encountered obstacles.

Besides, I would like to thank my lovely family who always supporting and motivating me from far whenever I feel stress and depress. Thank you so much for giving me uncountable supports.

Lastly, I would like to thank Multi Precision Industries Sdn. Bhd. including all workers for providing me facilities, supportive information and the supports in completing this study.

# TABLE OF CONTENTS

<b>ABSTRAK</b>	i
<b>ABSTRACT</b>	ii
<b>DEDICATION</b>	iii
<b>ACKNOWLEDGEMENT</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF TABLES</b>	ix
<b>LIST OF FIGURES</b>	xi
<b>LIST ABRREVAITIONS, SYMBOLS AND NOMENCLATURES</b>	xv
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 Background of Study	1
1.2 Problem Statement	5
1.3 Objectives	12
1.4 Scope of Study	12
<b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 The Factors that Influence the Posture and the Product Quality in Manual Milling Operation	14
2.1.1 Human Factors	15
2.1.2 Machine Factors	16
2.1.3 Environmental Factors	16
2.1.4 Postures Practiced in Manual Milling Operation	17
2.1.5 Methods to Determine the Factors	18
2.1.5.1 Workplace Observations	18
2.1.5.2 Questionnaire Survey	19

2.1.5.3	Interview	22
2.1.5.4	Pilot Study	23
2.2	The Effects of Factors on the Posture and the Product Quality in Manual Milling Operation	23
2.2.1	Posture Assessment Methods	24
2.2.1.1	Rapid Upper Limb Assessment (RULA)	24
2.2.1.2	Rapid Entire Body Assessment (REBA)	26
2.2.1.3	Ovako Working posture Assessment System (OWAS)	27
2.2.1.4	Quick Exposure Check (QEC)	28
2.2.2	Design of Experiment (DoE)	30
2.3	Design the Workstation for Manual Milling Operation	32
2.3.1	Key Factors in the Design of Workstation	33
2.3.2	Methods in Designing the Workstation	34
2.3.2.1	Quality Function Deployment (QFD)	34
2.3.2.2	Concept Screening Method	36
2.3.2.3	Cost and Benefit Analysis (CBA)	36
2.3.3	Design Software	37
2.4	Differences between Previous Study and Current Study	38
2.5	Summary	39

## **CHAPTER 3 METHODOLOGY**

3.1	Determine the Risk Factors that Influence Dimensional Accuracy and the Posture in Manual Milling Operation	40
3.1.1	Interview	40
3.1.2	Workplace Observation	43
3.1.2.1	Lighting Test	47
3.1.3	Literature Review	51

3.1.4	Questionnaire Survey	52
3.2	Analysis of Effects of Risk Factors on Dimensional Accuracy and the Posture in Manual Milling Operation	57
3.2.1	Selection of Variables	57
3.2.1.1	Actual Experiment by using Full Factorial Design	58
3.2.2	Assessment of Working Posture	63
3.2.3	Data Analysis by using Design Expert <sup>®</sup> Software	67
3.3	Design the Workstation for Manual Milling Operation	70
3.3.1	House of Quality (HOQ)	70
3.3.2	Concept Screening Method (Pugh Method)	73
3.3.3	Cost and Benefit Analysis	75
3.3.4	Workstation Design by Using CATIA <sup>®</sup> Software	77
3.4	Summary	79

## **CHAPTER 4 RESULTS AND DISCUSSION**

4.1	Risk Factors at Manual Milling Operation Workstation	83
4.1.1	Interview	84
4.1.2	Workplace Observation	86
4.1.2.1	Lighting Test	87
4.1.3	Cronbach's Alpha Test of the Questionnaire Survey	88
4.1.4	Demographic Information of the Respondents	89
4.1.5	Risk Factors Associated with the Manual Milling Operation	92
4.2	Effects of Risk Factors on the Product Dimensional Accuracy and Safe Working Posture	93
4.2.1	Comfort Level using Current Manual Milling Operation Workstation	94
4.2.2	Working Posture Assessment	95
4.2.3	Experimental Results from Design of Experiment (DoE)	96

4.2.3.1	Descriptive Statistics	96
4.2.3.2	Analysis of Variance (ANOVA)	97
4.2.3.3	Optimization	103
4.3	Improved Design of Manual Milling Operation Workstation	104
4.3.1	Design Requirements of the Manual Milling Operation Workstation	104
4.3.2	House of Quality (HOQ)	106
4.3.3	Concept Screening	109
4.3.4	Cost and Benefit Analysis (CBA)	117
4.3.5	Final Design for the Improved Manual Milling Operation Workstation	118
<b>CHAPTER 5 CONCLUSION AND SUGGESTION FOR FUTURE STUDY</b>		
5.1	Risk Factors which Influenced Product Dimensional Accuracy and Working Posture	122
5.2	Effects of Risk Factors on the Working Posture and the Product Quality in Manual Milling Operation	123
5.3	Improved Design of the Manual Milling Operation Workstation	123
5.4	Recommendations for Future Study	123
5.5	Sustainable Design Development	124
<b>REFERENCES</b>		125
<b>APPENDICES</b>		

## LIST OF TABLES

<b>Table 2.1:</b> Common postures practiced in manual milling operation	17
<b>Table 2.2:</b> Rule of thumb for various degree of reliability	20
<b>Table 2.3:</b> Rapid Upper Limb Assessment (RULA) levels and indications.	25
<b>Table 2.4:</b> Differences between previous studies and current study	38
<b>Table 3.1:</b> Data collection sheet of dimension A	61
<b>Table 3.2:</b> Data collection sheet of dimension B	61
<b>Table 3.3:</b> Data collection sheet of dimension C	62
<b>Table 3.4:</b> Summary of factorial design	62
<b>Table 3.5:</b> Data sheet for anthropometry data of the operators	66
<b>Table 3.6:</b> Data collection sheet of RULA score	66
<b>Table 3.7:</b> Customer requirements based on relative importance	71
<b>Table 3.8:</b> The translation of customer requirements to VOE	71
<b>Table 3.9:</b> Key to interrelationships matrix symbols	72
<b>Table 3.10:</b> Key to correlations matrix symbols for roof	72
<b>Table 3.11:</b> Concept screening matrix	74
<b>Table 3.12:</b> Rating symbols used in screening method	74
<b>Table 4.1:</b> Designation and gender categories	90
<b>Table 4.2:</b> Age group	90
<b>Table 4.3:</b> Nationality	90
<b>Table 4.4:</b> Height	91
<b>Table 4.5:</b> Weight	91
<b>Table 4.6:</b> Working experience in manual milling operation	91
<b>Table 4.7:</b> Education level	91
<b>Table 4.8:</b> Comfort levels at the existing manual milling operation workstation	94
<b>Table 4.9:</b> Descriptive statistics of work piece dimensions and RULA score	97
<b>Table 4.10:</b> ANOVA of the responding variables	100

<b>Table 4.11:</b> The importance ratings of the design features	106
<b>Table 4.12:</b> Customer requirements regarding manual milling workstation	107
<b>Table 4.13:</b> Concept screening matrix	110
<b>Table 4.14:</b> Assumptions of cost elements for the alternatives	117
<b>Table 4.15:</b> Results of cost and benefit analysis	118

## LIST OF FIGURES

<b>Figure 1.1:</b> Steel plates after squaring process in manual milling operation	3
<b>Figure 1.2:</b> Operator performs manual milling operation	4
<b>Figure 1.3:</b> Operators perform the manual milling operation in awkward posture	6
<b>Figure 1.4:</b> The causes of inaccurate product dimension and awkward posture in manual milling operation	7
<b>Figure 1.5:</b> Pareto chart of the risk factors	11
<b>Figure 1.6:</b> Vertical-spindle column-and-knee-type milling machine	13
<b>Figure 2.1:</b> Nordic questionnaire	21
<b>Figure 2.2:</b> RULA worksheet	24
<b>Figure 2.3:</b> RULA analysis using CATIA software	25
<b>Figure 2.4:</b> REBA scoring sheet	26
<b>Figure 2.5:</b> OWAS questionnaire body mapping	27
<b>Figure 2.6:</b> Quick Exposure Check (QEC) sheet	29
<b>Figure 2.7:</b> Score interpretation	30
<b>Figure 2.8:</b> Key factors in designing the workstation	34
<b>Figure 2.9:</b> Outline of the structure of House of Quality (HOQ)	35
<b>Figure 3.1:</b> Interview with Mr. Khoo Weng Hong–Supervisor of advanced metal cutting section	41
<b>Figure 3.2:</b> Flow chart of the interview process	42
<b>Figure 3.3:</b> Visitor Pass of Multi Precision Industries Sdn. Bhd.	43
<b>Figure 3.4:</b> Manual milling operation workstation in MPI	44
<b>Figure 3.5:</b> Warehouse for raw materials	44
<b>Figure 3.6:</b> Lighting condition at the manual milling section in MPI	44
<b>Figure 3.7:</b> Pallet for placing raw material	45
<b>Figure 3.8:</b> Measuring the dimensions of the milling machine	45
<b>Figure 3.9:</b> Flow chart of the workplace observation	46
<b>Figure 3.10:</b> Standard lighting level in metal working and processing sectors	47



<b>Figure 3.11:</b> Layout of lighting measuring points	48
<b>Figure 3.12:</b> Measuring the lighting level by using the Foot Candle Meter	49
<b>Figure 3.13:</b> Standardized measuring distance for lighting test	49
<b>Figure 3.14:</b> Measuring the distance of the measuring points by using meter rule and marked by using paint marker	50
<b>Figure 3.15:</b> Data collection sheet for lighting test	50
<b>Figure 3.16:</b> Science Direct website	51
<b>Figure 3.17:</b> Google Scholar	51
<b>Figure 3.18:</b> Affinity Diagram template	52
<b>Figure 3.19:</b> Conducting questionnaire survey with the operator	53
<b>Figure 3.20:</b> Setup in Minitab® software	54
<b>Figure 3.21:</b> Item analysis is used to perform Cronbach's alpha test	55
<b>Figure 3.22:</b> Item analysis window to select variables that need to be analysed	55
<b>Figure 3.23:</b> Flow chart of preparation questionnaire survey	56
<b>Figure 3.24:</b> Specimen of the experiment	58
<b>Figure 3.25:</b> Operator with height of 160 cm performing manual milling operation	59
<b>Figure 3.26:</b> Operator with height of 180 cm performing manual milling operation	59
<b>Figure 3.27:</b> Experiment with extra lighting	60
<b>Figure 3.28:</b> Experiment with magnifying glass for clearer display	60
<b>Figure 3.29:</b> Measuring the specimen with Vernier calliper	60
<b>Figure 3.30:</b> Measuring the anthropometry data of the operator	63
<b>Figure 3.31:</b> Manikin in measurement editor	64
<b>Figure 3.32:</b> Manikin in human builder	64
<b>Figure 3.33:</b> RULA score for left side	65
<b>Figure 3.34:</b> RULA score for right side	65
<b>Figure 3.35:</b> Selection of number of factors with number of experiment	67
<b>Figure 3.36:</b> Naming the independent variables	68
<b>Figure 3.37:</b> Naming the dependent variables	68
<b>Figure 3.38:</b> Table of data	68
<b>Figure 3.39:</b> Flow chart of data analysis	69
<b>Figure 3.40:</b> House of Quality (HOQ) Matrix	73

<b>Figure 3.41:</b> Cost elements of the proposed alternatives	75
<b>Figure 3.42:</b> Spreadsheets of NPW analysis	76
<b>Figure 3.43:</b> Technical drawing of the milling machine	77
<b>Figure 3.44:</b> Flow chart of the design process	78
<b>Figure 3.45:</b> Flow chart of the summary of methodology	82
<b>Figure 4.1:</b> Affinity diagram obtained from interview	85
<b>Figure 4.2:</b> Operator performing manual milling operation	86
<b>Figure 4.3:</b> Fluorescent light at top of the manual milling operation workstation	87
<b>Figure 4.4:</b> Collected lighting level in current manual milling operation workstation	88
<b>Figure 4.5:</b> Cronbach's alpha result of section B	89
<b>Figure 4.6:</b> Cronbach's alpha result of section D	89
<b>Figure 4.7:</b> Risk Factors Associated with the Manual Milling Operation	93
<b>Figure 4.8:</b> RULA score and the operator's working posture (left side)	95
<b>Figure 4.9:</b> RULA score and the operator's working posture (right side)	95
<b>Figure 4.10:</b> Half normal plot of Dimension A	98
<b>Figure 4.11:</b> Half normal plot of Dimension B	98
<b>Figure 4.12:</b> Half normal plot of Dimension C	99
<b>Figure 4.13:</b> Half normal plot of RULA score	99
<b>Figure 4.14:</b> Optimization results from Minitab® software	104
<b>Figure 4.15:</b> House of Quality (HOQ)	108
<b>Figure 4.16:</b> Concept A	111
<b>Figure 4.17:</b> Concept B	112
<b>Figure 4.18:</b> Concept C	113
<b>Figure 4.19:</b> Concept D	114
<b>Figure 4.20:</b> Concept E	115
<b>Figure 4.21:</b> Final conceptual sketching of the improved manual milling operation workstation	116
<b>Figure 4.22:</b> New design of manual milling operation workstation	119
<b>Figure 4.23:</b> Detailed drawing of the magnetic based adjustable lamp	120
<b>Figure 4.24:</b> Detailed drawing of the magnetic based magnifying glass with light	120

<b>Figure 4.25:</b> RULA score (left side) of the operator working in the improved design of the manual milling operation workstation	121
<b>Figure 4.26:</b> RULA score (right side) of the operator working in the improved design of the manual milling operation workstation	121

## **LIST ABBREVAITIONS, SYMBOLS AND NOMENCLATURES**

GDP	-	Gross development product
CNC	-	Computer numerical control
NC	-	Numerical control
MPI	-	Multi Precision Industries Sdn. Bhd.
WMSDs	-	Work related musculoskeletal disorders
PPE	-	Personal protective equipment
WELS	-	Workplace exposure limit
FKP	-	Fakulti Kejuruteraan Pembuatan, UTeM
UTeM	-	Universiti Teknikal Malaysia Melaka
RULA	-	Rapid upper limb assessment
REBA	-	Rapid entire body assessment
OWAS	-	Ovako working posture assessment system
NBM	-	Nordic body map
QEC	-	Quick exposure check
DoE	-	Design of experiment
ANOVA	-	Analysis of variance
QFD	-	Quality function deployment
HOQ	-	House of quality
QC	-	Quality characteristics
CR	-	Customer requirements
CBA	-	Cost and benefit analysis
NPW	-	Net present worth
NPV	-	Net present value
cm	-	Centimetre
mm	-	Millimetre

m	-	meter
kg	-	kilogram
®	-	Registered
™	-	Trademark
SPSS	-	Statistical package for social science
Lux	-	Luminance flux
VOE	-	Voice of engineers
VOC	-	Voice of customers
ISO	-	International Standard Organization

# **CHAPTER 1**

## **INTRODUCTION**

This chapter presents the background of the study, problem statements, objectives of the study, and the scope of study. The background of the study is focused on the working principles of manual milling operation and various risk factors associated with this operation. The problem statements reveal the impacts of different risk factors to the operators of manual milling operation. In the objectives, the intention of this study is to propose a design of the workstation for improving the quality of the milled product in line with reduced the impacts of various risk factors. At the end of this chapter, the scope of the study highlights the focus and limitations of the study.

### **1.1 Background of Study**

Accordingly for Malaysia (1991, 2000, 2006), the Malaysian Gross Domestic Product (GDP) had developed a standard development rate of 6.7% during 1971 to 1990, meanwhile during 1990 to 1999 and 2001 to 2005, Malaysia achieved a record of development rate where respectively 8.1% and 4.5% per annum. Malaysia was recognized one of the most active in reforming their investment management in manufacturing market among the ASEAN, especially during the 1980s and 1990s. The most significant and remarkable strategy of the Malaysian had successfully spur Malaysia's economic growth by attracting foreign direct investment (FDI) and partially was credited to its own trade. Manufacturing sector had become a part of major growth for Malaysian economy since the late of 1970s. The export earnings of the sector contributed 80.5% of the total export earnings in 2005, it was

approximately 31.4% of the Malaysian GDP (Chandran *et al.*, 2009). Hence, the contribution of manufacturing sectors is highly significant to the growth of Malaysian economy.

The fundamental idea of manufacturing processes is to create or transform the raw materials into useful products with a predetermined set of physical geometry. There are various manufacturing processes such as moulding, casting, joining, machining and so on while sharing a common set of goals. The goals of these processes are to meet the performance requirements in term of tolerance and the production cost. Moreover, the goals also have been set to reproduce with constant quality in mass production and have consistent material properties throughout the manufacturing processes.

In machining process, a product is created to its desired dimensions by removing excess material of a work piece via a force exerted through a certain material removal tool (Kalpakjian, 2008). Milling operation and turning operation are both common machining processes where milling and turning operation are applied in rectangular work piece and cylindrical work piece respectively. Milling operation is very versatile where it can be used for drilling, boring, producing slot, pocketing, chamfering, facing, squaring and others applications. Basically, milling machine is divided into Computer Numerical Control (CNC) and manual control. CNC milling machine uses Numerical Control (NC) codes in controlling the positions of the cutting tools while manual milling machine is a type of conventional milling operation operated by the human operators. Manual milling machines still widely used in many industries though CNC milling machines show high efficiency in productivity and quality because manual milling operation able to perform simple operations such as squaring process and chamfering process to reduce the lead time of the overall production.

Figure 1.1 shows the steel plates being processed by manual milling operation. The steels plates are cut into pieces by the plasma cutter then follow by squaring process by manual milling operation. Figure 1.2 shows that an operator is performing the manual milling operation by using vertical-spindle column-and-knee-type milling machine.



**Figure 1.1:** Steel plates after squaring process in manual milling operation  
(Source: Multi-Precision Industries Sdn. Bhd., 2015)