



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**Ergonomic Intervention to Reduce the Risk of
Musculoskeletal Disorders (MSDs) for Manual
Materials Handling Tasks**

Thesis submitted in accordance with the partial requirements of the Universiti
Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering
(Manufacturing Process)

By

Lai Huey Shy

Faculty of Manufacturing Engineering

May 2008



UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

BORANG PENGESAHAN STATUS TESIS*

JUDUL: ERGONOMIC INTERVENTION TO REDUCE THE RISK OF MUSCULOSKELETAL DISORDERS (MSDs) FOR MANUAL MATERIALS HANDLING TASKS

SESI PENGAJIAN : 2007/2008

Saya LAI HUEY SHY

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka .
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:
69, JALAN PERDANA 2, TAMAN
PERDANA RAYA, 28600
KARAK, PAHANG

Cop Rasmi:

Tarikh: **25 MARCH 2008**

Tarikh: _____

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process). The members of the supervisory committee are as follow:




ISA BIN HALIM
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

Mr Isa Bin Halim

(Official Stamp & Date)

DECLARATION

I hereby, declare this thesis entitled “Ergonomic Intervention to Reduce the Risk of Musculoskeletal Disorders (MSDs) for Manual Materials Handling Tasks” is the result of my own research except as cited in the references.

Signature : 

Author's Name : LAI HUEY SHY

Date : 25 MARCH 2008

ABSTRACT

This project presents the application of ergonomic intervention to reduce the risk of musculoskeletal disorders (MSDs) for manual materials handling tasks. Malaysia is one of the rapidly industrializing country in Asia region but it also faced challenges of the risk of MSDs. This is due to lack of attention on safety awareness in workplace. The major risk factors for MSDs are heavy manual material handling, repetitive tasks and awkward working postures. Since the manual materials handling tasks are contributed to the risk of MSDs, therefore this project was conducted to reduce the risk of musculoskeletal disorders for manual materials handling tasks by using RULA and Revised NIOSH Lifting Equation. The results found that MSDs experienced by the worker are caused by manual materials handling tasks. Then, ergonomics intervention approach was used to propose the materials handling devices and workstation design for safe working condition. Two materials handling devices and two new workstations have been designed by using CATIA software. Lastly, the effectiveness of the proposed design for working posture had been evaluated by using RULA analysis, however lifting limits are assessed by using Revised NIOSH Lifting Equation. From the evaluation, it can be concluded that the proposed design is capable to reduce the risk of MSDs for manual materials handling tasks in manufacturing industry.

ABSTRAK

Tesis ini menyampaikan aplikasi ergonomik untuk mengurangkan risiko musculoskeletal disorders (MSDs) ketika kerja pengendalian barangan secara manual. Malaysia adalah Negara yang membangun dengan pesat di dalam sektor perindustrian tetapi ia masih menghadapi risiko MSDs. Ia adalah kerana pekerja-pekerjanya di kilang-kilang masih tidak menyedari kepentingan keselamatan di tempat kerja. Kecenderungan risiko yang menyebabkan MSDs ialah kerja pengendalian barangan yang berat secara manual, kerja-kerja yang berulang-ulang dan postur kerja yang tidak sesuai. Oleh itu, kerja pengendalian barangan secara manual telah dikenalpasti menyumbang risiko MSDs. Projek ini telah dikendalikan untuk mengurangkan risiko MSDs bagi kerja pengendalian barangan dengan tangan dengan mengaplikasikan pengendalian ergonomik. Penilaian telah dikendalikan untuk mengenal pasti risiko MSDs yang telah dialami oleh pekerja yang terlibat dengan pengendalian barangan secara manual. Selain itu, dua alat pengendalian barangan dan dua tempat kerja yang baru telah direkabentuk dengan menggunakan perisian CATIA. Akhirnya, keberkesanan postur (angkat atau letak) pekerja telah dinilai dengan menggunakan RULA, manakala cara pengendalian barangan telah dinilai dengan menggunakan Revised NIOSH Lifting Equation. Hasil penilaian tersebut, ianya boleh disimpulkan bahawa rekabentuk yang telah dicadangkan adalah mampu mengurangkan risiko MSDs untuk kerja pengendalian barangan secara manual di industri pembuatan.

DEDICATION

For my beloved family and friends who always encourage and give me all the support that I really need during accomplish this thesis.

ACKNOWLEDGEMENTS

I wish to acknowledge and express my deepest gratitude and appreciate to my supervisor, Mr Isa Bin Halim for his continuously guidance, supported, suggestion and assistance through the project. Besides, the greatest thanks should goes to Miss Lau Fei Fei for the permission and ample opportunity to facilitate fruitful case study in Maynaisteel Sdn. Bhd.

TABLE OF CONTENTS

Abstract.....	i
Abstrak.....	ii
Dedication.....	iii
Acknowledgement.....	iv
Table of Contents.....	v
List of Figures	x
List of Tables.....	xiii
List of Abbreviations, Symbols, Specialized Nomenclature.....	xiv
1. INTRODUCTION	1
1.1. Background of Study	1
1.2. Problem Statement	4
1.3. Project Objectives.....	5
1.4. Scope and Limitation of Project	7
1.5. Potential Benefits from the Project.....	8
1.5.1. Benefits to Industry.....	8
1.5.2. Benefits to University	9
1.5.3. Benefits to Student.....	9

2. LITERATURE REVIEW	10
2.1. Implementation of Ergonomics Interventions to Prevent Musculoskeletal Disorder.....	10
2.2. Effectiveness of Health and Safety Interventions in the Workplace	12
2.3. Method and Tools Used for Ergonomic Study.....	13
2.4. Design Recommendations for A Complex Manual Materials Handling Activity.....	17
2.5. Low Cost Work Improvements That Can Reduce The Risk of Musculoskeletal Disorders.....	19
2.5.1. Action Taken to Reduce Musculoskeletal Loads.....	20
2.5.2. Promoting Support for Similar Low Cost Improvements.....	25
2.6. The Psychophysical Approach to Risk Assessment in Work-Related Musculoskeletal Disorders.....	26
2.7. Biomechanical Models in High Exertion Manual Material Handling Jobs...27	
2.8. The Impact on MSDs of Changing Physical and Psychosocial Work Environment Conditions in the Automobile Industry.....	28
3. METHODOLOGY	29
3.1. Identification of Relevant Case Study.....	29
3.2. Phase 1: Investigation the Risk of Musculoskeletal Disorders (MSDs) Experienced By the Workers	30
3.3. Phase 2: Redesign the Current Manual Materials Handling Devices and Workstation for Occupational Health Improvement.....	34
3.4. Phase 3: Evaluate the Effectiveness of the Proposed Solution.....	40

3.5. Summary of Methodology.....	40
4. CASE STUDY.....	42
4.1. Identification of MSDs associated with MMH Tasks	42
4.2. Description of Case Study.....	43
4.2.1. Description of Case Study One: Transferring A Steel Plate to CNC Machine.....	43
4.2.2. Description of Case Study Two: Carrying Materials.....	44
4.2.3. Description of Case Study Three: Polishing of Precision Mold.....	46
4.2.4. Description of Case Study Four: Mold Manipulation.....	47
5. RESULTS.....	48
5.1. Identification of MSDs Associated with MMH Tasks	48
5.2. Results of Existing Condition for Each Case Study.....	53
5.2.1. First Assessment : Evaluation the Existing Working Posture.....	53
5.2.1.1. Result of Bending Posture For Case Study One.....	56
5.2.1.2. Result of Carrying Materials for Case Study Two.....	59
5.2.1.3. Result of Polishing of Precision Mold for Case Study Three.....	61
5.2.1.4. Result of Mold Manipulation for Case Study Four.....	63
5.2.2. Second Assessment: Evaluation of Existing Lifting Limits.....	65
5.2.2.1. Result of Lifting Index for Case Study One.....	65
5.2.2.2. Result of Lifting Index for Case Study Two.....	66

5.2.3. Improvement on Redesign of Material Handling Device & Workstation	67
5.2.3.1. Proposed Design One: Scissor Lifting Table.....	68
5.2.3.2. Proposed Design Two: Manual Roller Conveyor.....	69
5.2.3.3. Proposed Design Three: Redesign Workstation.....	70
5.2.3.4. Proposed Design Four: Adjustable Workstation.....	71
5.3. Evaluation of the Effectiveness of Proposed Solution.....	72
5.3.1. First Assessment : Result of Working Posture After Improvement...	72
5.3.1.1. Result of Working Posture for Case Study One	73
5.3.1.2. Results of Carrying Materials for Case Study Two.....	76
5.3.1.3. Result for Case Study Three	78
5.3.1.4. Result for Case Study Four.....	80
5.3.2. Second Assessment : Results of Lifting Limits After Improvement..	82
5.3.2.1. Result of Lifting Index for Case Study One	82
5.3.2.2. Result of Lifting Index for Case Study Two.....	83
5.3.3. Comparison Results of Before and After Proposed Solutions.....	84
6. DISCUSSION.....	88
6.1. Identification of MSDs Experienced by the Workers.....	88
6.2. Assessment of Working Posture and Lifting Limits at Existing Working Condition and Redesign for Improvement	89
6.2.1. Redesign of Materials Handling Device and Workstation	92

6.3. Evaluation the Effectiveness of the Proposed Solutions	94
---	----

7. CONCLUSION & RECOMMENDATION FOR FUTURE

WORK	97
-------------------	----

7.1. Identification of MSDs Associated with MMH Tasks.....	97
--	----

7.2. Redesign the Material Handling Device and Workstation for Working Posture and Lifting Improvement.....	98
--	----

7.3. Evaluation the Effectiveness of the Proposed Solutions.....	99
--	----

7.4. Recommendation for Future Work.....	100
--	-----

REFERENCES	101
-------------------------	-----

APPENDICES

- A RULA Score System
- B Assessment of Worker in Bending Posture

LIST OF FIGURES

2.1	Lumbar Motion Monitor	16
2.2	Number of Musculoskeletal overexertion injuries and Bureau of Labor Statistics Incidence Rates Manufacturing Industry.	18
2.3	Proportion of Injuries by Part of Body Injured	18
3.1	A Blank Form of ISA Risk Factor Reporting Form	32
3.2	Nordic Questionnaire	33
3.3	Selecting of RULA analysis in CATIA	35
3.4	Data Input for Lifting Task by Using Revised NIOSH Lifting Equation	37
3.5	Manual Trolley	39
3.6	Summarization of Methodology Adopted in the Project	41
4.1	A worker lifts a steel plate from a pallet	44
4.2	A worker is carrying a mold part from polishing workstation	45
4.3	A worker is putting a mold to another table	45
4.4	The worker is doing finishing process	46
4.5	The worker is turning over the mold with unstable working posture	47
5.1	Isa Risk Factors Reporting Form for the Observation of MMH Tasks	51

5.2	Nordic Questionnaire used to determine MSDs	52
5.3	Anthropometry Data of Workers are incorporated into CATIA Software	54
5.4	Analysis of working posture while worker placed the metal into trolley	57
5.5	Result of RULA Analysis for Bending Posture	58
5.6	Analysis of carrying task using RULA while worker is carrying the metal	59
5.7	Detail result of carrying task for metal transfer	60
5.8	Analysis of working posture while the worker performing polishing process	61
5.9	Detail result of static posture for polishing task	62
5.10	Analysis of working posture while worker apply excessive force to manipulate the mold.	63
5.11	Detail result of working posture for excessive force	64
5.12	Data inputs	65
5.13	Task multipliers, FIRWL, STRWL, FILI and STLI for each task	65
5.14	Composite lifting index for the job	66
5.15	Data inputs	66
5.16	Task multipliers, FIRWL, STRWL, FILI and STLI for each task	67
5.17	Composite lifting index for the job	67
5.18	Scissor Lifting Table	68
5.19	Manual roller conveyor	70
5.20	New workstation	71
5.21	Adjustable workstation	72
5.22	Lifting posture by using an adjustable scissor table	74

5.23	Result of RULA Analysis for Lifting Posture	75
5.24	Analysis of carrying task	76
5.25	Detail result of carrying task for metal transfer	77
5.26	Analysis of working posture at new workstation	78
5.27	Detail result of working posture for polishing task	79
5.28	Analysis of mold manipulation tasks in adjustable workstation	80
5.29	Result of working posture while manipulating a mold	81
5.30	Data inputs	82
5.31	Task multipliers, FIRWL, STRWL, FILI and STLI for each task	82
5.32	Composite lifting index for the job	82
5.33	Data inputs	83
5.34	Task multipliers, FIRWL, STRWL, FILI and STLI for each task	83
5.35	Composite lifting index for the job	84
5.36	Line Chart to show the comparison of RULA Score	86
5.37	Line chart to show the comparison of LI value	87
6.1	Comparison of RULA score for working posture in bar chart	95
6.2	Comparison of LI value for lifting limits tasks in bar chart	96

LIST OF TABLES

2.1	Examples of Action Taken to Reduce Musculoskeletal Loads in Different Industries	20
2.2	Improvements of Musculoskeletal Loads in Typical Improvement	24
5.1	Anthropometry Data of Two Particular Workers	55
5.2	Input Data for RULA	56
5.3	Input Data for RULA	73
5.4	Results of RULA Score on Before and After Proposed Solutions	85
5.5	Results of Lifting Index for Before and After Proposed Solutions	86

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

SMIs	-	Small and Medium Industries
MSDs	-	Musculoskeletal Disorders
NIOSH	-	National Institute of Occupational Safety and Health
RULA	-	Rapid Upper Limb Assessment
RWL	-	Recommended Weight Limit
LI	-	Lifting Index
REBA	-	Rapid Entire Body Assessment
LBP	-	Low Back Pain
LMM	-	Lumbar Motion Monitor
EMG	-	Electromyography
SNQ	-	Standardized Nordic Questionnaire
STLI	-	Single-Task Lifting Index
MMH	-	Manual Material Handling
Mm	-	Milimeter
Min	-	Minute
S	-	Second
Kg	-	Kilogram

CHAPTER 1

INTRODUCTION

Chapter one describes the overall background of this project. The scope of this project is focused in Malaysian Small and Medium Industries (SMIs). The content of this chapter includes background and problem statement, project objectives, Scope and limitation of project, and potential benefits from the project.

1.1 Background of Study

Ergonomic risk factors are the aspects of a job or task that impose a biomechanical stress on worker. Ergonomic risk factors are the synergistic elements of musculoskeletal disorders (MSDs) hazards. The following ergonomic risk factors are most likely to cause or contribute to the MSDs such as force, vibration, repetition, contact stress, awkward postures, extreme temperatures and static postures. The term musculoskeletal disorders (MSDs) refers to conditions where the worker who had experienced discomforts or injuries of neck, shoulder, lower back, and elbow, hand, hip and knee, as well as multiple joints manifesting ache, tingle, swelling and pains. However, workstation analysis is useful to identify all risk factors present in the workstation. The analysis includes the checking of excessive vibration of tools, tools, working level should be adjusted to worker and working postures and movements in the workstation should be assessed for four levels of risk.

Over the last four decades, ergonomic researches and practitioners have devoted considerable resources to solve the problems associated with manual materials handling (MMH). Almost a broad consensus also agreed that manual lifting is physically the most stressful material handling activity because it is best to contain the manual lifting injury hazard. Results of such efforts are reflected in terms of various guidelines and weight limit recommendations for manual lifting activities.

Musculoskeletal disorders (MSDs) were recognized as having occupational etiologic factors as early as the beginning of the 18th century. Work and activity-related musculoskeletal disorders (WMSD) have a complex multifactorial etiology including not only the physical aspects of the activities that people perform but also the psychosocial aspects. These disorders may involve muscular, tendinous, ligamentous, nervous tissues and include both acute as well as chronic onset. A number of sources of information ranging from biomechanics, epidemiology, and clinical case series have identified a number of major risk factors associated with development of upper limb musculoskeletal disorders. These include forcefulness, adverse posture, repetition or continuous activity, angular velocity and acceleration, or joints and duration of exposure.

Manual materials handling is defined as transporting or supporting a load, by one or more workers, including lifting, lowering, pushing, carrying, or moving a load, which, by reasons of its characteristic or unfavorable ergonomics condition, involves a risk, particularly back pain to workers (Odile, H.L.R.et al., 1999). In other words, manual materials handling can be defined as the unaided moving of objects, often combined with body twisting and awkward postures, and these conditions will contribute to musculoskeletal disorders (MSDs). Previous study had shown manual materials handling, activities such as lifting, carrying, pushing, and pulling represent an occupational risk factors that has to be confined within safe limits. Hence,

ergonomic intervention is required to ensure a worker performs the task safely and comfortably. In ergonomics study, there are various interventions that can be introduced to improve working condition. The aim of this intervention is to create and establish a safe working condition in the work environment.

However, despite these pervasive efforts to contain the hazards of manual material handlings the cost, number, and severity of injuries has either continued to grow or remains unchanged, at least in the United States. The majority of industrial manual materials handling jobs include more than one handling activity. It has been presumed that manual lifting activity limits a person's ability to perform manual materials handling activities. The complex manual materials handling task, which involved lifting, turning, carrying, and pushing activities, was also analyzed using both the old and Revised NIOSH Lifting Guidelines 1981 (Waters et al.,1993).

Manual handling of loads has been associated with shoulder disorders in some studies. It found a higher prevalence (13%) of recurrent shoulder pain for letter carriers than for meter readers (7%) and postal clerks (5%). The maximum bag weight of the letter carriers was 11.4 kg. Letter carries whose maximum bag weight had been increased by 4.4 kg had a prevalence of 23% of recurrent shoulder pain. A study was determined life-long lifting as lifted tonnes, and found an increased risk of radiographically assessed osteoarthritis of the acromioclavicular point joint for 710 to 26000 tonnes and an even higher risk for more than 26000 tonnes. This means that an exposure-response relationship was also found for lifted load and acromioclavicular joint for arthrosis. Unfortunately, it is not known whether intensive lifting for a short period is associated with a different risk than less intensive lifting for a longer period. It should also be noted that the data on lifting were based on questionnaires and interviews with no assessment of validity.

1.2 Problem Statement

The most common form of occupational ill-health in many of today's industrialized nations is musculoskeletal disorders (MSDs) that related with manual material handling tasks. Manual materials handling activities and workstation design are the main causes for the joint pains, nerve entrapment problems, sprains and strains, and sometimes chronic and acute injuries in the body parts such as hands, wrists, arms, neck and back. In 2002, MSDs accounted for 487, 900 (34%) of injuries and illnesses in the US involving days away from work, at an estimated cost of around \$2 billion annually (BLS, 2004). These problems minimize capabilities and capacities of the workers and thus negatively affect their health as well as productivity. Worker's compensation losses associated with manual materials handling is one of the most significant loss in many industry sectors (Z.Whysall, 2006).

The magnitude of the problem of work related musculoskeletal disorders is now widely documented. In the UK, these conditions form the largest category of work related ill health, with estimates for 1995 suggesting 1.2 million individuals experienced a musculoskeletal condition (HSC, 1998). Besides, there is a significant number of workers do suffer from repetitive motion injuries, as well as overexertion due to heavy lifting. The effects of overexertion in MMH activities can be short term or long term, depending upon the intensity of such activities and physical capabilities of the individuals involved. Short-term effects include sprain or muscle fatigue. Long term effects include low-back pain and accelerated disc degeneration, among other musculoskeletal disorders. That injuries resulting from MMH are not uncommon can be grasped from the fact that they now cost the United States over 150 billion dollars annually (Mital et al., 1997).

However, the risk of musculoskeletal disorders can be prevented or greatly reduced

by complying with existing safety and health law and following guidance on good practice. Unfortunately, MSDs are an increasing problem. This increasing will affects employee, employer and even government. For the employee, they cause personal suffering and loss of income. However, the employer is reducing business efficiency. Moreover, the government is increase social security costs.

1.3 Project Objectives

Manual materials handling tasks involved more than one type of activity (lifting, pushing, carrying, etc.). Manual materials handling require workers to handle the materials in good condition and avoid injuries. However, the lack of awareness of ergonomic and healthy issue among the workers had lead them under the risk of occupational diseases that may affect their health.

Specifically the project tries to achieve the following objectives:

- a) To identify the musculoskeletal disorders (MSDs) experienced by the particular worker who perform manual materials handling tasks.

This project tries to investigate the MSDs experienced by the workers while they performing manual materials handling activities in Malaysian Small and Medium Industries (SMIs). The activity of workers will be analyzed to determine whether they perform the MMH safe or not. Ergonomics risk factor is synergistic elements that contribute to MSDs hazards. Apart from that, workers will be interviewed to obtain the MSDs experienced by them such as injuries of neck and lower back pains.

- b) To redesign the material handling device and workstation for working posture and lifting improvement of workers.

Four designs will be proposed in order to reduce the risk of MSDs in the workplace. Redesign the workstation can be used to reduce the MSDs due to unsafe working condition. The principle of anthropometrics is applied to the design so that it can enhance human comfort and productivity. However, redesign a manuals material lifting devices are need in order to reduce the MSDs due to the awkward posture while lifting objects.

- c) To evaluate the effectiveness of the proposed solutions.

The solutions have been proposed will be evaluated to determine the effectiveness of them. The positive results may enhance the occupational health and reduce the MSDs experienced by the workers thus increase the production rate.