ERGONOMICS ASSESSMENT AND INTERVENTION FOR HANDWHEEL VALVES OPERATION PROCESS

by

KHALEEL MAHMOUD HAMMOUD ALDMOUR
(1832422263)

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School of Manufacturing Engineering
UNIVERSITI MALAYSIA PERLIS

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Say: My Lord! “Increase me in knowledge.”

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LIST OF ABBREVIATIONS

ART	Assessment of Repetitive Tasks
CTDs	Cumulative Trauma Disorders
DUE	Distal Upper Extremity
DUEMSDs	Distal Upper Extremities Musculoskeletal Disorders
EMG	Electromyography
ERF	Ergonomics Risk Factor
ERFs	Ergonomics Risk Factors
IJC	Indo-Jordan Chemicals Company
JSI	Job Strain Index
MAC	Manual Handling Assessment Chart
MSDs	Musculoskeletal Disorders
NMQ	Nordic Musculoskeletal Disorders
OCRA	Occupational Repetitive Action
OWAS	Ovako Working Posture Analysis System
REBA	Rapid Entire Body Assessment
ROSA	Rapid Office Strain Assessment
RPE	Rating of Perceived Exertion
RULA	Rapid Upper Limb Assessment
WMSDs	Work-related Musculoskeletal Disorders

LIST OF SYMBOLS

I	Intensity of Exertion
D	Duration per Exertion
E	Efforts per Minute
P	Hand/Wrist Posture
DD	Duration of Task per Day
IM	Intensity of Exertion Multiplier
EM	Efforts per Minute Multiplier
DM	Duration per Exertion Multiplier
PM	Hand/Wrist Posture Multiplier
HM	Duration of Task per Day Multiplier
FIRSI	Frequency Independent

PENILAIAN ERGONOMIK DAN INTERVENSI BAGI PROSES OPERASI INJAP TANGAN RODA DI KALANGAN OPERATOR LOJI

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji, menilai dan memperbaiki kesan-kesan operasi injap tangan roda dalam industri kimia. Aktiviti ini adalah suatu aktiviti fisikal yang memerlukan operator-operator loji mengenakan daya yang tinggi secara berulang dalam postur yang janggal. Pendedahan berterusan kepada aktiviti-aktiviti ini menyumbang kepada peningkatan aduan-aduan dan terhasilnya masalah-masalah MSD. Dalam kajian ini, kaedah-kaedah Ergonomics Risk Assessment (ERA) seperti Nordic Musculoskeletal Questionnaire (NMQ), senarai-senarai semak awal ERA, Rapid Entire Body Assessment (REBA), penilaian skala Borg Rating of Perceived Exertion (RPE), Revised Strain Index (RSI) dan Composite Strain Index (COSI) telah digunakan. Sejumlah 49 operator loji lelaki daripada pelbagai kerakyatan (Jordan, India, Mesir) dan pelbagai julat usia dari 22-52 tahun dan juga 35 injap pada pelbagai julat ketinggian (17 cm, 224 cm), arah (menegak, mendatar), dan saiz diameter (10.8 cm, 43 cm) telah digunakan dan diapplikasikan dalam kajian ini. Keputusan kaedah ERA menunjukkan bahawa faktor-faktor risiko postur yang janggal berserta pengenaan daya berlebihan oleh operator semasa proses menggerakkan injap tangan roda mendedahkan operator-operator loji kepada risiko MSDs tahap tinggi. Keputusan NMQ menunjukkan yang kebanyakan bahagian badan yang terkesan di kalangan operator loji adalah pergelangan kaki, bahagian atas dan bawah belakang badan, tangan dan bahu manakala Borg RPE pula menunjukkan yang keamatan daya yang dikenakan adalah 9.28, 6.51, 3.77 dan 8.93 bagi injap tangan roda masing-masing pada ketinggian dari tanah ke lutut, lutut ke pinggang, pinggang ke bahu dan atas bahu. Bagi kaedah REBA, tahap risiko MSDs direkodkan di antara 9-11, 5-11, 5-7 dan 6-10 bagi injap-injap tangan roda masing-masing pada ketinggian dari tanah ke lutut, lutut ke pinggang, pinggang ke bahu dan atas bahu. Untuk kaedah-kaedah RSI dan COSI, hasil kajian menunjukkan yang tahap risiko Distal Upper Extremities Musculoskeletal Disorders (DUEMSDs) mendapat skor 11.894 bagi tangan kanan dan 12.191 skor bagi tangan kiri. Bagi memperbaiki process ini, intervensi ergonomik dijalankan dengan mencadangkan empat kaedah dan melakukan penilaian semula. Borg RPE menunjukkan keamatan daya yang dikenakan telah berkurang kepada 6.04, 4.87, 3.46, dan 6.85 bagi injap-injap tangan roda masing-masing pada ketinggian dari tanah ke lutut, lutut ke pinggang, pinggang ke bahu dan atas bahu. Bagi kaedah REBA, risiko telah berkurang ke julat di antara 5-8, 5-7, 3-7, dan 6-8 bagi injap-injap tangan roda masing-masing pada ketinggian dari tanah ke lutut, lutut ke pinggang, pinggang ke bahu dan atas bahu. Akhir sekali, tahap DUEMSDs berdasarkan kaedah-kaedah RSI dan COSI telah berkurang kepada 8.26 dan 7.01 masing-masing bagi tangan kanan dan tangan kiri. Sebagai kesimpulan, intervensi ergonomik telah menunjukkan kesan yang signifikan dalam meminimumkan risiko kejanggalan postur dan pengenaan daya berlebihan semasa proses membuka dan menutup injap-injap tangan roda terutama sekali apabila ketinggian injap-injap adalah dari tanah ke lutut, lutut ke pinggang, pinggang ke bahu, dan atas bahu.

ERGONOMICS ASSESSMENT AND INTERVENTION FOR HANDWHEEL VALVES OPERATION PROCESS

ABSTRACT

The study aims to examine, assess and improve the effects of the handwheel valves operation process in the chemicals industry. This activity is a physically demanding activity which requires the plant operators to exert high force repetitively in awkward postures. Prolong exposure to these activities contribute to the increase of complaints and development of MSDs problems. In this study, Ergonomics Risk Assessment (ERA) tools such as Nordic Musculoskeletal Questionnaire (NMQ), Initial ERA checklists, Rapid Entire Body Assessment (REBA), Borg Rating of Perceived Exertion (RPE) scale assessment, Revised Strain Index (RSI) and Composite Strain Index (COSI) were applied. A total of 49 male plant operators from different nationalities (Jordan, India, Egypt) and various ages ranging from 22-52 years as well as 35 valves at different heights ranges (17 cm, 224 cm), direction (vertical, horizontal), with diameter sizes range (10.8 cm, 43 cm) were subjected to this study. The results of the ERA tools showed that awkward posture and forceful exertion risk factors during the process of actuating the handwheel valves exposed plant operators to a high level of MSDs risk. The NMQ results showed that the most affected body parts between the plant operators were for the ankles, lower back and upper back, hands and shoulders whereas the Borg RPE showed that the intensity of force exertion were 9.28, 6.51, 3.77, and 8.93 for handwheel valves at heights ground to the knee, knee to waist, waist to shoulder, and above shoulder respectively. As for REBA method the level of MSDs risk recorded a range between 9-11, 5-11, 5-7, and 6-10 for handwheel valves at heights ground to the knee, knee to waist, waist to shoulder, and above shoulder respectively. In RSI and COSI methods, the results showed that the level of Distal Upper Extremities Musculoskeletal Disorders (DUEMSDs) risk has an 11.894 score for the right hand and 12.191 score for the left hand. In order to improve the process, the ergonomics intervention was carried out by proposing four tools and reassessment were conducted. The Borg RPE showed that the intensity of force exertion had reduced to 6.04, 4.87, 3.46, and 6.85 for handwheel valves at heights ground to the knee, knee to waist, waist to shoulder, and above shoulder respectively. For REBA method, the risk was reduced to a range between 5-8, 5-7, 3-7, and 6-8 for handwheel valves at heights ground to the knee, knee to waist, waist to shoulder, and above shoulder respectively. Finally, the level of DUEMSDs based on RSI and COSI methods had reduced to 8.26 and 7.01 for the right hand and left hand respectively. In conclusion, the ergonomics intervention showed a significant improvement in minimizing the awkward posture and forceful exertion risks during the process of opening and closing the handwheel valves especially when the valves heights ranges between ground to the knee, knee to the waist, and above shoulder.

CHAPTER 1 : INTRODUCTION

1.1 Introduction

This chapter provides an overview of ergonomics (human factors), which has become one of the most important sciences of the modern era. The chapter begins by defining ergonomics and its significance in various fields of industrial, economic, social and agricultural from the prior researchers. The chapter also covers the reason for interest in ergonomics science due to the proliferation of Work-related Musculoskeletal Disorders (WMSDs) problems among workers in different sectors around the world. The first chapter continues to mention the company in which the research conducted as a case study background. In addition, the research problem statement, research objectives, research questions, the scope and limitations of the research. Furthermore, the chapter explained the Ergonomics Risk Factors (ERFs) and their effect on workers body parts around the world including some instances from different countries.

1.2 Overview of Ergonomics (Human Factors)

Ergonomics is derived originally from two ancient Greek words. The word ergon comes from (work) and nomos comes from (rules or laws), the combination of these two words can be described as the laws of work (Deb & Venkateshvaran, 2018; Singla, Kwok, Deriban, & Young, 2018; Zahoor et al., 2017). Ergonomics today is the science concerned about evaluating and designing the systems, environments, and products to be efficient, safe and satisfying for the end users. Ergonomics as a relatively new concept concerned about work environment arrangement that commensurate the people capabilities who are working inside it, and it is a process mainly aimed at prevention, blocking and alleviating the workplace illnesses by development best actions and solutions for the workplace components design (Omar, Dahalan, Mohd, Shah, & Azman, 2016).

Ergonomics science objectives not limited only for reducing the workplace health risks but take into account improving the system performance inside the workplace as much as possible (International Ergonomics Association, 2018). In addition, ergonomics contribute to building a great and logical connection between all the components inside the workplace such as workers, machines, products, and overall system components (Boatca & Cirjaliu, 2015).

Based on the study by Zunjic (2017) define ergonomics more specifically as a multidisciplinary science aims to improve comfort, efficiency, safety, and worker satisfaction inside the workplace by identifying any factor that would be affected humans body inside the workplace. These factors such as conditions of the work, nature of the work, means of work, machines, and products from all aspects including sociological, biomechanical, physiological, anatomical, organizational, psychological, and physics (Zunjic, 2017). These aspects can be measured by applying multiple research methods reveal about the presence of risks that threaten workers health.

From aforementioned, one can observe that one of the fundamental aims of ergonomics is to design the job to fit the workers inside the workplace. In other words, machines, products and tasks should fit the workers rather than forcing them to fit the job, and this can be done by balancing between job requirements and capabilities of workers to acquire optimum outcome. Lee et al. (2014) stated that ergonomics term refers to five main principles that must be considered inside the workplace such as performance, comfort, safety, ease of use, and productivity.

According to the International Ergonomics Association (2018) ergonomics can be subdivided into three main categories; physical, cognitive, and organizational ergonomics that can be applied to all aspects of human activity (as shown in Figure 1.1). Physical ergonomics take care of the interactions between body parts with tools or surrounding environments as well as the effects of those interactions on the body with regard to repetitive motion, workplace layout, posture, material handling, musculoskeletal stress and any associated injuries or disorders (Lee et al., 2014). The second domain, cognitive ergonomics or psychological engineering is concerned about processes or activities that affects humans mentality, perception, and memory such as computers, storage jobs, and information presented by a system to the user and decision making (dos Santos, Vieira, & Balbinotti, 2015). The last domain called organizational aspect relates to the improvement of sociotechnical systems, including workplace policies, design, communication, teamwork, shift work and organizational arrangements (Dos Santos et al., 2015; Lee et al., 2014).

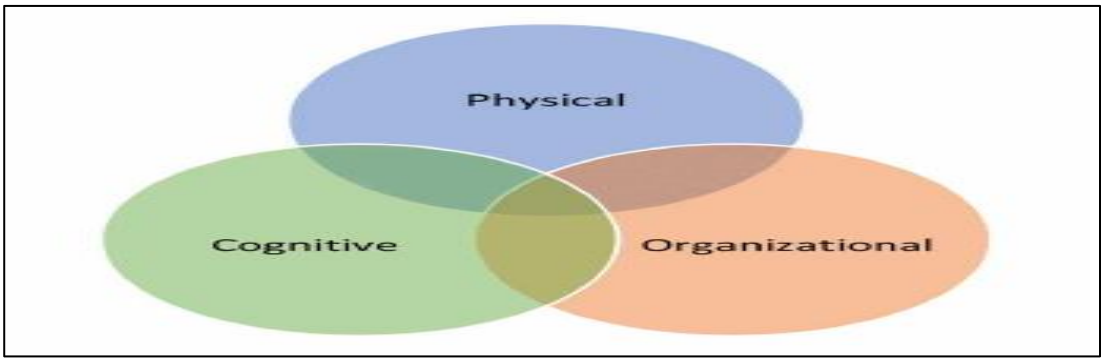

Figure 1.1: Ergonomics domains and areas (DOSH, 2017).

These definitions and aims of ergonomics shed light on understanding the relationship and connection between the workers and their work environment. Work environments comprises of different domains such as the physical environment (temperature, noise, workers personnel space, illumination), social and psychological environment (workers relationship, interpersonal communication) , and what tasks are required from the workers as well as the effects of how work is organized to ensure workers complete satisfaction (Finna & Forgacs, 2010).

In ergonomics , the ergonomists divided the physical ERFs into seven categories. Shabin and Babu (2014) reported that there are seven categories of physical ERFs start from awkward posture, repetition, static posture, forceful exertion, contact stress, vibration, and environment (noise, illumination, temperature, and ventilation). The awkward posture risk factor is one of the most popular risk factors at work, appears when workers need to stretching their body into uncomfortable postures that can harm their muscles such as working overhead, kneeling, twisting, reaching and neck bending (Chen, Qiu, & Ahn, 2017).

In the case of repetition risk factor, this risk appears significantly in jobs that needed long periods of work without rest. Repetition risk factor exposes the workers to a high level of risk causes WMSDs especially if accompanied by another ergonomics risk factor such as awkward posture or forceful exertion (Mossa, Boenzi, Digiesi, Mummolo, & Romano, 2016). Forceful exertion risk factor appears when the work needs a high level of force or power to carry out the job such as pushing, pulling, lowering, lifting, and carrying (DOSH, 2017). The first ERFs (awkward posture, forceful exertion, repetition) are the most popular risk factors found in most jobs.

On the other hand, static posture risk factor involves maintaining a body in the same posture for a prolonged period, and it typically appears in office working jobs (Md Shakibul Haque & Kumar, 2015). Vibration risk factor includes whole-body vibration and hand-arm vibration. This risk occurs when the task requires using vibrating tools that have a high vibration levels (e.g. percussive or riveting tools) for more than half hour per day or using tools with medium vibration level for two hours per day (e.g. grinders, drills) (Yang, 2012).

The other ERF that known as contact stress risk factor exists in two form- internal and external. Internal contact stress refers to a situation when a nerve, blood vessel, and tendon exposed to stretched or bent around a bone or tendon while the external contact stress refers to a case when a part of the body rubs against a component of the workstation components such as desk edge (DOSH, 2017). The last ERFs called environmental risk factor occurring when the body is affected by temperature, noise and extreme atmospheric pressure environments at the workplace (DOSH, 2017).

The focus on ergonomics is in increasing day after day due to the prevalence of WMSDs among workers in different jobs around the world. Consequently, ergonomics is beneficial in the workplace because it optimizes workers health and wellbeing as well as system performance. The ERFs are considered as the root causes of WMSDs problems that affected workers health. In addition, the prevalence of WMSDs among workers causes financial problems to companies with respect to health insurance and financial compensation. The musculoskeletal disorders definitions and their implications will be explained in the following section.