UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INTEGRATION ON ERGONOMIC RISK FACTORS TO IMPROVE WORKER'S COMFORT LEVEL IN COMPOSITE TRIMMING PROCESS

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AZURIN BIN SHUKUR

A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Philosophy
in Manufacturing Engineering

Faculty of Manufacturing Engineering

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DECLARATION

I declare that this thesis entitled "INTEGRATION ON ERGONOMIC RISK FACTORS TO IMPROVE WORKER'S COMFORT LEVEL IN COMPOSITE TRIMMING PROCESS" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
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Date	:	25/10/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

Signature :

Supervisor Name : Prof. Madya Dr Nur Izan Syahriah Binti Hussein

Date : 25/10/2022

DEDICATION

I would like to thanks to my beloved wife for giving full support and motivation to me to prepare and complete this project and thesis start from the beginning. Also to my supervisor and co supervisor for guided me along my research and my friends for your help and support.

ABSTRACT

In today's manufacturing industry especially the aircraft composite panel manufacturing sector, matters related to ergonomic risk factors are given less attention. This causes 20% of workers to take sick leave in a week due to the method of the process itself and this affects the production with a decrease of 16% to 20% per week. In addition, there are no previous studies that combine vibration, work environment factors and body posture to show a comprehensive effect on workers' health and comfort. This study was conducted to identify matters related to ergonomic factors on the worker's comfort level. It also to formulate and integrate ergonomic risk factors during the cutting process. The next objective is to verify the level of employee comfort by using the RULA and REBA methods. To achieve the first objective, a survey method using a survey form was used to obtain feedback on the level of workers' comfort for 12 situations of comfort that existed when the composite cutting process was performed and then subsequently performed a descriptive analysis. To achieve the second objective, vibrations from hand tools were obtained using a vibrometer and analyzed using Minitab software to produce a regression equation at a panel thickness of 3 mm. Working environment factors such as air humidity, temperature, noise and lighting at the composite cutting area for both open and close area were measured using specific measuring tools and then analyzed using Minitab software and from this analysis automatically generate regression equations for working environment factors for indoor and open workplaces. For body posture, the moment when the worker was cutting the panel was studied using the RULA and REBA methods. The results of the survey method from the descriptive analysis showed that the workers were uncomfortable for the twelve work situations presented. Studies for the working environment show that the open workplace is in a comfortable situation while the indoor place is less comfortable. For body posture, show scales value of 6 and 7 by using RULA and scale 8 to 11 by using REBA. This scale means that the process or posture needs to be studied immediately or changed as soon as possible and by using the same method, the industry players will be able to perform the necessary improvement actions or interventions until they reach the allowable RULA and REBA value. This study has been able to provide a useful output in which the generated regression equations will be used by manufacturing industry players related to composite cutting process to know and control the vibration level from hand tools. By using regression equations for working environment factors, the industry players will be able and easily to control the working environment at their composite cutting site to ensure the comfort level of their workers is maintained.

INTEGRASI TERHADAP FAKTOR-FAKTOR RISIKO ERGONOMIK UNTUK MEMPERBAIKI TAHAP KESELESAAN PEKERJA DALAM PROSES PEMOTONGAN KOMPOSIT

ABSTRAK

Dalam industri pembuatan hari ini khususnya sektor pengeluaran panel komposit kapalterbang, perkara-perkara yang berkaitan dengan faktor risiko ergonomik kurang diberi perhatian. Ini menyebabkan 20% pekerja akan mengambil cuti sakit dalam seminggu akibat dari cara kerja itu sendiri dan ini menjejaskan pengeluaran dengan pengurangan sebanyak 16% ke 20% seminggu. Disamping itu masih tiada kajian sebelum ini yang menggabungkan getaran, faktor persekitaran kerja dan postur badan untuk menampakkan kesan yang komprehensif terhadap kesihatan dan keselesaan pekerja. Kajian ini telah dilakukan bertujuan untuk mengenalpasti perkara berkaitan faktor ergonomik terhadap tahap keselesaan pekerja. Ia juga bertujuan untuk memformulasikan dan mengintegrasikan faktor-faktor risiko ergonomik semasa proses pemotongan. Tujuan seterusnya ialah mengverifikasikan tahap keselesaan pekerja dengan menggunakan kaedah RULA dan REBA. Untuk mencapai objektif pertama, kaedah kajiselidik menggunakan borang kajiselidik digunakan untuk mendapatkan maklumbalas terhadap tahap keselesaan pekerja untuk 12 situasi yang wujud ketika proses pemotongan komposit dilakukan dan seteruskan melaksanakan analisis deskriptif. Bagi mencapai objektif kedua pula, getaran daripada alatan tangan diperolehi menggunakan vibrometer dan dianalisis menggunakan perisian Minitab untuk menghasilkan persamaan regressi pada ketebalan panel 3 mm. Faktor persekitaran kerja seperti suhu, kelembapan udara, bunyi dan pencahayaan di tempat pemotongan komposit diukur menggunakan peralatan tertentu dan kemudian dianalisis menggunakan perisisan minitab dan dari analisis ini akan terus menjana persamaan regressi untuk faktor persekitaran kerja bagi tempat kerja tertutup dan tempat kerja terbuka. Untuk postur badan, momen ketika pekerja sedang memotong panel dikaji dengan menggunakan kaedah RULA dan REBA. Hasil kajian dari kaedah kajiselidik dari analisis diskriptif menunjukkan pekerja tidak selesa untuk keduabelas situasi kerja yang dikemukakan. Kajian untuk persekitaran kerja pula menunjukkan tempat kerja terbuka berada pada situasi yang selesa sementara di tempat tertutup agak kurang selesa. Untuk postur badan pula menunjukkan skala 6 dan 7 dengan menggunakan RULA dan skala 8 hingga 11 menggunakan REBA. Skala ini membawa maksud proses atau postur perlu dikaji segera atau diubah secepat mungkin dan dengan kaedah ini juga pemain industri yang seumpamanya akan dapat melakukan tindakan penambahbaikan yang perlu sehingga mencapai skala yang dibenarkan. Kajian ini telah dapat memberikan output berguna yang mana persamaan regressi yang dihasilkan akan digunakan oleh pemain industri pembuatan yang berkaitan dengan proses pemotongan komposit untuk mengetahui dan mengawal tahap getaran daripada alatan tangan. Dengan menggunakan persamaan regressi untuk faktor persekitaran kerja, pemain industri berkenaan akan dapat juga mengawal persekitaran kerja di tempat pemotongan komposit mereka dengan mudah untuk memastikan tahap keselesaan pekerja mereka terjaga.

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LIST OF SYMBOLS AND ABBREVIATIONS

m/s	-	Meter per second (Speed)
m/s^2	-	Meter per second square (Vibration)
%RH	-	Relative Humidity Percentage (Air Quality)
^oC	-	Degree Celcius (Temperature)
lux	-	Measurement Of Light Level Intensity (Lighting)
dB	-	decibels (Sound/Noise)
MSD	-	Musculoskeletal Disorders
NIOSH	-	National Institute for Occupational Safety and Health
HAVS	-	Hand-Arm Vibration Syndrome
VWF	-	White Finger Vibration
CFRP	-	Composite Fibre Reinforce Panel
HTV	-	Hand-Transmitted Vibration
CTS	-	Carpal Tunnel Syndrome
CCOHS	-	Canadian Centre for Occupational Health and Safety
OSHA	-	Occupational Safety and Health Administration
JKKP	-	*Jawatankuasa Keselamatan dan Kesihatan Pekerja*
RULA	-	Rapid Upper Limb Assessment
REBA	-	Rapid Entire Body Assessment

LIST OF APPENDICES

LIST OF PUBLICATIONS

Hussein N.I.S, Shukur A, Kamat S.R, Yuniawan D. The Impact of Worker Experience and Health Level to Vibration Absorbed by Hand. *Journal of advannced Manufacturing Technology*. Vol. 13, Issue Special Issue 1, pp. 91 – 103, 2019.

Hussein N.I.S, Shukur A, Kamat S.R, Yuniawan D. A Regression Analysis: Ergonomic Comfort vs, Air Quality, Noise, Lighting and Temperature in the Composite Trimming Process Working Room, *Journal of Mechanical Engineering*. 2020.

CHAPTER 1

INTRODUCTION

1.1 Background

In today's world, there are a lot of health problems and uncomforted working condition’s complaint on ergonomic risk factor issue at workplace that occur among the workers in manufacturing industries due to the working under predetermined or inevitable condition or procedure. This has become a universal problem which happens in most industries, especially in the manufacturing industries around the world. This happened in the industries that require workers to use certain hand tools or power hand tools for doing certain process that exceeded ISO standard working environment. The function of the hand tool is based on rotating motors that produce vibrations (Silvia, 2019). Something that moves or rotates will produce vibrations as well as noise, which means that the motor in the hand tool becomes the point source that generates vibration unless there is a mechanism that is fixed on it to reduce the vibration and noise.

The amount of vibration or sound produced by motor rotations depends on the speed, size of the motor, location or angle of the hand and the body while gripping the hand tool during a cutting process as well as the working environment conditions. All these are considered as ergonomic risk factors that can affect the workers’ health. These are interrelated elements that will have short-term and long-term effects on the workers in terms of health and vibration-related diseases as a result of their hands absorbing the vibration. The are a lot of manufacturing industries got these problems due to the use of hand tools. Sixth European Working Condition Survey reported nearly 20% of workers in 28 EU Member States in the industrial sector were subjected to vibrations created by tools or machines for at least one quarter of their working time (Silvia, 2019). The data from a national statistical survey has shown that 14% of all employed people in Sweden were affected to handheld vibrations for at least 25% of their working time (Wihlborg, 2017). Between 2008 and 2017, more than 7000 new claims for Hand Arm Vibration Syndrome were registered in the UK (UK Department for Works and Pensions, 2018). High vibration thresholds existed in Italy under Directive 2002/44/BC to ensure workers avoid excessive exposure to vibrations (Italian Government, 2008). This shows that the problems arising from the vibrations that are absorbed by the hands will affect the body. Any vibration issues due to long periods of exposure to hand tools can cause the developing of condition known as a Hand Arm Vibration Syndrome or HAVS.

This study involves two companies that produce aircraft components or panels made from composite materials, as shown in Figure 1.1. All these components are made from high quality, lightweight and strong Composite Fibre Reinforced Panel (CFRP) composites to accommodate the loads and pressures that exist on the aircraft. Two companies were chosen for this study, Company A and Company B because they have a composite trimming or cutting process, which are considered to be quite complicated, high-risk and thought work processes. Therefore, only five workers with enough skill and experience should be selected to do the job to ensure the quality of the product since each composite panel is quite expensive and sensitive (NIS, 2019).

Figure 1.1: A composite panel

However, it can be noted that there are some areas of study that are lacking in the research conducted by previous reviewers based on the physical (clinical) reports that involved the workers in this area, which were likely to be related to various ergonomic risk factors such as working environment, body posture, type of equipment and the process involved. The workers in these two companies are usually working in a closed room and open area where the edge of the panel is being cut inside the room and the open area. The workers in both companies wears a PPE (Personal Protective Equipment) suit as shown in Figure 1.2.

By wearing those PPE suits, the workers may feel uncomfortable and hot as they are in the suit for 20 to 25 minutes. In addition, the air circulation in the cutting room should be in good condition to reduce heat as well as in open area. Therefore, while they are working, they also need to deal with the uncomfortable condition of wearing PPE, in standing position while doing the cutting process, a noise coming out from the cutting process and the vibration absorb from a hand tool. Hence, this condition has become a justification point for this study to be carried out as it concerns the body posture, hand tools and working environment in the context of ergonomic risk factors.

Figure 1.2: Workers in PPE suit

Referring to Figure 1.3, the scope of this study is focused on three issues: under the physical category, the first is focus on studying the vibration of the hands when using hand tools, the second is the body posture in a standing position which corresponds to the position of the worker when doing the cutting process of the composite panels and the third is the working environment category, which consists of air quality, temperature, noise and lighting.

These are the main factors involved in the trimming process that influence the health and comfort of the workers because all these elements are related to or give an impression of the amount of vibration that is absorbed from the hand tool to the hands and arms. A certain experiment for each factor was done to get a group of data before it was analysed for the result.

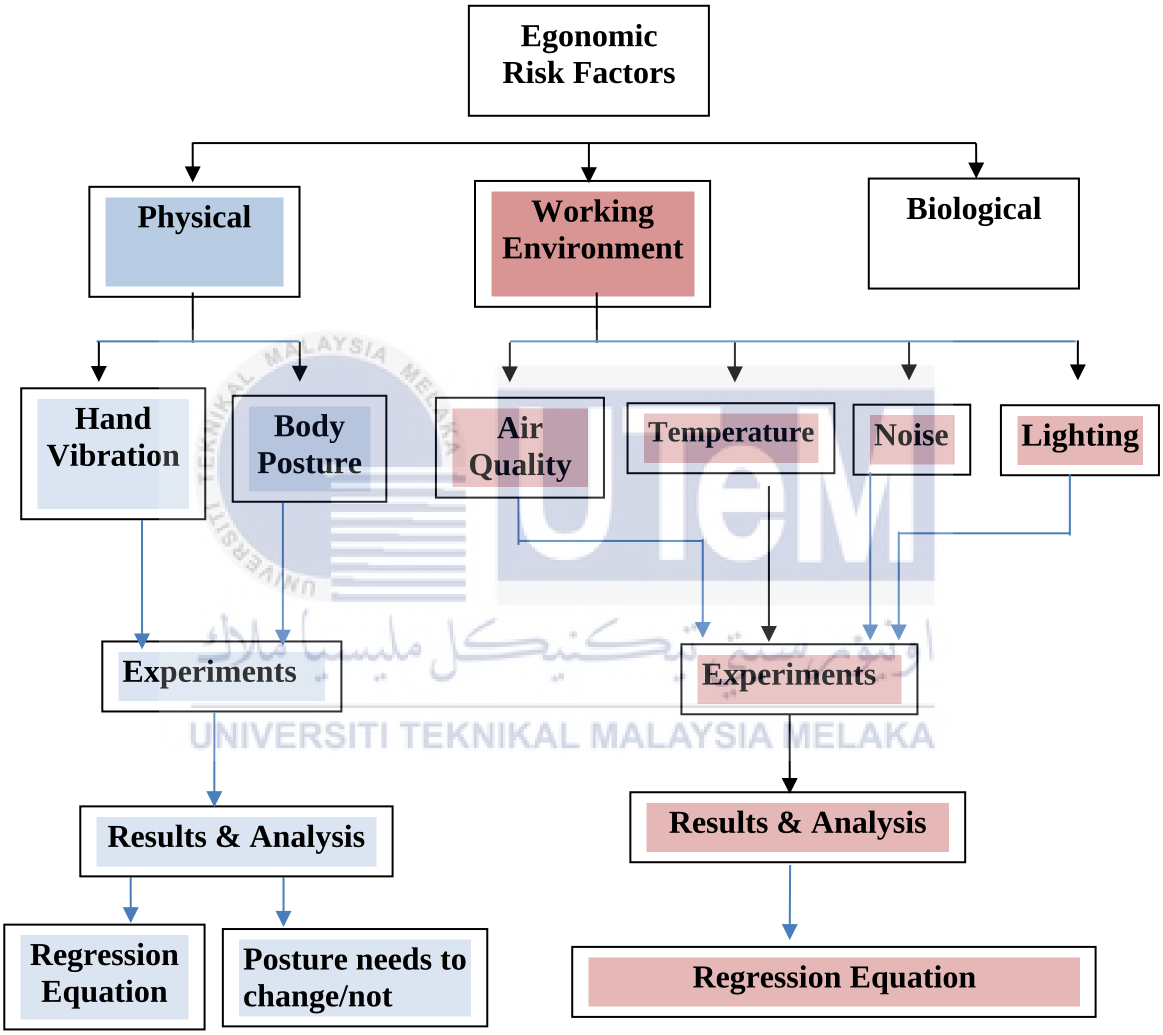

Figure 1.3: The Scope of research

There are a few ways that can be used to reduce the vibrations absorbed by the hands and one of them is to use gloves. Many gloves provide a considerable reduction of the vibration transmitted to the palm, especially at higher frequencies (Hamouda, 2018). Nevertheless, the efficiency of these gloves when they are used with different vibration