Faculty of Manufacturing Engineering

DESIGN A MANUAL CALF MASSAGER FOR PROLONGED STANDING WORKER BY USING ERGONOMIC APPROACH

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DECLARATION

I declare that this thesis entitled "Design a Manual Calf Massager for Prolonged Standing Worker by Using Ergonomic Approach" 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 : 02 SEPTEMBER 2016

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Industrial Engineering).

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DEDICATION

Every challenging work needs self efforts as well as guidance of Almighty ALLAH and great support especially those who were very close to our heart. My humble effort and hard work I dedicated to my late loving father and my amazing sweet mother:

Mr. Mat Zin Bin Hassan

Mrs. Rokiah Binti Taib

Whose affection, continuous care, love, encouragement and prays of day and night make me able to get such success and honor. I hope that this achievement will complete the dream that you had for me all those many years ago.

ABSTRACT

Majority of manufacturing industrial labors normally has to perform the operating task in standing position for a long period of time. In this context, the problems related to prolonged standing activity among workers posed significant impact to the workers that may lead to musculoskeletal disorders (MSD) including pain, increased fatigue and stiffness in active muscles. There is an urgent need to address and recognizing the suitable and reliable way for resolving this problem. Therefore this study focusing to develop a manual calf massager (MCM) design in order to reduce muscle fatigue associated to prolonged standing worker. The data of the problems encountered and design specifications were obtained through questionnaire survey among 60 respondents of production worker in PHN Industry Sdn. Bhd. Based on the findings, large number of participants have experienced muscle fatigue in calf parts due to the prolonged standing activity. Hence, the most favored criteria of the design requirements are effortless and user friendly, high efficiency, portable devices, foldable design, multi-purpose use, adjustable device and durability based on the consumer desire. The selection of concepts design was finalized by using Pugh Selection Method; Screening and Scoring method. The final 3D modelling design of the MCM was drawn using SolidWork software. While for the validation analysis, subjective method was applied to gain the psychological feedback from the workers and also to the medical practitioners. According to the validation results, it can be summarized that majority of the workers satisfied with the overall performance of MCM design. Positive feedback gained from the physiotherapist where they believed that MCM chair will be as an archetype in preventing pain become worsening especially contributable to MSD. Besides, most of them showing curiosity to try this new calf massager design.

ABSTRAK

Kebanyakan pekerja industri pembuatan kebiasaanya perlu melakukan kerja mereka dalam kedudukan berdiri bagi jangka masa yang lama. Dalam konteks ini, masalah-masalah yang berkaitan dengan aktiviti berdiri lama ini telah memberikan kesan yang ketara kepada pekerja-pekerja yang boleh mengakibatkan gangguan muskuloskeletal termasuklah kesakitan, meningkatkan keletihan dan ketegangan pada otot. Keperluan untuk menangani segera dan mengenalpasti cara yang sesuai dan boleh dipercayai untuk menyelesaikan masalah ini adalah amat wajar. Oleh itu, kajian ini memberi tumpuan untuk menghasilkan rekabentuk pengurut betis manual (MCM) dalam mengurangkan keletihan pada otot melibatkan pekerja yang berdiri lama. Data daripada masalah yang dihadapi dan ciri-ciri rekabentuk telah diperoleh melalui kajian soal selidik terhadap 60 orang pekerja pengeluran di PHN Industry Sdn. Bhd. Justeru itu, kriteria yang paling digemari adalah rekabentuk dengan kurang penggunaan tenaga dan mesra pengguna, kecekapan tinggi, mudah alih, boleh dilipat, pelbagai fungsi, kebolehubahsuaian, dan tahan lasak berdasarkan kehendak pengguna. Pemilihan konsep rekabentuk telah ditentukan dengan menggunakan kaedah pemilihan Pugh; kaedah saringan dan pemarkahan. Rekabentuk akhir MCM dalam bentuk 3D telah disediakan menggunakan perisian SolidWork. Manakala bagi analisis pengesahan, kaedah subjektif telah digunakan untuk mendapatkan maklum balas psikologi terhadap pekerja dan juga kepada pengamal perubatan. Menurut hasil pengesahan, ia boleh dirumuskan bahawa kenyakan pekerja berpuas hati dengan prestasi keseluruhan rekabentuk MCM. Maklum balas positif yang diperolehi daripada ahli fisioterapi di mana mereka percaya bahawa kerusi MCM akan menjadi medium pencegahan untuk mengelakkan rasa sakit yang semakin teruk terutama ke arah penyumbangan MSD. Selain itu, sebahagian besar daripada mereka menunjukkan rasa tidak sabar untuk mencuba rekabentuk pengurut betis baru ini.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ACM	-	Automatic Calf Massager
BMI	-	Body Mass Index
HoQ	-	House of Quality
MCM	-	Manual Calf Massager
OSHA	-	Occupational Safety and Health Administration
PERKESO	-	Pusat Rehabilitasi Pertubuhan Keselamatan Sosial
ROM	-	Range of motion
RPE	-	Rating Perceived Exertion
sEMG	-	Surface electromyography
SOCSO	-	Social Security Organisation
SPSS	-	Statistical Package for the Social Science
SS	-	Self Stretching
SM	-	Self Massage
WMSD	-	Work-related musculoskeletal disorder
VAS	-	Visual Analogue Scale
VoC	-	Voice of Consumers
VoT	-	Voice of Technical
V15	-	Version 15
Eq.	-	Equation
3D	-	Three Dimensional
rij	-	Raw rating of concept *j* for the *i*th criterion
wi	-	Weighting for *i*th criterion
n	-	Number of criteria
Sj	-	Total score for concept *j*
$\sum$	-	Summation

CHAPTER 1

INTRODUCTION

Chapter 1 introduces the background information about this study, problem statements, objectives, scopes, methodology and the structure of the research reports. In general, it promoted the idea of the project conducted and provides an initial overview of the entire contents of the project under title 'Design a Manual Calf Massager for Prolonged Standing Workers by Using Ergonomic Approach'.

1.1 Background of Study

In today's business, most of organizations need to design and innovates their products to compete manufacturing demands or organizations around the world due to the great challenge between competitors and in order to sustain in the industrial market. Kotler and Keller (2012) clearly identified that designs are a number of features that have an impact on how a product looks, feel, and function on consumers. Andersson (1990) stated that, an ergonomic approach to product design would lead to greatly improved products in terms of ease and efficiency of use and ergonomically designed products definitely can be well accepted by the entire marketing system. In definition, a marketing system means the network direct market players which absolutely involved producers, buyers and consumers who drive economic activity in the market (Lee and Trim, 2006). Thus, the new products will be introduced in a more holistic way, when the problems occurred between the existing products in the market after a period of time or the users tend to have a new desire especially regarding industrial problems.

In this context, the problems related to non-ergonomic consideration or awkward posture in industrial activity nowadays pose much trouble to some workers due to inappropriate body posture can cause musculoskeletal disorder (MSD) contributable to muscle fatigue at the end of the working tasks (Omar et al., 2004). Theoritically, MSD is a type of injury that include damage to muscle, tendons, or ligament which cause by long time exposure to back injury, shoulders, hand, wrist and other parts of body. Besides awkward posture, inappropriate designs of workstation that promotes unnatural postures, stressful muscle, static standing, frequent movement, continuous exposure to hand-arm vibration, and poor environmental quality which also can lead to MSD.

Basically, the majority of manufacturing industrial labours particularly has to perform the task of operating in standing position for a long period of time. Fundamentally, working in standing posture completely gave flexibility to workers to be more effective towards work performance contributable to the company productivity due to the agility of leg movement where possessing a large degree of exemption (Halim and Omar, 2011). However despite the productivity success, there has a number of problems encountered regarding this standing position. In this context, the problems related to prolonged standing activity among workers posed significant impact on the manufacturing industry. Prolonged standing tasks in manufacturing industry may lead to musculoskeletal disorders including pain, increased fatigue and stiffness in active muscles (Rahim et al., 2010).

Currently, a number of studies have attempted to evaluate the impact of prolonged standing position through various occupations in the industry. Thus, there is an urgent need to address and recognizing the suitable and reliable way for resolving this problem. Based on that reason, this study fully concentrated to examines the psychological experienced

towards muscle fatigues measurements for assessing the subjective fatigue experienced in order to reduce the negative effects of prolonged standing trough manufacture industrial workers. Moreover, it is also necessary to consider the ergonomic features that need to be implemented into this project through creating the stylish design that clearly stepped beyond the dimensions and to obtain the superb functions while not reduce the functionality of the product prior.

1.2 Problem Statement

Although standing jobs pose much flexibility to industrial workers, but there are still various detrimental needs to be primarily concerned. A search of the literature revealed few studies related to the risks associated with prolonged standing have been documented. In most assembly lines in manufacturing industry and service occupations, employees may experience pain and discomfort associated with long periods of standing. Briefly, prolonged standing tasks in the manufacturing industry may contribute to musculoskeletal disorders, including pain, increased tiredness and stiffness in active muscles (Rahim et al., 2010).

Furthermore, there is some evidence where clearly discussed that calf fatigue plays a crucial role in regulating the ramifications of prolonged standing. The earliest and most common symptoms from prolonged standing are discomfort and fatigue in legs part such as calf, knees, and thighs as mentioned by (Hughes et al., 2011). It has been conclusively shown that the function of the calf muscle is particularly diminished and restricted due to the static contraction in back and leg parts, as a consequence of the prolonged standing activity according to the recent studies reported by Halim and Omar (2011) as cited by Krijnen (1998). A hypothesized reason for the increased discomfort and overall body fatigue

associated with prolonged standing conditions is reduces blood circulation in the lower legs and static muscle fatigue (Zander et al., 2004; Rahim et al., 2010).

Based on the above mentioned issues, it is clearly seen performing process job while standing associated with prolonged time period can potentially affect the calf fatigue to industrial workers. Recent evidence suggests to massage where effected on muscle and subcutaneous circulation in the human calf (Mori et al., 2004) where Case-Lo (2015) defined subcutaneous is under the skin. In clinical and sports settings, massage is utilized widely and believed to be efficacious in the recovery from muscle fatigue and it is thought to increase tissue circulation, thereby decreasing hypertonicity and enhancing recovery from muscle fatigue (Mori et al., 2004). This seemed to indicate that massage not only reduces the level of moto-neuron excitability and consequently of muscle reflex activity, but is quite specific with much less effect on the contralateral limb than previously thought and with inhibition taking place only during treatment (Callaghan, 1993).

However in reality, very few studies have attempted to quantify the impact of massage towards calf muscle correlation in order to minimize discomfort and muscle fatigue associated with prolonged standing activity. Mori et al., (2004) also reported that only some studies were measured and analysed on the influence of massage on subcutaneous circulation. It could conceivably be hypothesised that, in order to reduce or eliminate the calf fatigue associated with long-term standing posture of production operators while performing manufacturing jobs is by using ergonomic design of calf massager simultaneously in results of significant different in terms of fatigue rate. Hence, the solutions have been applied to improve lower extrimity muscle or tibialis anterior muscles in the legs (Rahim et al., 2010).

1.3 Objective

Basically, the main purpose of this project is to design a manual calf massager in order to reduce muscle fatigue associated to prolonged standing worker in industry. Based on the problems arise, there are few objectives for this research that may help in providing the solutions:

1. To investigate the psychological fatigue and design requirements towards prolonged standing workers
2. To design a manual calf massager based on the consumer (worker) satisfaction
3. To validate the manual calf massager design based on psychological feedback

1.4 Scope of Study

Generally, this study only concentrated on constituent at the actual industrial workplace, such as worker anthropometry, working posture, and job activity associated with prolonged standing drawbacks. Therefore, this study takes place at PHN Industry Sdn Bhd. Which is the stamping company located at Kelemak, Melaka. In each constituent, factors that contributed significantly to MSD associated with awkward posture were critically studied. Factors associated with worker are included psychological and psychophysical experience when workers are performing their processes jobs and duration of work particularly considered respectively. The psychological fatigue experienced by the workers is obtained through the subjective method where basically involved questionnaire surveys and also the interview method.

Obviously, there are many awkward posture issues occurred in PHN Company or any other manufacturing industry company. However, this study only focused on reducing the worst effects due to prolonged standing activities involving ergonomic risk through the

assignable workers. Meanwhile, the calf fatigue was selected as indicator in this study for developing and validating the posture analysis. Furthermore, the effect of the massager on muscles other than the calf muscle has not been studied. The developed posture analysis has been found as a useful advisory analysis to identify and evaluate the discomfort and muscle fatigue experience attributable to prolonged standing activity among the industrial workers.

It is believed that, 'prevention is better than cure'. In this situation, the attempt to tackle the early phase symptom of MSD is better to avoid its worsening. Thereby, this study comes out with manual calf massager (MCM) chair design as a new archetype in order to resolve the initial and most common symptoms from prolonged standing where lead to discomfort and fatigue.

CHAPTER 2

LITERATURE REVIEW

This chapter is fully concentrated on the referenced review of the relevant literature applied to this study through theoretically and empirically. Through this study, the process of collecting and gathering the data are obtained from various sources such as books, newspapers, magazines, journals, seminar papers, theses, and also through interviews with relevant parties. Basically, this parts aims is to disclose five major element contributable to this research which are risk factor towards MSD in industrial workplace, significant complication due to prolonged standing activity, the influence of ergonomic design on work performance, the role of massage to eliminate muscle fatigue and lastly is assessment methods towards psychological analysis.

2.1 Risk factor in Industrial Workplace

Today, the world population is estimated about 6.9 billion, with 3.1 billion number of workers working in more than 55 major industrial sectors. While providing job opportunities, a large number of workplaces in the industrial sectors may lead to occupational injuries if there is no awareness or consciousness regarding occupational health and safety (Halim et al., 2012b). The Social Security Organisation (SOCSO) has recorded the severity of industrial injuries that contribute to poor occupational health. In their annual reports, it was stated that industrial workers suffered seriously from head, neck, trunk, upper limb and lower limb, upper back and lower back injuries (Halim et al., 2005).

In addition, occupational injuries have an effect on direct medical costs and indirect losses in wages and productivity. As an example the total cost of fatal and non-fatal occupational injuries were estimated at USD 11.5 billion in 2002 in the construction industry alone. In industrial workplace, back pain affects the occupational health of workers and contributes to a low quality of life that can cause absenteeism. In addition, according to Halim et al. (2012), back pain may lead to direct and indirect loses, such as a rise in medical and compensation costs (direct losses), and low productivity due to sickness and absenteeism (indirect loses). In Malaysia, back pain is recorded as a common complain among industrial workers, where 1805 cases have been reported (Isa et al., 2015).

In industry, manual lifting still a prevalent choice even though mechanized and automated equipment are provided. Manual handling occurs in almost all working environments especially in industrial sectors. The process include lifting boxes at a packaging line, handling construction materials, pushing carts, handling patients in hospitals, and cleaning. Mismatch between workers' capability and lifting height, twist angle, and load mass in manual lifting can contribute to occupational injuries such as back pain (Isa et al., 2013). Back pain was recorded as a common complaint in Malaysia which lead to direct cost; increase of medical and compensation cost) and indirect loses; low productivity due to sickness and absenteeism (Isa et al., 2013).

2.1.1 MSD Complication

Manual handling may result in two major groups of injuries respectively. Firstly, injuries related to the cuts, bruises, fractures due to sudden or unexpected actions such as accidents. Secondly is damage in musculoskeletal system of the body such as muscles, tendons, ligaments, bones, joints, bursa, blood vessels and nerves as a result of gradual and