Analysis the Awkward Posture Ergonomic Risk and Workstation Improvement Simulation in Mechanical Assembly Manufacturing Industry using DelmiaV5

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Abstract. Ergonomics knowledge is crucial in any industries, without knowledge applied, one easily exposed towards the risks of the working environment. Based on the survey conducted showed awkward posture and heavy lifting were the most highlighted issues occurred. Aim of this study is to analyse the working posture in mechanical assembly manufacturing industry and analyse the effect of the improvement workstation. The use of Rapid Upper Limb Assessment (RULA) in order to analyse the most level of risk of workers during working, develop human manikin following the anthropometric data collected from industry real population, as well to replicate the posture of the workers, simulate the working process via simulation using DELMIA V5. Results reported one of the highest ergonomic risk occurred in this department is drilling activity. The manikin successfully developed with 105 measurements for 685 male workers. Simulations effectively simulated using DELMIA V5 in virtual environment. Step ladder suggested as virtual and this improved the value of RULA score. In conclusion, the software and method used were powerful tool in designing the virtual improvement and this research expected to create a design guideline for the industry that help workers with an ergonomic way at the workstation before and during working.

1. Introduction

Awkward position indicated as the body posture that unusual or hardly to perform by the body. This awkward position caused stress to the muscle in the body that resulted pains that lead to fatigue and injury. Health issue due to awkward position is common especially to workers in the heavy industry includes mechanical assembly manufacturing industry. This awkward posture influenced the
performance of the worker which has a greater impact to the company itself. This problem as well mostly related with the design of the workstation, which reported not ergonomically designed. Ergonomic are human-centered and focusing on evaluation of task performance and human performance when there is interaction of user with complex systems which be achieved by applying a task analysis procedure [1]. Ergonomic also a task or activity intended to analyse and solve the injuries of the human due to working problem. Besides, ergonomic is a continuous improvement effort to design or redesign and propose an improvement to the workplace or workstation layout in. The guidelines on ergonomic deficiencies are derived from the accident reports which commonly name employees as direct causes of accident. The main cause of accidents found of significance for prevention purposes include the misalignment of workstations with the psychophysical capabilities of workers [2].

Other ergonomics issues are related with the body posture itself. In order to curb the problem with ergonomics issue related, a well study of the body posture of the worker or human is important to obtain a good workstation. The non-success or inaccurate of the human body posture examination can lead to risk and injury. Most result from the previous studies or researches showed that working with the hands above the shoulders or using repetitive movements and working in awkward posture were associated with shoulder and neck pain, rotator cuff syndrome, and epicondylitis. Other ergonomic risks include vibration, both sitting and bending prolonged sitting without support, carrying out repetitive tasks with hands and fingers, frequent lifting activity, and standing with awkward posture were associated with a high prevalence of shoulder and neck pain [3]–[5].

This project covered the analysis of ergonomic risk specifically to the awkward posture analysis using physical and simulation analysis. This project significantly has potential to help the workers and industry where occupational health of the workers can be improved and avoid any occupational injuries as this work. Results could be extended to the society to enhance the awareness of ergonomic analysis before and during working activities.

2. Methodology

This study took place among the production workers in mechanical assembly department at ABC Company Sdn. Bhd. Working posture worksheet is used to identify and observe the working posture whereas Nordic survey is used as structured interview to screening the MSD problem. Besides, this research is focusing the manikin development with own population measurements where the anthropometric measurements data of workers in aerocomposite industry are taken from data collected in previous research. DELMIA (Digital Enterprise Lean Manufacturing Interactive Application) is among the well-known software that is used to simulate the dynamic simulation aiming to observe the motion of the worker in the workstation virtually by using the manikin developed in the CATIA V5. Numerous studies simulation in DELMIA V5, the ergonomic risks or awkward posture can be analysed based on result obtained. CATIA V5 software is used for the manikin development and DELMIA V5 is used to simulate the design. RULA analysis, energy expenditure and biomechanics single action analysis are used to analyse the working posture of the worker and DELMIA V5 is used to simulate and prove the improvement and effectiveness of the model produced. DELMIA V5 software only focusing a simulation of the model since no fabrication and real implementation can be used to improve the posture in DELMIA V5.

3. Results and discussion

There are seven working postures observed and selected precisely related to awkward posture in localised drilling process. From these seven observed postures, one posture selected according to the result of Employee Assessment Worksheet with highest RULA score and that posture was required by the industry for further critical analysis. The simulation in DELMIA V5, the ergonomic risks or awkward posture can be analysed based on result obtained as in numerous previous researches [3], [6].
For this study, improvement related with workstation design, 2 concepts were suggested; 2 steps ladder and 3 steps ladder.

3.1. RULA Analysis
RULA is a method for the assessment of risk of the body posture by maintaining inadequate by the poor design of working area. The RULA method provides an important and useful tool for evaluating working postures of the worker that may create a risk tool. RULA score starts from 1 to 7 which 1 is the least risky whereas 7 is high risk. Figure 1 showed the results of RULA assessment analysis for current workstation and workstation with improvement.

Figure 1. RULA Analysis result for:
(a) current workstation design (b) 2 steps ladder workstation improvement (c) 3 steps ladder workstation improvement
3.2. Energy expenditure analysis

Energy expenditure was analysed after the worker complete performing the task which from the first position of the worker before the process until the last position of the worker after complete all the tasks. Result from energy expenditure analysis indicates that the higher the number of energy, the higher the calories burnt which significantly indicate that the task carried by the worker is heavy and requires large energy to perform it. Thus, worker will easily to get fatigue due to huge energy required to complete the task. Table 1 showed the results of energy expenditure analysis for current workstation and workstation with improvement.

Table 1. Energy expenditure analysis for: current workstation design (b) 2 steps ladder workstation improvement (c) 3 steps ladder workstation improvement

| Energy Expenditure Summary | Energy Expenditure Summary |
|----------------------------|----------------------------|
| **Total Energy**           | 1.510                      |
| **Total Time**             | 26.156                     |
| **Total Walk Distance**    | 12117.961                  |
| **Average Rate**           | 0.058                      |

End of Report

Average rate energy expenditure = 0.058 kcal/s

Average rate energy expenditure = 0.049 kcal/s

3.3. Biomechanics single action analysis

This ergonomic tool measures a worker's biomechanical data in a pose. The Single Action Analysis tool calculates and produces information such as the lumbar spinal loads (abdominal force, abdominal pressure, body movements) and the forces and moments on manicinal joints from the current manicinal posture. All the output incorporated in the model is based on the scientific community's research results and algorithms. Table 2 showed the results of biomechanics single action analysis for current workstation and workstation with improvement.
Table 2. Biomechanics single analysis for:
(a) current workstation design (b) 2 steps ladder workstation improvement (c) 3 steps ladder workstation improvement

| Biomechanics Summary       | Biomechanics Summary       |
|----------------------------|----------------------------|
| L4 – L5 Moment            | L4 – L5 Moment            |
| -36 Nxm                   | 42 Nxm                    |
| L4 – L5 Compression       | L4 – L5 Compression       |
| 1132 N                    | 1214 N                    |
| Body Load Compression     | Body Load Compression     |
| 464 N                     | 487 N                     |
| Axial Twist Compression   | Axial Twist Compression   |
| 48 N                      | 0 N                       |

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L4 – L5 Compression: 1322 N
Axial Twist Compression: 48 N

(b) L4-L5 Compression: 1214 N
Axial Twist Compression: 0 N

End of Report

L4-L5 Compression: 2649 N
Axial Twist Compression: 52 N

For improvement related with workstation design, two concepts were suggested; 2 steps ladder and 3 steps ladder. From the RULA analysis, both right and left showed the lowest scores compared to current workstation design and 3 steps ladder workstation design which 3 for right and 4 for left. For energy expenditure result, 2 steps ladder showed the least energy used to burn the calories since the working posture only needs less energy to perform the task which is 0.049kcal/s compared to current workstation design and 3 steps ladder workstation design. Whereas for biomechanics single action analysis, L4-L5 compression is 1214 N that indicates the bending is not more than 45° which better than current workstation design. The axial twist compression is 0 N that indicates the posture is comfort since the worker does not have to twist their arm during drilling process. Thus, an improvement of the workstation with 2 steps ladder for this process was the best improvement that should be suggested to the industry.

4. Conclusion

In conclusion, the working posture of the worker at mechanical assembly workstation is completely simulated using RULA and DELMIA analysis software. A conceptual design of 2 steps ladder workstation design is suggested as an improvement to the current workstation design based on the results of analysis obtained with the lowest value of RULA score, energy expenditure and biomechanics single action analysis. In addition, this software was powerful predictive tool to measure the ergonomic risk.
value and improve the workstation design of the industry. This simulated results as well is an excellent work platform in order to integrate and compare physical with virtual augmented reality system.

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