Analysis and improvement of work postures in an automobile industry

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Abstract : Work related musculoskeletal disorder (WMSD) is the common health problems for the industrial workers. The objective of this study is to analyze the working posture of workers engaged in vehicle assembly by applying different postural analysis tools and to identify the various risk factors associate with WMSD. The initial work was carried out by interviews and observations to identify the job tasks that contribute significantly to WMSD. It is observed that the employees working at the vehicle assembly section face major health related issues (WMSD). Discomfort experienced by operators during process has been studied. The Jack software - Task Analysis Toolkit (TAT) was used for postural analysis with 95th percentile Indian anthropometric scaling data. RULA (Rapid Upper Limb Assessment) analysis concludes that the working posture of Rear wheel assembly and Rear view mirror assembly is improper and score has crossed 5. To overcome WMSD, the conveyor's height has been changed from 570 mm to 850 mm as per NIOSH standard. Through investigation, recommendations for reducing risk have been provided with the requirements to improve working posture.

Keywords: RULA, Musculoskeletal disorder, Assembly line, awkward posture

1 Introduction

Work-related musculoskeletal disorders (WMSDs) constitute an important occupational problem for both developed and developing countries, with rising costs of wage compensation and medical expenses, reduced productivity, and lower quality of life [1,5]. It has been estimated that, an annual incidence of occupational injury was found to be impacting one million workers and causing more than one hundred thousand death in India alone [2]. The International Labor Organization (ILO) also estimates that 40% of all costs related to work related injuries [3]. Repeated musculoskeletal disorders (MSD) are only a subset of work-related MSDs and there is a significant underreporting of injury cases with less than 10% reported [7].

In order to prevent WMSD, major risk factors causing WMSD should be quantitatively analyzed. WMSD are caused by multi-factorial interactions of various risk factors, which can be classified into three main groups: individual, psychosocial, and physical. Among the physical workload, body posture, repetitive and forceful activities, static muscle load, mechanical stress, vibration, and cold are known to be the most prevalent [4,8]. Productivity of worker greatly depends upon ergonomic design of workstation. Neglect of ergonomic principles brings inefficiency and pain to the workforce. Improper workstation design can be an important factor responsible for the development of various work related musculoskeletal disorders (WMSD). An ergonomically deficient workplace can cause physical and emotional

stress, low productivity and poor quality of work. Efficient ergonomics in workstation design shows better interaction between man-machine systems [9]. The main concern of work system design in developing countries is usually the improvement of machines tool [10]. Inadequate or no consideration is given to the work system design as a whole. Since the relation between awkward postures and pain has been discussed, several researchers have pointed out that poor working postures contribute to musculoskeletal problems in industry [9,12]. The objective of this study is to analyze the working posture of workers engaged in vehicle assembly by applying different postural analysis tools and to identify the various risk factors associate with WMSD [6].

2 Methodology

This study was conducted in vehicle assembly workstation of a two wheeler manufacturing plant. Almost all parts of the vehicle were assembled by manual process. Assembly process consists of parts of different size and weights. Job tasks that contribute significantly to WMSD were identified by carrying out initial observations and interviews [5]. Also study regarding operator performance and comfort in repetitive assembly task was carried out. The anthropometry data were taken from employees working on that section. After studying, a methodology has been proposed to analyse the posture changes in assembly workplace in relation to both technological and environmental parameters.
The posture assessments were carried out by both theoretical calculation and also computer aided technique. Static ergonomic posture analysis is done by capturing pictures of assembly process using high definition camera. The worker body postures and the movement of other body members are captured and analyzed using RULA posture analysis method. Discomfort experienced by operators during process was studied and RULA (Rapid Upper Limb Assessment) analysis [6] of working postures was analyzed in Technomatix – Jack software to find out awkward postures [11]. The correct ergonomic postures were identified and the adjustable fixtures were designed based upon the input [9].

3 Posture assessment and recommendations

Observations were carried out in an automobile industry. It is observed that the employees working at the vehicle assembly section were facing major health issues. The vehicle assembly stage is mainly divided into 1 main assembly and 20 sub assembly stages. The four most awkward working postures of the workers performing the assembly operation were identified and photographed. A line diagram was developed from the photographs (Figure.1 a, b, c, d) using CAD software.

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Figure.1 Line diagram of awkward postures in the assembly line and its corresponding RULA analysis

The segmental joint angles have been captured from the diagram to analyze the activities. The JACK-Task Analysis Toolkit (TAT) was used for postural analysis with 95th percentile Indian anthropometric scaling data. TAT is an add-on module to JACK (Human simulation and ergonomics analysis software), Siemens PLM Software. Using RULA analysis, a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs were obtained. Scores were then used to compile the risk factor variables, generating a single score that represents the level of WMSD risk. RULA analysis concludes that the working posture of Rear wheel assembly and Rear view mirror assembly is improper. These postures require further investigation and are recommended for modification. Redesign of conveyor might reduce the RULA score, since it plays the significant role in assembly station, where all tasks are done with conveyor.

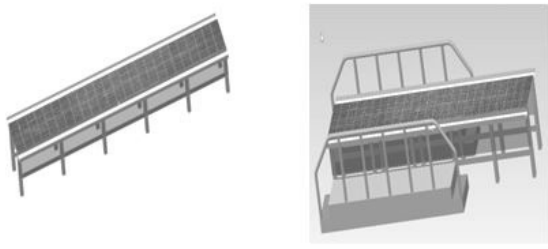

Figure.2 Existing and modified conveyor with RULA analysis

To overcome WMSD, height of conveyor (Figure.2) is adjusted on which different assembling stages can be carried out. Design of conveyor was made on the basis of anthropometry data collected from the employee. The conveyor's height has been changed from 570 mm to 850 mm as per NIOSH (National Institute of Occupational Safety & Health) standard. As a result the RULA score has come down to 3 from 5. This change reduces the back pain and stress developed in hip region. Normal height of conveyor should be 920 mm for the standing position. After considering the range of vehicle height it was modified to 850 mm. From stage 1-10 the operator can stand on the ground and the job is done. After 10th stage the employee can use the foot step, such that he can assemble the mirror and dial comfortably.

The process is further improved by modifying the layout of rear wheel assembly stage (Figure.3). It was found that the operator working in this assembly stage was more comfortable than before. Twisting postures was reduced, by placing trolleys on both sides of the operator.

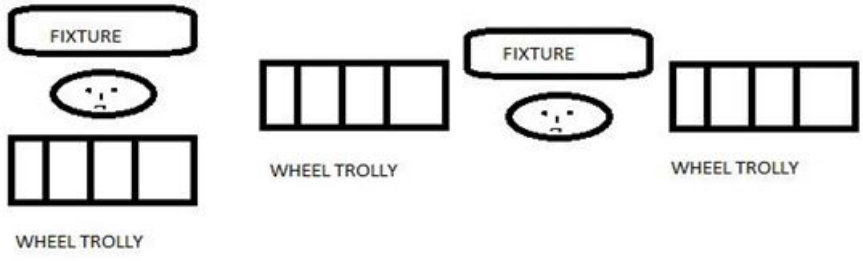

Figure.3 Existing and modified layout of rear wheel assembly stage

At shot blasting stage (Figure.4) operator lifts a vehicle frame that weighs 13 kilograms for every two minutes in the entire shift. Lifting index was calculated. It was as high as 3.3 and require immediate attention to the process. It is suggested to use hoist for lifting and suitably assist the vehicle frame for shot blasting, instead lifting manually. This equipment reduced the human effort considerably.

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Figure.4 Shot blasting stage of vehicle frame

The workstation should be properly designed as per NIOSH standard, if the worker is doing his intended work in standing position for more than 2 hours. A flooring technique called as anti-fatigue flooring (Figure.5), was recommended in all assembly stages. It considerably reduced the worker's lower back discomfort and spinal pain, lumbar region disorder, and increased the stress concentration (Figure.6) on the foot.

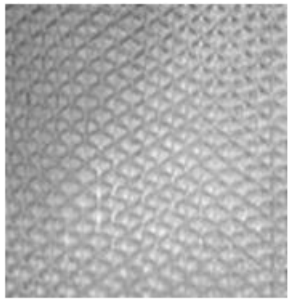

Figure.5 Anti-fatigue floor mat

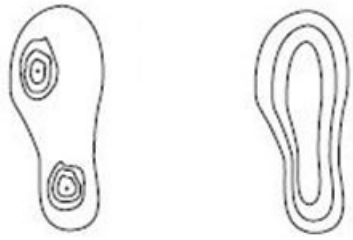

Figure.6 Stress Distribution of Normal and Anti-Fatigue Flooring

4 Conclusion

Posture assessment was performed on the employees working in a vehicle assembly shop. The RULA score indicated 'at risk' jobs. The model provides the severity of the posture towards WMSD. Through the investigation of risk factors, a recommendation for reducing risk was provided to improve working posture. Significant insights have been gained through this methodology that combines assessment techniques to mitigate occupational risk involved in work environments. The conveyor's height has been changed from 570 mm to 850 mm. As a result the RULA score has come down to 3 from 5, thereby increasing the productivity by 3.58 %. The layout of rear wheel assembly stage was modified to eliminate few twisting risky postures. A hoist was suggested for lifting and suitably assists the vehicle frame for shot blasting. The workers were comfortable on anti-fatigue flooring when compared to hard floor based on the feedback, where 92% of users recommended anti-fatigue flooring. This study can be further improved by analyzing psychosocial factors of the employee, Energy expenditure and Heart rate variability.

References

1. Andersson, E. R. (1992). Economic evaluation of ergonomic solutions: part I—guidelines for the practitioner. International Journal of Industrial Ergonomics, 10(1), 161-171.
2. Battini.D., Faccio.M., Persona.A and Sgarbossa.F. (2011). New methodological frame-work to improve productivity and ergonomics in assembly system design. International Journal of Industrial Ergonomics, 41, 30-42.
3. Eswaramoorthi, M., John, M., Rajagopal, C. A., Prasad, P. S. S., & Mohanram, P. V. (2010). Redesigning assembly stations using ergonomic methods as a lean tool. Work, 35(2), 231.
4. Fritzsche, L., Wegge, J., Schmauder, M., Kliegel, M., & Schmidt, K.-H. (2014). Good ergonomics and team diversity reduce absenteeism and errors in car manufacturing. Ergonomics, 57(2), 148–161.
5. García, M., Sánchez, A., Domingo, R., & Sebastián, M. Á. (2014). A cost-benefit ergonomics methodology applied to service industry with digital human modelling. European Journal of Industrial Engineering, 8(4), 533–553.
6. McAtamney, L., & Corlett, E. N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. Applied ergonomics, 24(2), 91-99.
7. Morse, T., Dillon, C., Kenta-Bibi, E., Weber, J., Diva, U., Warren, N., & Grey, M. (2005). Trends in work-related musculoskeletal disorder reports by year, type, and in-dustrial sector: A capture-recapture analysis. American journal of industrial medicine, 48(1), 40-49.
8. Neumann, W. P., Kihlberg, S., Medbo, P., Mathiassen, S. E., & Winkel, J. (2002). A case study evaluating the ergonomic and productivity impacts of partial automation strategies in the electronics industry. International journal of production research, 40(16), 4059-4075.
9. Sanders, Mark S., McCormick, Ernest J. (1987). Human factors in engineering and de-sign (6th ed.). New York, NY, England: Mcgraw-Hill Book Company.
10. Snook, S. H., & Ciriello, V. M. (1991). The design of manual handling tasks: revised tables of maximum acceptable weights and forces. Ergonomics, 34(9), 1197-1213.
11. Sougata Karmakar., Sanjog J and Thaneswer Patel. (2014). Digital Human Modeling and Simulation in Product and Workplace Design: Indian Scenario. International Journal of Engineering Research and Applications, AET, 6-12.
12. Waters, T. R., Putz-Anderson, V., Garg, A., & Fine, L. J. (1993). Revised NIOSH equa-tion for the design and evaluation of manual lifting tasks. Ergonomics, 36(7), 749-776.

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