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Ergonomic Considerations for Design of Industrial Workstation: A Review

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Abstract - *High demand for the products in industries makes the workers to deliver their more effort to complete the work within a specific period of time. Because of inevitable requirement, workers are tend to work in improperly designed workstation without consideration of the ergonomic principles. The ergonomic principles plays a major role in worker's productivity. The objective of this paper is to review the literatures in application of ergonomic principles for workstation design, factors like repetition of work, handling the heavy loads, working with awkward and troublesome postures make the assembly line workers to have a musculoskeletal disorders(MSDs) and various problems faced by the worker's in working environment. Further, the scope of research in workstation design is also established.*

Key Words: Ergonomics, worker fatigue, industrial assembly, anthropometric data, workstation design, musculoskeletal disorders

1.INTRODUCTION

Optimizing the safety, health, comfort and efficiency of the workers in the working environment is the aim of ergonomics. The productivity of workers mainly depend upon the ergonomically designed workstation. Analyzation and improvement of workstation and layout is done by the lots of research. Proper ergonomics in workstation gives a good interaction between the worker and working environment. If the workstation is not designed with considering the anthropometry data, then the efficiency of workstation gets decreased.

Ergonomics is also known as Human factors, comfort design and functional design is a method of designing the products and system to give a high interaction between the people and the working environment. International Ergonomics Association defines ergonomics as the scientific discipline concerned with the understanding of interactions among humans and the other elements of a system and the profession that applies theory, principles, data and methods to design to optimize human wellbeing and overall system performance.

Operator performance and comfort at the time of repetitive assembling task was well clearly studied (Shikdar et al. 2009). Now-a-days in assembly line production, the manual labor share is said to be as high, thus proper attention must want to be given to ergonomics (Alena otto, et al. 2011). Factors like posture, force, repetition of work and vibration which results in the higher rate of injury are to be considered strictly while designing the workstation.

In order to work efficiently and to manufacture good quality products and to increase productivity, the workplace wants to be designed by considering ergonomic principles (M.Muhundhan, 2013).In the current situation, manufacturers realized that instead of investing a lots of money to material, man, machine, method, providing a ergonomical workplace is cost saving (Gurunath et al. 2012). Thus ergonomically designed workstation in industries with proper modular structure provides many benefits, e.g. increased motivation and satisfaction of employee, higher performance, and processing quality.

The task of ergonomics is to optimize the human–machine–environment system adjusting working conditions to physical, psycho-physical and physiological nature of a human, taking into account relevant differences that exist between humans in relation to their jobs and workplace. By James H. Stramler (1993) ergonomics is defined as the field which is involved in doing research regarding human psychological, biological, social, and the physical characteristics, maintaining the information obtained from that research, and working to apply that information with respect to the design, operation, or use of products or systems for optimizing human, health, performance, safety, and habitability.

1.1 Implementation of ergonomics to workstation

By providing the ergonomic considerations in designing the workstation, following are the advantages realized by S. C. Mali et al. 2015.

- Productivity gets increased by providing a comfortable workplace to workers, thereby making the jobs easier

- Product quality is improved because of fewer errors in the ergonomically designed workplace
- Musculoskeletal disorders are allowed to get reduced
- Absenteeism by the workers are reduced due to the lower injury rates faced during their workday
- Ergonomics creates a better safety culture
- Workers comfort increased
- Workers fatigue reduced

2. LITERATURE REVIEW

Following are the literature review of some of the papers which gives more information about their share in field of ergonomics and the factors which are to be considered while designing the workstation. The work done on ergonomic analysis by some of the researchers.

Gurunath, et al. (2012) covered the ergonomic analysis of an assembly workstation. The study was conducted on a welder by capturing the working postures of the worker through video camera. Observations are done in each and every step of the recorded video. Details from the collected video shows that the workplace was not in ergonomical manner and there is a need to modify the workstation layout according to the ergonomic principles.

Baba Md Deros et al. (2011) this paper presents about the study on assembly line workstation design. This study was conducted on workers of automotive component manufacturer. Working postures of the workers during their ordinary work are observed and recorded. Ergonomic factors are thoroughly observed and analysed whether the workers are able to perform the given work and finally the result shows that the workplace was need to be redesign by CAD work to eliminate the awkward postures which tends to MSDs.

Alena otto et al. (2017) describes about the reduction of physical ergonomic risks at assembly line balancing and job rotation. Here the overview of the current optimization approaches to assembly line balancing and job rotation scheduling that considers physical ergonomic risks and some of researches that they utilized are clearly clarified.

Micael Teixeria Goncalves et al. (2017) configures the lean assessment tool for the workstation design of assembly lines with the idea of hierarchy of workstation needs to achieve full performance in workstations. Four levels including the concept of functionality, effectiveness, efficiency and satisfaction are visualised in pyramid view. A checklist based on the current best practices in workstation design is taken for the consideration, based on the results, improvements in the recommending work zones, workstation area with dimensions are introduced for the improvement of waste elimination.

Alan H.S.Chan et al, (2017) noticed on the subjective estimates of times for assembly work by using a jig to assemble the components. By this reason, the worker is able to do his job easily and within a certain time. Actual and estimated time recording are observed and analysed, result shows that estimated time is better than, actual time and leads to increase in the productivity.

G.Mossa et al. (2016) pointed out the productivity and ergonomic risk in human based production systems in which the concept aims to find the optimal job rotation schedules in work environments characterized by low load manual tasks with a high frequency of repetition. After implementing the concept to industry, the optimal job rotation jointly achieves the productivity and ergonomic risk goals.

Armin Scholl et al. (2011) provide detailed study on incorporating ergonomic risks into assembly line balancing. Reassignment of tasks to workers is a best suitable method to reduce ergonomic risks and also the inexpensive method. Moreover the concept does not involve the introduction of new workstation into assembly line balancing.

Baba Md Deros et al. (2015) makes a study on ergonomic awareness among workers performing manual material handling activities. The main objective of this method to identify ergonomic awareness towards manual material handling among the workers and to identify body pain of the workers by making study on set of 32 workers. Result shows that the management take the responsibility for immediate changes in the workplace with the consideration of ergonomic principles.

M.Muhundhan, (2013) improved the workstation design for improving the productivity. Factors like repetition of work, force, posture tends to higher rate of injury. Placing the materials, tools and controls within easy reach makes the lower fatigue to the workers. A well organised workplace minimises material handling, improves efficiency and reduces operator fatigue. By implementing the proper workstation design productivity and efficiency of the worker can be improved in terms of quality and quantity.

Vaidya et al, (2014) evaluates the body posture of worker in small scale industries by conducting study on 15 workers. Postural analysis using RULA and REBA shows that the workers are working above the secure limit and also that most of the workers are working in awkward postures and hence there is a need to change the workstation to avoid musculoskeletal disorders (MSDs).

Anil Mital et al. (1990) pointed out the effects of sitting and standing, each distance and arm orientation on isokinetic pull strengths in horizontal plane. 25 male workers participated in this study and the result shows that more strength is released during standing and describes that

strength exertion becomes stronger as the angle of arm moves to 900 from the front plane.

Jefrey et al. (1992) compares the anthropometry dimensions of South Indian industrial workmen with central, western and northern parts of India. Sample of 128 workmen are allowed to take 27 body dimensions. The result indicates that South Indian mens are smaller than other region mens. Hence there is care to be taken at a time importing a new equipment.

Ashraf Shikdar et al. (2011) developed a smart workstation to assembly line. A fully adjustable workstation was developed, thus the operator is able to work in sitting posture, standing posture and sit stand posture. Experiment was done on a set of college students and the performance of the participants are 43% higher than the smart assembly workstation compared to the existing assembly workstation. Flexibility in workstation reduces the operators fatigue and boosts the operator performance with increase in productivity.

Juan Luis et al. (2015), proposed a design of adjustable workstation for very short and tall people. In the existing workstation, the workplace is fixed, moreover the workers have to handle different axis of dimensions. The objective of this paper is design a new workstation which makes the workers to be comfortable. Muscular fatigue assessment analysis was done on existing and feature workstation. Result shows that high level of fatigue on shoulders, neck,back, and hands are developed by existing workstation and feature workstation is used to reduce the workers fatigue.

Lusia permata, (2016) aimed to determine the standard time of the assembly process. Work measurement was conducted at a manufacturing industry in Indonesia that produces plastic products. Time study is used to measure the performance of the operator that doing jobs in normal pace.

Biman Das, (1987) highlights the methodology that was applied to incorporate ergonomic principles and data to design a manufacturing working system. Moreover he summarized that ergonomically designed working system tends to be more effective in terms of time, safety, and worker productivity, job attitudes and satisfaction.

Takeshi Ebara et al. (2008) describes the effect of adjustable sit stand workstation. The sit stand workstation allows the workers to sit and stand autonomously at the time of working, hence 24 participants participated in the study to identify the effects of workstation. Experiments was done by making the workers to sit at standard workstation, to sit on high chair and to use sit stand workstation. Results shows that sitting condition workstation was superior as comparing with other workstations.

Roger, (1981) proposed the consideration of ergonomic principles in the workstation for the improvement in productivity. Effects of not considering the ergonomic principles and the advantages of considering the ergonomic principles are briefly discussed in this model. Finally the consideration of ergonomic principles in the workstation revealed a high positive advantages to the workers in the industries.

Stephen Konz, (1990) outlined the guidelines for the workstation design. Moreover the way of handling the materials and equipment are well discussed. Concept of minimizing the material handling activities is briefly noted. Information flow and material flow inside the workstations are pointed to the workers in industries.

Melam at el. (1989) studied the factors that are related to the human work in the industries. Body motion and posture, physical effort and environmental factors like ventilation, room temperature are briefly pointed out in this study. Later the ergonomic stress level of the different workers working in the industries are surveyed. Result shows that most of the workers are allowed to the stress.

M.L.Resnick et al. (1997) targeted productivity improvements by making the workplace with ergonomic considerations.in this concept, fifteen subjects are allowed to perform a different industrial tasks in a variety of layout. The effect of work height, tool mass and movement distance on working time are calculated. Finally, the results indicate that workstations are allowed to some changes for maximizing the performance and to improve the worker productivity.

Stuart Smellie et al. (2003) pointed the limitations of standard workstation for its user population. This study aimed to take standard office workstation, assess its usage and then looking upon the factors and parameters in which the normal population is not suitable for that workstation. By the experiment, it is seen that majority of the workers need the footrest in the workstation and then height adjustable in the workstation is necessary for another certain workers. Finally, the armrests and seat depth are having capability of causing fatigue problems, thus the armrests are allowed to be neglected.

Jorgen (1995), described the relationship between the ergonomics and the quality in assembly work. Direct causes of quality deficiencies were identified, such as discomfort from strained parts of the body, time pressure and organizational factors. The result showed that important factor for the job satisfaction is the only key to perform the workers task with high quality. Thereby, the study confirms the particular relationship between the ergonomics and the quality of the final product.

Anna Ivarsson et al. (2015) investigated the relationship between physical workload and quality within line-based

assembly. The experiment was done by physical workload and the work rotation between 52 workstations to find the real and potential quality deviations for 10 weeks. The result shows that workplace with higher workload has more deviations as comparing with the workplace with less workload. Static working posture has more deviations results in high level fatigue causing factor. Hence, the static working posture allowed to get reduced.

Andrea Leskova, (2014) designed a manual workstation with the ergonomic considerations. This paper is a reference to help for planning, designing and implementation of ergonomic workstations by considering the variables like type of work, employee size, lightning and other key factors. Finally it relates the workstation with flexibility for the increase in productivity.

Vijaya Ramnath et al. (2014) analysed occupational safety and health of workers by implementing ergonomic based kitting assembly system. In this paper an overall analysis was carried out to minimise the wastages and to improve the efficiency in an assembly line. Data collection is carried through different ways of interviews with managers and supervisors, safety engineer, safety specialists, workers, in order to know their views on both the negative and positive impacts of Kitting assembly system. The result shows that similar improvement in the existing workstation tends to increase the productivity of the industry.

Marie-Eve Chiasson et al. (2015) focused on the influence of musculoskeletal pain on workers ergonomic risk-factor assessments. An analyzation was done on 473 workers by making questions to them about the musculoskeletal disorders experienced in various body regions during the 12months and 7 days. Results show that the workers were exposed to regular musculoskeletal disorder (MSD) risk factors, according to the FIOH assessment and the high percentages of reported pain.

S. Consiglio et al. (2007), developed a hybrid assembly workstation. Hybrid workplaces commonly useful for both the human beings and the robot through the flexibility. In this paper, different concepts for hybrid workplaces are introduced and compared with respect to investment costs and configuration effort. Due to the improvement in the usage of the robots, the productivity of the industry gets improved within a short period of time.

Boenzi et al. (2016), focused on the ergonomic improvement through job rotations in repetitive manual tasks in case of limited specialization and differentiated ergonomic requirements. In this paper workers are suggested to do different works instead of doing the same work for prolonged period of time. Through this concept, the workers are not allowed to any kind of the high risk fatigue, thereby the workers' productivity is increased in certain life period. The OCRA (Occupational repetitive action) score method is used for ergonomic assessment in case of infrequent job rotation.

Michael Zulch et al. (2017) was aimed to evaluate the U-shaped workstation. Due to reason of available congested workspace, the customer was not satisfied through the delivery of the products, thus the workstation was designed in U-shaped structure to increase the production thereby satisfying the customers in a short period of time. At the result, the productivity of the industry is improved by certain level as comparing with the normal time production.

Stephan Konz, (1990) described the workstation organization and the design. In this paper, the author pointed out the handling of the material during the normal time work and also the information flow. Through proper handling of the work equipment the worker is not able to attend any kind of the fatigue and risk factors. Hence the worker is able to perform his work for an extended period.

Isa Halim et al. (2011) had shown the health effects associated with prolonged standing in industrial workplace. Information on health effects, assessment methods, and control measures associated with prolonged standing jobs in industrial workplaces makes the workers working in improper working condition to get attention in order to reduce the future problems like back pain, musculoskeletal disorders and other fatigue causing problems.

3. CONCLUSIONS

From the above literature review, it is finalized that assembly work involves various manual operations. There are many reasons in the industries for the decrease in the quality of final product, upon many reasons poor workstations are the root cause for problems. The above literature review confirms that the ergonomic principles are allowed to consider while designing any industrial workstations in order to increase the productivity and worker comfort. The objectives of most of the work carried by the authors is to detect the proper and improper working posture of the workers working in an industry.

The previous study of various tasks shows that the workers are working in an awkward postures at current situation. Thus, the ergonomic considerations are taken into account for decreasing the musculoskeletal disorders and to improve work efficiency in the industry. The paper presented a literature review focusing the studies on ergonomic effective design of industrial workstations. Review found that most of the industries must want to adapt ergonomic principles while making the workplace.

From the above literature review, it is found that various factors like workstation height, sitting chair flexibility, anthropometry data, reach zone, ability of the workers are

effectively used for the analysis and improvement of the workstation.

REFERENCES

[1] Baba Md Deros, Nor Kamaliana Khamis, Ahmad Rasdan Ismail, Haris Jamaluddin, Azmi Mat Adam, Sarudin Rosli, "An ergonomics study on assembly line workstation design", American Journal of Applied Sciences, vol.8, no.11, 2011, pp. 1195-1201.

[2] Gurunath V Shinde and V. S. Jadhav, "Ergonomic analysis of an assembly workstation to identify time consuming and fatigue causing factors using application of motion study", International Journal of Engineering and Technology, vol. 4, no. 4, Aug-Sep 2012, pp. 220-227.

[3] Alena Otto and Armin Scholl, "Incorporating ergonomic risks into assembly line balancing", European Journal of Operational Research, vol. 212, 2011, pp. 277-286.

[4] Alena Otto and Olga Battaïa, "Reducing physical ergonomic risks at assembly lines by line balancing and job rotation", "Computers & Industrial Engineering", vol. 111, 2011, pp.467-480.

[5] Alan H. S. Chan, Errol R. Hoffmann and Cally M. W. Chung, "Subjective estimates of times for assembly work", International Journal of Industrial Ergonomics, vol.61, 2017, pp. 149-155.

[6] Micael Teixeira Gonçalves and Konstantinos Salonitis, "Lean assessment tool for workstation design of assembly lines", vol.60, 2017, pp. 386-391.

[7] Juan Luis Hernandez-Arellano, J Nieves Serratos-Perez and Ariel de la Torre, "Design proposal of an adjustable workstation for very short and very tall people", International Conference on Applied Human Factors and Ergonomics, vol. 3, 2015, pp. *5699 – 5706.*

[8] Baba Md Deros, Dian Darina Indah Daruis, Ishak Mohamed Basir, "Procedia -social and behavioral sciences", vol.195, 2015, pp.1666-1673.

[9] M.Muhundhan, "Improved work station design for improved productivity", International Journal of Scientific Engineering and Technology, vol.2, no.3, Apr. 2013, pp.225-227.

[10] Jeffrey E. Fernandez, Krishn*ga.* Uppugonduri, "Anthropometry of South lndian industrial workmen", Ergonomics, vol.35, no.11, 1992, pp. 1393-1398.

[11] Anil mital and Hamid F, Faard, "Effects of sitting and standing, reach distance and arm orientation on isokinetic pull strengths in the horizontal plane", International Journal of Industrial Ergonomics, vol.6, 1990, pp. 241-248.

[12] R. D. Vaidya, K.G. Sontakke, N. A. Ansari, "Ergonomics evaluation of body posture of worker in SSI", Journal of Emerging Technologies and Innovative Research, vol.1, no.6, Nov. 2014, pp. 430-434.

[13] G. Mossa, F. Boenzi, S. Digiesi, G.Mummolo, V. A. Romano, "Productivity and ergonomic risks in human based production systems: A job-rotation scheduling model", International Journal of Production Ergonomics, vol.171, 2016, pp.471-477.

[14] M. L. Resnick and A. Zanotti, "Using ergonomics to target improvements", Computers Industrial Engineering, vol.33, no.2, 1997, pp. 185-188.

[15] Andrea leskova, "Designing of manual workstation structure with emphasis on ergonomics", Bulletin of Engineering Tome, vol. 7, 2014, pp. 41-46.

[16] Stuart Smellie, "The limitations of a standard workstation for its user population", Clinical Chiropractic, vol. 6, 2003, pp. 101-108.

[17] F. Boenzi, S. Digiesi, F. Facchini, G. Mummolo, "Ergonomic improvement through job rotations in repetitive manual tasks in case of limited specialization and different ergonomic requirements", IFAC, 2016, pp. 1667-1672.

[18] Ashraf Shikdar, Ibrahim Garbie and Mohammad MR Khan Khadem, "Development of a smart workstation for an assembly task", International Conference on Industrial Engineering and Operations Management, 2011, pp. 826-831.

[19] Jorgen A. IE. Eklund, "Relationships between ergonomics and quality in assembly work", Applied Ergonomics vol.26, no. 1, 1995, pp. 15-20.

[20] S. Consiglio, G. Seliger and N. Weinert, "Development of hybrid assembly workplaces", 2007.

[21] Anna Ivarsson & Frida Eek, "The relationship between physical workload and quality within line-based assembly".

[22] B.Vijaya Ramnatha, C. Suresh Kumar, G. Riyaz Mohamed, "Analysis of occupational safety and health of workers by implementing ergonomic

based kitting assembly system",Procedia Engineering, vol.97, 2014, pp. 1788- 1797.

[23] Roger J. Hasselquist, "Increasing manufacturing productivity using human factors principles", 1981.

[24] Stephen Konz, "Workstation organization and design", International Journal of Industrial Ergonomics, vol. 6, 1990, pp. 175-193.

[25] S. Melamed, J. Luz, T. Najenson, E. Jucha and M. Green, "Ergonomic stress levels, personal characteristics, accident occurrence and sickness absence among factory workers", Ergonomics, vol. 32, no.9, pp.1101-1110.

[26] Lusia Permata Sari Hartanti, "Work measurement approach to determine standard time in assembly line", International Journal of Management and Applied Science, vol.2, Oct.2016, pp. 192-195.

[27] Marie- Eve Chiasson and Judy Major, "Influence of musculoskeletal pain on workers' ergonomic risk-factor Assessments", Applied Ergonomics, vol.49, 2015, pp.1-7.

[28] Michael Zulch and Gert Zulch, "Ergonomic evaluation of U–shaped assembly system", International Journal of Industrial Ergonomics, vol.61 (2017), pp. 149-155.

[29] Biman Das, "An ergonomic approach to designing a manufacturing working system", International Journal of Industrial Ergonomics, vol. 1, 1987, pp. 231-240.

[30] Isa Halim and Abdul Rahman Omar, "Health effects associated with prolonged standing in the industrial workplaces", International Journal of Research and Reviews in applied sciences, vol.8, (July 2011), pp. 14-21.

[31] Takeshi Ebara, Tomohide Kubo, Tatsuki Inoue, Gen-I Murasaki, Hidemaro Takeyama, Tomoaki Sato, Hatsuko Suzumura, Sayuri Niwa, Toshimasa Takanishi, Norihide Tachi And Toru Itani, "Effects of Adjustable Sit-stand VDT Workstations on Workers" Musculoskeletal Discomfort, Alertness and Performance", Industrial Health,vol.46, 2008, pp.497–505.

[32] S. C. Mali and R. T. Vyavahare "An ergonomic evaluation of an industrial workstation: A review", International journal of current engineering and technology, vol.5,no. 3, (June 2015).

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