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Research Article

An Ergonomic Evaluation of an Industrial Workstation: A Review

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Abstract

This paper presents the review of the studies carried out on the ergonomic design of industrial workstations. For most of the small scale industries in India the ergonomics principles are not considered at the time of designing industrial workstation. So there is a necessity to consider ergonomic principals at the time of designing industrial workstation to reduce musculoskeletal disorders (MSDs) and prevent injuries to the industrial operators. The objective of this paper is to give an overall literature review on the work done related to ergonomic evaluation of industrial workstations and suggested ergonomic improvements. Ergonomic problems are major issues faced by the foundry industry. The ergonomics principals play very vital role in operators' productivity. The two factors, namely workstation layout and work design are important for operators' or workers' efficiency. Therefore, it is very much essential to review on the scientific studies whose aim is to achieve the ergonomic design of industrial workstations. Now a days manufactures found that improvements in ergonomics of workstation are more beneficial in terms of cost saving instead of investing cost in man, machine, material and method.

Keywords: *Ergonomics, Ergonomic design, Workstations, Industrial operators.*

1. Introduction

The aim of ergonomics is to optimize safety, health, comfort and efficiency of the human in the work system. Physiological activities in foundries in an ergonomic sense involve reaching, bending, lifting heavy objects, using continuous force, working with vibrating equipment and repetitive motion. It is important to implement safety and health policy and program to protect workers.

Ergonomics enhances human performance, including the health, safety and productivity of workers. The International Ergonomics Association (IEA) defines ergonomics as; the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance (Ansari, *et al*, 2013). In industrialized countries, upper limb work-related musculoskeletal disorders (UL-WMSDs) are the most common form of occupational diseases. So for considering this factor operator needs proper seating arrangement such that their problems regarding the MSDs can be reduced & productivity will be increased (Wanave, *et al*, 2013). To fulfill the company objectives it is important to produce the quality products. Labor is an important factor of any kinds of industry because they are directly related to the productivity of the system. Their ability, skills, productivity and performance have a great importance towards the increased production (Chowdury, 2014).

Small scale industry plays a vital role in the development of countries like India; they play an important role in employing the majority of the industrial workers. The majority of workers are suffering from musculoskeletal disorders which is a most common work-related problem in India (Ansari, *et al*, 2014). Ergonomics is concerned with making the workplace as efficient, safe and comfortable as possible. Effective application of ergonomics in work system design can achieve a balance between worker characteristics and task demands. This can enhance worker productivity, provide worker safety, physical and mental well-being and job satisfaction. For optimum design of a workstation, anthropometric data is required. (Das, *et al*, 1983). Reviewed the concept of workplace design and the application of anthropometric data. It reported that an adjustable chair was highly desirable at the workplace and a workbench of standard size. However, the standard height of the workbench could not be defined without the anthropometric data of the user population (Shikdar).

Ergonomics is the application of scientific principles, methods, and data drawn from a variety of

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disciplines for the development of engineering systems in which people play a significant role (Kroemer, 1994). The Institute for Occupational Ergonomics (1999) defined ergonomics as an understanding of the needs, limitations, and abilities of people, and the use of this understanding for the design of products and environments in which people live. Productivity of worker greatly depends upon ergonomic design of workstations. Efficient ergonomics in workstation design shows better interaction between man-machine systems. A lot of research has been done on analyzing and improving ergonomics of workstation, facility layout and tool design. A study regarding operator performance and comfort in repetitive assembly task has been done (Shikdar, *et al.* 2009).

1.1 Implementation of ergonomics to workstation

We can have the following advantages by providing a workplace free of ergonomic hazards

- Lower injury rates as MSD incidences go down;
- Increase productivity by making jobs easier and more comfortable for workers;
- Improve product quality because fewer errors will be made when using automated
  Processes that demand less physical effort;
- Reduce absences because workers will be less likely to take time off to recover from muscle soreness, fatigue, and MSD-related problems;
- Reduce turnover as new hires are more likely to find an ergonomically designed job within their physical capacity;
- Lower costs as workers' compensation and other payments for illness and replacement workers go down;
- Improve worker safety;
- Increase worker comfort;
- Reduce worker fatigue; and
- Improve worker morale.

2. Literature Review

Following is the literature review of some papers giving more information about their contribution in ergonomics field and industrial work station for human ergonomics evaluation factors perspective.

Some of the researchers doing their work in ergonomics analysis.

Ansari, *et al*. (2013) noticed on the ergonomics consideration required to be governed in the small scale industries (SSIs). The crack between ergonomic considerations and actual practices at the place of work gives the standpoint to design the workstation. The data of musculoskeletal disorders of employees working at the workplace of cultivators and harvester manufacturing unit are collected, analyzed and justified by using REBA.

Wanave, *et al*. (2013) covered the evaluation of the workstation to improve the productivity by reducing the back pain, shoulder injury, fatigue, etc. Musculoskeletal disorders (MSDs) continue to be a tremendous burden on industry with back injury and shoulder disorders being among the most common and costly disorders because of not having a proper workstation. In industrialized countries, upper limb work-related musculoskeletal disorders (UL-WMSDs) are the most common form of occupational diseases.

A. Chandra, *et al*. (2011) investigated assumptions of normality commonly made by designers in establishing workplace, equipment and tool design. The study analyzed hand anthropometric dimensions of male industrial workers of Haryana state. The objective of this analysis was to check the precision in anthropometric measurement.

Rahman (2014) Covered research work in a leading ceramic industry of Bangladesh in order to study and assess the work postures of workers working in the production section through RULA. The objective of the research work was to analyze the various work postures of the workers of the selected ceramic industry. To analyze the work postures of workers, rapid upper limb assessment (RULA) technique has been used.

S. Vaclav, *et al*. The suggested procedure for design manual assembly workstation in a CAD environment to achieve such design of workstations, which will create good conditions for productivity and high quality of human work. This is the reason why is necessary to take in account ergonomics aspects of the workspace. In describing procedure are using CATIA ergonomics modules for analysis of designing solutions and optimize layout of manual workstations.

Ansari, *et al*. (2014) provide detailed study was conducted on 15 workers engaged in small scale industry situated at MIDC Wardha (Maharashtra, India). Video tape on different activities of the workers was prepared and then the images were cropped from it for the analysis. This study presents an assessment of work posture of workers engaged in different activities of small scale industry. Evaluation of the posture was carried out using RULA and REBA. Assessment is carried out using the worksheet. Evaluation using postural analysis by RULA and REBA indicates that the workers are working above the secure limit.

Shikdar, had shown that A fully adjustable, ergonomically designed assembly workstation was developed with special features such as a motorized table with upward, downward and angular movements, ergonomic chair with adjustable seat pan, arm and back supports, and a mechanism for bins and tool adjustments. The workstation could be used as sit, stand or sit-stand workstation. An experiment was conducted using college students who worked on both existing and the smart assembly workstations. The objective of this eliminates anthropometric and ergonomic problems of fixed workstation and thus boost operators' performance and reduce occupational health and safety problems.

Noriega, (2009) this paper presents two cases of study where ergonomic evaluations were conducted in

work situations related to the operation of Advanced Manufacturing Technology (AMT) equipment: Computer Numerical Control (CNC) Milling Machine and (CNC) Lathe. The Marley and Kumar (1996) Body Map format among 10 workers was conducted for pain in discomfort study and Hignett and Mc Atamney (2000) REBA method was used for ergonomic evaluation. Shoulders, middle back, hand and arm pain were identified. The evaluation results indicated a medium risk level for both work stations according to REBA. Recommendations for changes in equipment components and the workstation are presented.

Stalin, *et al*. (2014) Gave general principles related to ergonomics and material handling in the industry. Ergonomics involves workstation set-up and design, body posture, prevention of computer related injuries and more. Material Handling is the field concerned with solving the pragmatic problems involving the movement, storage, control and protection of materials, goods and products throughout the processes of cleaning, preparation, manufacturing, distribution, consumption and disposal of all related materials, goods and their packaging. The objective of the project is to implement proper ergonomics and material handling in the industry.

Bossomaier, *et al*. The authors provide the readers with an accurate overview of the main scientific approaches proposed (during the last two decades) by researchers and scientists working in this specific area. In particular, two main scientific approaches have been identified. The first approach is based on the direct analysis of the real workstations, while the second one uses computerized models to design workstations ergonomically. Each scientific approach will be presented through a detailed description of the research works it involves. The initial search identifies a huge number of articles which were reduced to about 60 studies based on content and quality. Note that the research works description represents the core part of this literature review.

Mahatme, *et al*. (2014) provided detailed ergonomic analysis and workstation design for sheet-metal disc, teeth cutting operation on a power press. Presently the operation under consideration is manual. The worker manually picks the disc from the input bin and places it onto a press bed for teeth cutting and after completion, removes the disc and places it into an output pin. For studying the ergonomic conditions of the worker, a detailed RULA and REBA analysis of the work is carried out. A conceptual CAD model is developed for this purpose. The simulation of the CAD model is done, which verifies its workability. The design of the CAD model is done. The software used for RULA analysis and CAD model development and simulation is CATIA V5R19. For REBA analysis REBA assessment worksheet is used.

Wanave, *et al*. (2014) had shown that the evaluation of the workstation to improve the productivity by reducing the back pain, shoulder injury, fatigue, etc. In industrialized countries, upper limb work-related musculoskeletal disorders (UL-WMSDs) are the most common form of occupational diseases.

It is shown that the suggested workstation improves working posture and results in reduced postural stress on operators' bodies and, consequently, reduce the prevalence of MSDs symptoms.

Charnes, *et al*. (1996) provide a review on awareness of Virtual Reality with respect to simulation. A brief tutorial will be presented to clarify the terminology employed in the field. Examples of applications in a range of fields will be given, using Virtual Reality software combined with a variety of simulation engines. Virtual Reality devices will be available, affording attendees to experience different modes of involvement with the simulated environment. Dufort, *et al*. (1999) studied that the development and reliability evaluations of a checklist for measuring the state of housekeeping in the industry. This study involves the development and reliability evaluations of a checklist for measuring the state of housekeeping in the industry. The instrument was tested in fifty nine companies in the transportation equipment and machinery manufacturing sector in Quebec, Canada each employing between twenty and sixty workers. The checklist, walk through procedure usually required under thirty minutes.

Choi, *et al*. (2002) had discussed the initial efforts to implement simulation modeling as a visual management and analysis tool at an automotive foundry plant manufacturing engine block. The foundry process was modeled using Pro Model to identify bottlenecks and evaluate machine performance, cycle times and production data (total parts, rejects, throughput, products/HR) essential for efficient production control. Results from the current system identified an assembly machine work area as the bottleneck (although utilization was greater than 95% for two assembly machines) resulting in high work-in-process (WIP) inventory level, low resource and machine utilization. Based on these results, optimum numbers were identified through the use of scenarios by varying the number of assembly machines and processing time of each machine.

Shinde, *et al*. (2012) study was conducted on assembly workstation of the welding shop. Ergonomic study of this assembly workstation was done by using motion study. Observations were made by studying each element of motion film recorded by the video recorder. The results from this study shown that there is a need to modify workstation layout according to ergonomic principles.

Wilson, *et al*. (2012) covered a review of the evidence for the physical and cognitive factors that characterize an ageing workforce in manufacturing. From an ergonomics and human factors (E/HF) perspective, characteristics of manufacturing tasks and the effects of ageing provide an insight into how the industry will have to adapt to support the user needs of the older worker in the future. The approach taken is

drawn from an Ilmarinen's framework of age, experience, and work performance, from which specific E/HF issues are explored.

Fang, *et al*. (2007) investigated the risk factors of WMSDs for hairdressers by identifying the body regions associated with significant discomfort. Twelve professional Taiwanese hairdressers were invited to join this pilot study in Taiwan using a hairdresser-oriented musculoskeletal questionnaire to develop the study. The results from the study show that 91.7% of subjects reported shoulder discomfort as the most frequent problem followed by discomfort in the lower back (83.3%) and in the neck region (75%). The Objective of the study reveals that the effects of ageing could increase discomfort levels in the lower back and lower leg.

Trentin, *et al*. (2012) had shown that thermography as a means to make an ergonomic evaluation of a job in metal casting, an area that involves activities that are energy sapping wearisome and uncomfortable for workers. Use was made of the method of macro-ergonomic analysis of work proposed by Guimarães (1998), in a medium sized industry, in the sectors of manual molding and finishing. 27 workers were evaluated. Based on this method and statistical analysis, the finishing sector was identified as the most critical one, in which thermograms were collected during the work activity of a volunteer.

The results indicate that the analysis of thermograms assists in the evaluation of work activities, as the physical exertion expended is quantified. This technique can potentially aid the study and improvement of jobs in the industry, particularly those that most weary the human body.

Gupta, *et al*. (2009) provided a detailed ergonomic evaluation of the pedal sheller was conducted and compared with the conventional hand beating method considering different physiological parameters like heart rate at rest (HR Rest), heart rate at work (HR work), Work pulse (WP), heart rate per nut and subject rating scale like Overall Discomfort Rating (ODR) and taking six male and six female agricultural workers in the age group of 20- 40 years.

It was suggested that in order to increase the capacity of shelling further and making the newly developed sheller ergonomically efficient, the pedal sheller could be modified to be operated by an external power source (electric motor) basing on the same principle of impulse and tension by incorporating suitable mechanisms.

Tiwari, *et al*. (2014) gave general study, which was carried out in the city of Taj. Ten foundry industries of small and medium in nature were selected. Nominal group technique (NGT) and idea Engineering was used to gather the basic information. Various physiological parameters of workers were measured.

The basic objectives of the study were to improve the worker's productivity in general and the overall productivity in particular. Eight tasks/postures were selected and their improved methods were analyzed. The Fuzzy dominance method & A.H.P assessment were carried out for final results.

Kumar, *et al*. (2014) had shown that the goal of ergonomics is to reduce work related musculoskeletal disorders by adapting the work to fit the person, instead of forcing the person to adapt to the work. Ergonomics is concerned with the design of systems in which people carry out the work.

The results shown that a study of ergonomic investigation about the working culture in the micro, small and medium scale industries in Jharkhand and their effect on the net productivity.

Francesco Longo and Nadia Rego Monteil, provides a general framework for Digital Human Modelling & Simulation (DHMS) and includes a review of successful case studies where the purpose is to design industrial workstations combining ergonomics and an engineering approach.

The objective of this study is to provide both a starting point for more research and also a classification scheme for DHMS based studies. As a result, this article will help the reader to understand how a DHMS study can be usefully developed in different sectors and by means of different methods and tools.

Peters, *et al*. (2002) had shown that to make improvements to the production systems of the steel casting industry through ergonomic improvements. Ergonomic improvements will assist the operators to more efficiently and consistently produce quality products. Student researchers conducted ergonomic assessments at twenty-six companies. During these 1-2 day visits, five jobs, chosen by the company, were studied. A videotape of the jobs was obtained, the dimensions of the workstation were taken, and the operators and supervisors were interviewed. During these events, short videotape segments were reviewed and the ergonomic hazards identified. The objective of this, the research team presented a proposed solution and the justification. The interactive nature of the events allowed the team to collect additional industrial input to improve the solutions.

Ray, *et al*. A study was conducted with an aim for better designing of workstations for the small scale Industry. The study examined the work posture of 75 women workers engaged in a small scale industry, performing the task of sorting, inverting and packing socks. . To understand whether the continuous sitting on floor Posture is the culprit for this kind of problem and whether it can be rectified, a study was conducted with an aim for better designing of workstations for the small scale Industry.

Myhre, *et al*. (2012) OSHA rates for employee injuries are higher for healthcare employees than for employees of any other industry. Healthcare has been identified by OSHA as having "a weak culture of worker safety." NIOSH, CDC, OSHA, ANA, among others, has developed ergonomic guidelines and tools to assist healthcare professionals in developing effective ergonomic programs. However, employee injuries in

healthcare persist. This presentation identifies the essential components for developing an effective ergonomic program for healthcare professionals.

Battini, *et al*. Investigated how ergonomics and assembly system configurations are intimately related in practice, and to develop a conceptual framework for the assembly system design, in conjunction with ergonomics optimization of the work place. An industrial case to illustrate the application procedure is presented and advanced simulation software is used, as the final step, to validate the procedure and support the theoretical framework.

Vaidya, *et al*. (2014) It was concluded that; there is a lack of ergonomics, social contact and understanding of small scale manufacturing industries (SSMIs). Postural analysis using REBA, RULA indicates that the workers are working above the secure limit. A major quantity of the workers is working in awkward postures. Thus the workers are under moderate to high risk of Musculoskeletal disorders (MSDs).

M. Iqbal, *et al*. (2011) focused on the importance of ergonomics in product design, working environment, and its influence in industrial workstation design, the interdisciplinary nature of ergonomics and the implications of ergonomics in industrial engineering function. It also contains the importance of ergonomics for an industrial engineer to design a product.

L. P. Singh, focused on posture analysis of the workers working in forging industry. The study was conducted on 130 workers engaged in various process of small scale forging firms of northern India. Video recording of different activities of the workers was done and then the images were cropped from it for the analysis. Posture analysis tools RULA, REBA and OWAS were used. The results of REBA shown that about 10.65% of the workers were under very high risk level and needed a necessary action immediately.

Singh, *et al*. (2012) study was aimed to evaluate the musculoskeletal disorder (MSD) of workers engaged in Small scale forging industries. A study was conducted on 102 workers in a forging industry using the posture analysis tool RULA Method. A video showing the different activities of the workers was shot and then the images were cropped from it for the analysis.

The results of RULA showed that about 20.33% of the workers were under high risk levels and required immediate change. About 45.32% of the workers were at lower risk levels and 34.33% of the workers were at medium risk levels. The present Study recommended the awareness and proper ergonomics training to the workers.

Singh, *et al*. (2013) study was aimed to evaluate the musculoskeletal disorder (MSD) of workers engaged in Small scale forging industries. A study was conducted on 102 workers in a forging industry using the posture analysis tool REBA Method. A video showing the different activities of the workers was shot and the snapshots were taken from it for the analysis.

The results of REBA showed that about 7.63% of the workers were under very high risk levels and required immediate change. About 44.6% of the workers were at high risk levels which required changes soon and 45.03% of the workers were at medium risk levels . About 2.67% of the workers were at lower risk levels.

The present Study recommended the awareness and proper ergonomics training to the workers.

Shikdar, (2004) main objective of this research was to conduct an assessment of ergonomic-related problems in oil rigs in a desert environment. A checklist, physical audit and medical records were used in the invstigation.

The results showed significant health, environment and work-related problems that could be attributed to ergonomic deficiencies in the work system of the oil rig. Ergonomics should be considered in the work system design so as to reduce or eliminate problems in oil rigs in hot desert environments.

Karandikar, *et al*. (2013) investigated ergonomic aspect of machine design and the design of a workstation to kill the root cause of the problem. The guidelines provide a conceptual basis for a good workstation design. The procedure for determining the workstation dimensions and layout has been explained. A case problem (Barrel Injector number punching machine) is discussed to illustrate the workstation design procedure with the application of engineering anthropometry.

DULINA, *et al*. (2011) investigates to tackle solving the ergonomic design of workplaces, closely with the research team of the Central European Institute of Technology (CEIT). Together, in addition, ergonomics and detailed design of workstation devoted to the digitization using 3D laser scanning, 3D design of production systems, planning processes, development and analysis of time management, simulation and optimization of production and logistics systems.

Ulin, *et al*. (1990) had describes the use of macros for manipulating manikins and workstation components and for designing the workplace. AutoCAD, a popular computer aided design software package, was used to demonstrate the feasibility of these concepts. Specifically, macros are used for drawing work equipment using parametric designs, manipulating manikins and analyzing jobs.

Cimino, *et al*. provides a literature review on the workplace ergonomic effective design in the manufacturing systems and industrial plants sector.

The main objective is to provide the reader with an accurate overview of the main scientific approaches proposed (during the last decades) by researchers and scientists working in this specific area. The paper passes through the description of several research works as they run through the literature.

Chaudhary, *et al*. (2013) India is a developing country and Musculoskeletal disorders (MSDs) are a common problem in Indian industries. In Indian cardboard industries we find MSDs is high i.e. the exposure of workers to MSD risk is high. All work is done manually by the workers. Most workers are male.

The manual work load can therefore cause MSDs amongst the workers. The paper describes the MSDs are observed by ergonomic body posture analysis tools. Body postural analysis using RULA, REBA indicates that the workers are working above the safe limit. Which tells us that the body posture in not safe, need investigation and change.

Sengupta, *et al*. (1997) had shown that A three dimensional (3D) human modeling program has been developed to work in conjunction with computer aided design software, AutoCAD. The program allows the creation and manipulation of variable size, 3D human models and provides the flexibility of a professional CAD system. The special features of the program and its application in workstation design are described and illustrated with examples. This program operates on a personal computer and provides a low cost but effective alternative to mainframe based similar systems.

McAtamney, *et al*. RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. This tool requires no special equipment in providing a quick assessment of the postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list, which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator.

3. Result and Discussion

From above literature review, it is observed that foundry work involves various manual operations. There are many types of products, particularly in the foundry industry, makes automation infeasible for many Segments. In addition, many foundry industry workplaces suffer from poor facility design and large work in process inventories.

The above literature review showed that there is a necessity to consider ergonomics principals at the time of designing industrial workstations for increasing productivity and worker comfort. There are many small scale industries (SSI) in that ergonomics study essential Present days. Anthropometric and strength data of Industrial workers are very essential for the safe, user-friendliness and efficient design of Industry Workplaces. All manual assembly workstations should be designed by taking into account the worker who will work there. This is the reason why is necessary to apply ergonomic demands to manual workstation design.

The objectives most of the work carried by various authors was to identify the good and bad work posture of the workers working in an industry. From the study of the various tasks or methods used by foundry workers, we can say that the workers were working in various awkward situations. An ergonomic investigation will be needed to decrease WMSD problems in order to improve work efficiency in the industry.

The application of Ergonomics is very much in Europe and North America. Recently, Southeast Asian countries, including Bangladesh have been applying the concept of ergonomics industrial workstation design.

So there is a necessity to consider the application of ergonomics at the time of designing industrial workstation in India.

Conclusion

The paper presented a literature review concerning the studies on ergonomic effective design of industrial workstations. Review found that especially in small scale industries, hardly any ergonomics principles are used. Moreover, most of the tasks are carried out manually in such industries.

From the above literature review, it is observed that various tools such as RULA, REBA, strain index, biomechanics analysis, carry, push-pull analysis can be effectively used for the analysis and improvement of the industrial workstation.

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