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A Review on Computer Based System in Industrial Ergonomics for Manufacturing Organizations

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ABSTRACT : The current paper focus on the issues related to the application of ergonomics principles and knowledge for the design of working environment and products in manufacturing industries and then outlines a plan to develop a Computer Assisted Intelligent Ergonomics System (CAIES) using the principles of expert system with a knowledge base to allow a production engineer or supervisor or even a worker with a minimal ergonomics background or no prior knowledge of ergonomics, to diagnose and solve industrial ergonomics problems. The relationship between the application of ergonomics and improvement of productivity and enhancement of product quality is also highlighted in this paper and then it is shown that the poor acceptance and application of ergonomics is due to lack of exposure to ergonomics knowledge and availability of ergonomics knowledge in a suitable form leading to its utilization in manufacturing activities.

Keyword : Ergonomics, Expert Systems, Work Place Design.

I. INTRODUCTION

There is a growing concern to improve productivity, safety, and quality in manufacturing industries. Some of the common problems of these industries are improper workplace design, ill-structured jobs, mismatch between workers abilities and job demands, adverse environment, poor human-machine system design and inappropriate management programs. They lead to workplace hazards, poor workers' health, mechanical equipment injuries, disabilities, and in turn reduce worker productivity and product/work quality and increase cost [1, 3].

It would, therefore, be extremely difficult to attain the objectives of the manufacturing industries without giving proper consideration to ergonomics. 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. Many research studies have shown positive effects of applying ergonomics principles in workplaces, occupational health and safety, machine design, job design, environment and facilities design [3].

The studies carried out also indicate a relationship between ergonomic work conditions and the quality of the work. A typical example is the study conducted by Eklund [9] to evaluate relationships between a number of ergonomic conditions and product quality in car assembly. The most physically demanding tasks, the tasks with the most difficult parts to assemble, and the most psychologically demanding tasks, were identified by interviews with experienced assembly workers. Information on quality deficiencies was obtained from the internal quality statistics of the company and from interviews with quality control personnel. The results showed that the quality deficiencies were three times as common for the work tasks with ergonomics problems, compared with the other tasks. An increased risk of quality deficiencies was seen for all three categories of ergonomics problems investigated. The study therefore confirms close relationships between ergonomics and quality.

Ergonomics is defined as the design of the workplace, equipment, machine, tool, product, environment, and system, taking into consideration the human's physical, physiological, biomechanical, and psychological capabilities, and optimizing the effectiveness and productivity of work systems while assuring the safety, health, and wellbeing of the workers [6]. Ergonomics is also referred as Human Factors Engineering deals with the application of information about human behavior, capabilities and limitations to the design of systems, machines, tools, tasks / jobs, environments, etc. for productive, safe and effective human use [1]. A manufacturing industry is a complex human-machine-environment-organization system. For productive and effective functioning of this system management should ensure optimum functioning of the system components. In general, the aim in ergonomics is to fit the task to the human and not the human to the task However, there is still a low level of acceptance and limited application of ergonomics in the manufacturing industries. Neglect of ergonomic principles brings inefficiency and pain to the workforce. An ergonomically deficient workplace can cause physical and emotional stress, low productivity and poor quality of work [2].

Workstations can be designed to maximize performance and reduce costs by considering both ergonomics and productivity together. Productivity was found to improve significantly when ergonomics was applied in the work design in industries [4].

The poor acceptance and application of ergonomics is probably due to lack of ergonomics knowledge, training in ergonomics. With this idea a long term research plan is identified to identify strategies for the application of ergonomics principles in the manufacturing organization. As

a part of this research, the currant paper reports the plan for development of the software package and its applicability in manufacturing industries. The possibilities regarding the development and application of expert systems for industrial ergonomics are examined and discussed in this paper.

II. ERGGONOMICS AND EXPERT SYSTEMS

The field of ergonomics is rapidly becoming a key area of interest to industrial organizations which are concerned with providing a comfortable, safe, and pleasant working area for their employees as well as producing high quality user friendly products to customers at the same time stressing on continuous improvement in productivity. This interest in applying ergonomic principles to industrial workplaces and products is most likely a result of correlations established between the design of a workplace on ergonomics principles and the resulting productivity and health of the worker [13].

Designers of workplaces and products have the following three major tasks [11];

(*a*) Integrating information about processes, tools, machines, parts, tasks, and human operators.

(*b*) Satisfying design constraints which often conflict.

(*c*) Generating a design acceptable to all parties involved.

While completing these tasks, designers often have difficulty in incorporating ergonomics information about the human operator into their designs, because ergonomics and other work environment knowledge is not widespread among the production engineers in manufacturing industry [10, 11]. Although such information exists for use in the job design process, one reason for the difficulties in using this information is that it is often poorly presented for use for designers.

A major obstacle to the widespread application of ergonomics knowledge to the manufacturing organizations is the inability to impart this knowledge to the ergonomics practitioner in suitable form. In some modern organizations which are using advanced technology, members of the work force and supervisors have been given an introduction to the concept of ergonomics as it applies to their particular industry. This provides many individuals with the ability to recognize potential ergonomic problems. However, it is found that solving the problems is a different matter as it requires the application of scientific data sources in a systematic fashion and this is more difficult to achieve for the individual with only an introductory knowledge of ergonomics [8].

Even with the abundance of reference material available, most of the design engineers lack the proficiency required to design work place and product ergonomically resulting in sound workplaces and good quality products. Many are unable to properly define the work classification, analyze the task requirements, or quantify the work force population. While theoretical research in these areas needs to continue, a practical method of systemizing and putting the current knowledge to use is needed [13].

It was found that when a workplace is to be designed at a manufacturing company, most likely the task is assigned to a production engineer or a supervisor. The layout and the components selected to be included in the new workplace are typically chosen more or less according to a company standard or tradition. .The critical question is: how to introduce the element of ergonomics in these activities [10].

As a result, several researchers have shifted their focus towards developing integrated tools that allow ergonomics information from several sources to be considered before an actual job is implemented By coupling ergonomics information from multiple sources with computer-aided design (CAD) software, designers are able to use a single analysis tool to assess ergonomics requirements, in particular postural comfort at the earliest stages of design. This allows the designer to incorporate features such as 3D modeling of workplaces and equipment, three-dimensional human form modeling to represent various anthropometries and postures, evaluative respective techniques and manipulate both the human form and the workplace design [11].

In response to the above mentioned need of organizing and presenting economics related information in a suitable form, attempts are made to apply a knowledge-based expert system to provide practical proficiency or expertise for the industrial workplace designer. Expert system technology in general has been applied to solve those problems requiring human judgment or expertise due to the uncertainty or complexity associated with them. Current expert systems, or knowledge-based systems as they are often called, are confined to well-circumscribed tasks. They are limited to using the specific facts and heuristics that they were "taught" by a human expert [13].

More precisely, expert systems are, "a class of computer programs that can advise, analyze, communicate, explain, explore, form concepts, identify, interpret, justify, learn, manage, monitor, plan, present, retrieve and schedule the activities related to a particular or specific problem on the basis of knowledge base created for them". This list of the possibilities provided by expert systems corresponds closely to the tasks performed by an expert of "industrial ergonomics" and hence, expert systems can be applied to industrial ergonomics [14]. Further, there is a trend to automate through the application of computers and information technology various activities related to the manufacturing planning production, materials supply, stock-keeping machining as well as supporting administration and many other areas. Extension of this trend of computerizing production planning activities to computerized workplace design appears to be natural choice [10].

These concerns suggest that, in order for an ergonomic expert system or computerized system to be used widely in a proactive manner, a few additional criteria should be met. First, a system must be readily accessible to designers and ergonomists in general industry. This implies that the system can be used to analyze a wide range of jobs, is available for use at a reasonable cost, and can run on a standard personal

computer. Next, the user should quickly and accurately be able to manipulate postures using techniques compatible with the design task especially when iterating through several design options [11].

The importance of safety and ergonomics has grown. The tradition of ergonomics and safety is to identify problems and to propose the redesign of the man-machine system. Computer-aided design and analysis offers new possibilities for integrating ergonomics and safety knowledge into these design processes and into different information systems. Computer-Aided Ergonomics and Safety (CAES) can be defined as the implementation of information technology in ergonomics and safety methods and the integration of those methods into design, production, and decision-making [12]. Therefore, from the above discussions, it is reasonable, to consider developing an expert system to assist facility engineers in the design of industrial workplaces. Workplace design is a problem domain which is relatively narrow, yet sufficiently unstructured and uncertain requiring the support of a dedicated expert system. A workplace design expert system has the potential to utilize guidelines from the literature, borrow experience from a human expert, and apply this knowledge in a practical sense [13].

III. LITERATURE SURVEY ON EXPERT SYSTEMS FOR ERGONOMICS

As highlighted above, the application of Knowledge Based System (KBS) technology in workplace design has been a subject for research in recent years. These KBS are generally appropriate for the use of an ergonomist, who is accustomed and motivated to reason with the human body in focus. The critical question then arises is, whether these KBS are of any use to a person who is not a trained ergonomist. [10]. The fruitful results leading to the efficient application of ergonomics principles for manufacturing organization is possible only when, the computer-assisted system are realized which can be used by any one in a 'consulting' mode, in which solutions are generated based on various production rules and a question/answer dialogue between the user and the system.[8]. In this direction attempts are being made and due to the substantial interest in the application of computer-assisted systems in the form of expert systems to support problem-solving and decision-making activities resulted in considerable research activities as reported in the literature.

Jeffrey *et al*. [7] have described an interactive Ergonomics CAD system (ErgoCAD) developed to allow human factors designers to determine the appropriate dimensions of an industrial workstation for a given population. ErgoCAD's routines and libraries are written in AutoLISP within AutoCAD, a microcomputer CAD software, providing a menu driven system containing a chair, work surface, and shelf modules. Task redesign can also be achieved efficiently and inexpensively with ErgoCAD. Thus ErgoCAD is a means by which individuals, not necessarily familiar with ergonomic principles, can interact with CAD software thereby designing an ergonomic workstation

The main fact that is highlighted here is, the human factors engineer relies upon the successful integration of anthropometric data bases with ergonomic design principles when designing the human-machine interface.

One area of special interest to ergonomists and health care professionals is the sitting workplace [5]. People spend a great deal of their life time sitting on furniture that is improperly designed or positioned (adjusted). This creates stresses, discomfort, and could be detrimental to health. Recently, there has been a surge of interest in applying ergonomic principles to workplace design. This is evidenced by the multitude of claims made by furniture and equipment manufacturers for ergonomically designed products. The term ergonomics is becoming a household word. In an attempt to reduce body discomfort and pain during sitting, manufacturers have introduced adjustable chairs and foot rests as well as flexible workplace stations. This is in compliance with the guidelines recommended by ergonomists which are available in the technical literature and are not available to consumers or individuals who use these chairs or work stations. Moty and Khalil [5] have presented a work to demonstrate the use of personal micro-computers to individualize the design of the sitting workplace. Engineering static and functional anthropometry as well as ergonomic design principles is implemented. This work presents a computer model for individualizing the design of the regular sitting workplace. The model considers the human characteristics such as dimensions, capabilities and limitations as emphasized by ergonomics and motion study principle in the design of tools and equipment. The computer algorithm combines inputted static and functional anthropometric data with principles of body mechanics and energy saving techniques to produce an optimal sitting workplace design.

Chen *et al.* [8] have reported a work on the development of an interactive computer-assisted Ergonomics Analysis SYstem (EASY). EASY is written in Foxbase Plus and QuickBASIC for IBM-PC compatible microcomputers. The system consists of three major components.

(*a*) The Ergonomics Information Analysis System (EIAS) for evaluation of tasks by the worker.

(*b*) The Physical Work Stress Index (PWSI) used by the supervisor or the ergonomist for further investigation of problem situations.

(*c*) The Dynamic Lifting Analysis System (DLAS) for manual material handling tasks. Extensive use of menus for database entry/editing and analysis provides an efficient and friendly interface design. The system was evaluated by comparing the results of EASY and individuals with an introductory knowledge of ergonomics with experts' conclusions for nine test jobs involving a variety of physical work stressors. The evaluation indicated that 83% of EASY's diagnoses were accepted by the experts with some variation between individual experts and between EASY and the other diagnosticians.

The expert system proposed by DeGreve and Ayoub [13] only provides work station designs based on anthropometric data. It gives critical dimensions of interest to the user in designing the work station as well as other anthropometric information of interest for further work with the work station. This system does not address standard times, performance on a given task or the body posture while at the work station, not will it, for example, address biomechanical and physiological stress while performing the activity. Laring [10] *et al.* has presented a tool that helps to meet the needs of concurrent engineering: a Knowledge Based System (KBS) that supports the design of a workplace, by a production engineer, in a CAD environment. The production engineer is asked to specify three structures: the products and parts of products, a plan for the work process and the layout of the workplace. The KBS subsequently performs an ergonomic analysis and presents an assessment to the production engineer, who then decides if any changes in any one of the three structures are necessary. The feasibility of the approach is analyzed.

Laurig [14] reported that the aims of a particular case of workplace and work sequence planning and design results in the following dilemma:

(i) It is obviously not possible to provide all potentially interested persons with the available industrial ergonomic knowledge in a form allowing immediate application to the individual problem

(ii) The potentially interested persons are not sufficiently acquainted with the available industrial ergonomic knowledge to be able to decide how far its application could contribute to solving their respective problems.

This unintentional development reveals itself in a general dependency on experts. Characteristic of this is the increasing number of people interested in the knowledge available from only a few experts. However, these experts are rarely able to communicate their knowledge in a general form. The development and employment of expert systems suitable for use in work design problems offer a chance to resolve this dilemma for industrial ergonomics.

It is possible to define conditions which can be considered as prerequisites for the successful development and introduction of expert systems for industrial ergonomics [14]. For example the Problems that relate to workstation and work method design are:

(*a*) Design of workspace and workstations according to the results of anthropometry.

(*b*) Evaluation and design of tasks according to the results of biomechanics and work physiology.

(*c*) Design of the visual conditions, the auditory and thermal environment.

IV. OUTCOME OF LITERATURE SURVEY

The major out come of the literature work carried our on application of expert system for

(i) It is recognized that ergonomic expertise has not been adequately utilized in industrial planning practice in manufacturing organizations and significance of application of ergonomics principles for day to day operations / activities is yet to be recognized

(ii) It is believed that ergonomic deficiencies in manufacturing industries are the root causes of workplace health hazards, low level of safety and reduced worker productivity and quality.

(iii) There is an urgent need for implementation of ergonomics knowledge in design and decision-making as well as in the use of machines, equipment and production systems and for this in the modern enterprises ergonomics and safety consideration need to be integrated into the design, analysis, and implementation phases of the system.

(iv) Most firms do not possess the expertise necessary for applying ergonomic principles to the design of industrial workplaces and products

(v) Workplace design literature offers many guidelines and principles to the potential designer but there are no clear-cut procedures available for direct application in an industrial setting. The experts in ergonomics are rarely able to communicate their knowledge in a form applicable by a practitioner.

(vi) The development of automation through extensive implementation of information technology is one of the major trends in modem society. Computer-aided production and design technology requires support and implementation of computer aided ergonomics and safety.

(vii) Information technology and computers will play an important role in managing this huge amount of ergonomic information, and will contribute to its systematic and widespread implementation.

(viii) Knowledge representation using expert systems seems to offer a valuable choice to overcome the gap between “producers” and “consumers” of industrial ergonomic knowledge [14].

The above points indicates that the industry has failed to derive maximum benefits from ergonomics research, since the outcome of the research is not organized and presented for industrial application in a form that leads to effective utilization of ergonomics knowledge for industrial activities. The application of computer-assisted systems in ergonomics is one feasible solution suggested for this purpose.

Based on these issues, the proposed research activity is started with the man purpose of developing a Computer Assisted Intelligent Ergonomics System (CAIES). This system uses the principles of expert system and will have a knowledge base to allow a production engineer or supervisor or even a worker with a minimal ergonomics background or no prior knowledge of ergonomics, to diagnose and solve physical ergonomics problems.

The proposed work concentrates on following objectives

1. To highlight the significance and need of application of ergonomics knowledge and principles for the design of work place, working environment and products in the manufacturing organization.
2. To outline the correlationship between ergonomics and enhancement of quality of product and improvement in productivity.
3. To identify the issues related to the application of ergonomics for manufacturing industries.
4. To evaluate the characteristics of expert system for their suitability to store and impart ergonomics related knowledge in a user friendly form.
5. To provide a user friendly computer assisted expert ergonomics system for manufacturing organization which serve a major step and contribution towards application of ergonomics for manufacturing activities.

The tasks to be performed are for the proposed works are :

1. Carry out a survey on the application of ergonomics in Indian industries.
2. Carry out a survey on the application of expert system.
3. Collect, organize and compile the knowledge related to ergonomics principle for manufacturing organization.
4. Formulate procedures and guidelines for the application of ergonomics data for manufacturing industries.
5. Formulate an ergonomics evaluation and assessment procedure for manufacturing industries that can be used to identify ergonomic deficiencies, assess the need of ergonomics and provide ergonomics solutions to the problems.
6. Develop computer assisted system for industrial ergonomics.

V. CONCLUSIONS

Though the significance of applying ergonomics for providing better working conditions and better product quality and achieving improved productivity is acknowledged, in reality the ergonomics knowledge is not being used to the expected level. Focusing on this aspect, in this paper related issues are identified and a solution is identified in the form of a need for development of a computer assisted system for ergonomics. Accordingly a research plan to work in this direction is presented.

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