1. Introduction

1.1 Ergonomics

The word "Ergonomics" comes from the Greek, "Ergon" meaning work and "Nomos" means law. Therefore, etymologically, this is the science of work. The term has been used historically in the European tradition. In the American tradition, the term "Human Factor Engineering" is used to refer to the same issues, so both terms can now be considered as synonyms and are used interchangeably. The latter is evidenced by the fact that the "Human Factor Society", founded in Tulsa (Oklahoma) in 1957, is now called the "Human Factor and Ergonomics Society" (HFES). Another term which is often used in the same context is “Engineering psychology” (Wickens & Hollands, 2000).

Ergonomics or human factors is 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. Complaints, accidents, even disasters, occupational diseases, drops in both productivity and quality, increased unit costs and a high number of breakdowns are just some of the consequences of the poor design of any product or system that does not take a man and his role as a factor of reliability and safety into account (Sagot et al, 2003).

Ergonomics is the field of study that seeks to fit the job to the person, rather than the person for the job. This is achieved through the evaluation and design of workplaces, environments, job tasks, equipment and processes in relationship to human capabilities and interactions in the workplace. Whenever there is a change in the workplace (new worker, new equipment, modification in equipment), new ergonomic solutions are required. It is important that all equipments/machinery/tools and other accessories are adjustable in order to meet individual worker's needs, as no two people are alike (Hendrick, 1995).

Effective use of ergonomic practices will assist in maintaining high levels of productivity, avoiding painful and costly worker injuries and increasing worker satisfaction. By designing the job around the person, workers will have a decreased risk
of injury and an improved perception of their "worker-centered" role at work (Meyers, 1995). Few ergonomics needs are discussed in the next section.

1.2 Ergonomics Needs

1.2.1 Importance in Ease of Use

Ease of use may be extremely important both for frequently used products, such as an office photocopier and for infrequently used products, such as a fire extinguisher. Ease of use is more challenging if the product has multiple features and/or modes of operation which may confuse or frustrate the user. When ease of use is an important criterion, industrial designers will need to ensure that the features of the product effectively communicate their function.

1.2.2 Importance in Ease of Maintenance

If the product needs to be serviced or repaired frequently, then ease of maintenance is crucial. For example, a user should be able to clear a paper jam in a printer or photocopier easily. Again, it is critical that the features of the product communicate maintenance/repair procedures to the user. However, in many cases, a more desirable solution is to eliminate the need for maintenance entirely.

1.2.3 User Interactions for the Products’ Function

In general, the more interactions users have with the product, the more the product will depend on work nature. For example, a doorknob typically requires only one interaction, whereas a portable computer may require a dozen or more, all of which the industrial designer must understand in depth. Furthermore, each interaction may require a different design approach or additional research.

1.2.4 Common Workplace Motions

The workplace should be comfortable for operators and adapt to their needs as much as possible. The human body has a natural range of motion (ROM). Despite the need to promote motion, users should try to avoid repetitive movements and certain extremes in their ROM over long periods of time. By considering both ROM and repetitive motion, products can be designed to operate within the optimal ranges to help reduce the occurrence of fatigue and muscle disorders (Pheasant, 1996).

1.3 Importance of this Study

India is an agriculture-based country. A large section of Indian population engages in agriculture. Although agriculture is generally recognized as the nation’s most hazardous industry and displays high rates of MSDs with evidence in which the ergonomic risk factors are involved and be pointed out, there is very little history of
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application of ergonomic approaches in agricultural equipment design (Desai et al., 2012). Thus, as the human workers play a major role in the country’s agriculture, due attention needs to be given to their capabilities and limitations during the design and operation of various farm equipments, so as to get higher productivity, enhanced comfort and ensure better safety (Woodson and Conover, 1973; Yadav et al., 2010).

Anthropometric data have the greatest importance in the design and development of farm equipments or machinery based on ergonomic considerations. There is much more difference in body dimensions of Western and Indian population and even in Indian population, as they vary region to region. In India attempts are made to generate region specific anthropometric databases for agricultural equipment design, but they are limited to very few. There is a need to go for extensive surveys for both male and female farm workers in different regions of the country in order to generate region specific anthropometric and strength databases for safe and efficient design/modification of agricultural equipments.

Musculoskeletal disorders have been a widespread problem in agriculture. The proper matching of machine requirements with the human capabilities is basically necessary for optimum performance of any man–machine system and for the safety of workers (Singh and Arora, 2010).

Ergonomics is the scientific study of people at work. The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. This is accomplished by designing tasks, work spaces, controls, displays, tools, lighting, and equipment to fit the employee’s physical capabilities and limitations.

Ergonomically well designed hand equipments may reduce the risk of occupational injuries. It also provides a comfortable work for the users and gives high product quality to the consumers (Bisht and Khan, 2013).

In the present study, anthropometric parameters (body dimensions) of Maharashtra agricultural workers are presented. Also, ergonomic evaluation of few farm equipments/implements is performed and improvements are suggested.

Following points depict necessity of present research work.

1.3.1 Extensive use of Manually Operated Equipments

Hand tools and manually operated equipments are extensively used in Indian agriculture for various farm operations starting from seedbed preparation to post-harvest operations. The most commonly used hand tools and equipments by the farmers
for manual operations are spade, weeders, thresher, sprayers, ploughs, sickle, paddy puller, straw puller, hoe, hand power tiller etc. (Nag and Datt, 1979).

1.3.2 Unavailability of Anthropometric Data of User Population

Ergonomic dimensions correspond best to the orientation of the designed hardware which is registered in different positions and postures that simulate the real working postures and positions in the conventional form. Hence, to achieve better efficiency, human comfort and safety, it is necessary to design the equipment keeping in view the operators’ capabilities and limitations. In western countries, a large amount of anthropometric data is available for reference and use. Some of the research institutions are now generating and maintaining database of strength parameters for both the classes of workers, male and female. Anthropometric data bank assembled and maintained by Aerospace Medical Research Laboratories, Dayton, Ohio (USA) is the largest single repository of raw anthropometric data in the world. ERGODATA is another data bank located at the Anthropology Laboratory of Paris University in France. However, it does not contain any data on Indian (Asian) population (Naqvi, 1993). The availability of an anthropometric database has unlimited applications. Western countries, where ergonomic awareness is much higher than in other areas of the world, have created huge databases for anthropometric design reference (NASA, 1978; Scott, 2009; Syed, 1993).

1.3.3 Poorly Designed Agricultural Equipments

The manufacture of agricultural machinery/equipment in India is quite multifaceted and comprises village artisans, tiny units, and small-scale industries. A little attention is paid by the manufacturers to incorporate anthropometric and strength parameters in the design due to the economics involved and lack of awareness among manufacturers. Thus, tools and equipments being manufactured in India by local artisans and small-scale manufacturers are low in working efficiency and often failed to reduce the drudgery of operation (Agrawal et al., 2010b).

Moreover, in India, in case of agricultural machinery, requirement of quality certification is limited to the sale of agricultural machinery financed under government schemes.

In order to safeguard the workers against accidents and ill health, a large number of safety legislations exist in India. However, the ergonomic factors concerning safety are not adequately addressed in these legislations. While environmental factors such as
noise, ventilation, illumination, etc. have been dealt with in detail, factors relating to man-machine-interaction need more emphasis in the legislation (Periyan and Iqbal, 2009).

1.3.4 Scarcity of Labor in Agriculture Field

Nowadays, there is huge scarcity of labor in the agricultural field. The present situation is that nobody wants to work in agricultural cultivation related activities. Some of the reasons for this are uncomfortable working environment, huge labor and fewer returns.

Ergonomics can be used as a tool for retaining employees and increasing productivity. It is therefore recommended that such tools could be used to reduce turnover rates and increase employee engagement. High rates of employee turnover, not only increase costs, but signify poor working conditions and low brand equity. Ergonomic interventions are increasingly used to reduce labor turnover rates, lower costs, increase revenue and accomplish more work with a little work force (Dempsey, 2007; Sen, 2009; Singh and Arora, 2010; Abarghouei and Nasab, 2012).

In the present era of user centeredness and market competition, ergonomic considerations are a must for agricultural equipment design as the users are no more bound to cope with whatever design imposed on them (Kumar and Chakrabarti, 2009).

1.4 Scope of the Study

The scope of the present work is as follows:

i. The present study considers collection of fifty nine body dimensions including weight which are useful for the farm equipments/machinery design. Other anthropometric parameters related to head dimensions, ear dimensions, etc. which have hardly any impact on the design of the farm equipments/machinery are not be considered in this study.

ii. The present work deals with collection of body dimensions of male farm workers/farmers. Study doesn’t include female workers due to time constraint and work involved.

iii. The present work adopts convenience sampling because of difficulty in getting the subjects for participation in the study voluntarily, migration of workers from one region to other and also due to economic and time factor. However, by use of stratification and selection of subjects from diverse areas from the strata, sample selection in the study is almost unbiased and random.
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iv. On priority basis (using AHP), the present work considers ergonomic analysis of the equipments/machinery which are fully manually operated or require considerable labor. Present work covers ergonomic analysis of three farm equipments/machinery namely maize thresher cum dehusker, electric hedge trimmer and knapsack sprayer.

v. The present study considers ergonomic evaluation of few part(s) or section(s) of the equipment/machine based on participation of the particular part(s) or section(s) in human interaction during operation of the equipment/machine. This is based on prioritizing the research in the stipulated time. Still from maintenance, performance and safety point of view, analysis can be performed for some more parts or sections of the equipment(s).

1.5 Organization of the Thesis

This report consists of six chapters. First chapter covers concepts involved in the present area under study. It includes various definitions and alternative terms used in the research community in the area. It highlights need and the importance of the present study.

Second chapter, “Review of Literature”, summarizes a review of previous studies which helped to find out research gap and to decide objectives for the present work.

Third chapter demonstrates the research methodology used for the study. It includes flowchart of the research process containing all the methods and tools used in the present work.

Fourth chapter presents the anthropometric data of Maharashtra male farm workers. The results of normality and homogeneity of variance test are also presented to check the suitability of the data for statistical analysis. The frequency analysis is presented to find the values of minimum, maximum, mean, variance, SD, SEM and 5th, 50th and 95th percentile. The chapter also includes results of one way ANOVA and post hoc test to check the differences in the means of body dimensions of farm workers from three different strata. Moreover, chapter also includes comparison of body dimensions of Maharashtra workers with that of workers of other regions in India and other countries. This chapter also deals with ergonomic evaluation of various farm equipments being used in the Maharashtra. In this chapter, DHM and simulation tools are used for the ergonomic evaluation of equipments.
Fifth chapter highlights the outcomes of the present research work based on the findings of the study. This chapter includes conclusions from the findings of the study, recommendations from the study, contributions of the present research and the scope for the future work in the area. This chapter also presents research at a glance.