ERGONOMICS IN INDUSTRY: A REVIEW

Abhishek Shukla
Shivam Yadav
Sarthak Das
Narendra Babu
Nikhil Kumar
Sanjay Mohan Sharma

Abstract
The objective of ergonomics is not to fit an individual to the task rather it aims to fit endeavor to an individual. Human Factor Ergonomics (HFE) has sustainable prospective in designing of different kinds of complex structures with man and machines etc., but it faces issues in compatibility and adherence to meet the market needs. This paper aims to describe review of relevant literature to scrutinize human factor in preservation and to establish demand for quality HFE. Review applies a novel framework that has unique combination that ascertains HFE by following categories: fundamental system approach, design driven approach, workplace macro ergonomics, cynosure outcomes as performance & well-being [Human Resource Management]. In terms of preservation, paper yields key insights concerning impact of decision making and also focuses on the quality HFE by providing strategic and specialized research excellence in HFE. The prerequisites for the mentioned structure such as collaboration between group of HFE and IEA has also been discussed.

KEYWORDS: - HUMAN FACTOR ERGONOMICS, PERFORMANCE & WELL BEING, FUNDAMENTAL APPROACH, DESIGN DRIVEN APPROACH, PRESERVATION, DESIGNING, WORK SYSTEM, SERVICE & PRODUCT SYSTEM, ERGONOMICS FUTURE, HFE PROFESSION & DISCIPLINES

NOMENCLATURE:- IEA [INTERNATIONAL ERGONOMIC ASSOCIATION], HFE [HUMAN FACTOR ERGONOMICS], SA [SOUTH AFRICA]

1. INTRODUCTION
Ergonomics pertains with making the workplace safe secure efficient and soothing as possible. Motto of this paper is to provide vivid image of the future of HFE i.e. Human Factor ergonomics discipline and profession. According to IEA, 2011 ergonomics is the scientific method of study concerned with understanding of interaction among human and other element of system and the profession that uses theory, principles, information and way to design in order to optimize human well-being and overall system performance. It also presents the determination of committee for future, established in December 2010 by IEA committee was headed by:-
Jan Dul (Chair, Netherland) and group of highly experienced professional, Ralph Bruderl(Germany), Peter Buckle(UK), Pascale Caragon (USA), Pierre Falzon(France), Bill marros(USA), John Wilson(UK), Ban Van der Doelen(Secretary, Netherland)

Later the report was presented in 2012, Brazil “Triennial world congress on ergonomics”. Objective was to form a HFE committee on strategies for future of HFE profession and disciple. We have gone through several papers which predict future of ergonomics for specific HFE areas. This paper does not pertain to function able plan to realise strategy which focus on discipline and profession in order to reach global excellence. With help of discussion by committee members and other HFE specialist about their thoughts, views, committee had been able to made strategy related to future HFE. For all this there had been brain storming session with 18A council member at Grahams town, SA(2011), many more Physical and electronic communication meeting at Amsterdam(March, Nov, 2011) Paris etc. Even many more input were taken from worldwide either by interviews or through emails conversation. We are adding references for illustration and for reading up to a great extent. This Paper consists of various information about western academics and considerable experience of working in industry area of commerce clients and practitioners even it may not reflect the view of 18A. We have just provided cognitive content which can be used by anyone (HFE societies, Individual organization) to develop their context. In starting of paper we discussed about HFE. To ensure design of man-made object taken as whole Ranging from consumer product to organization environment, shape around capabilities and aspiration as like well-being and optimism.

There are various problems such as illness, efficiency qualities deficits, dissatisfaction, low morale, bad attitude, toward job etc. HFE can overcome such issues. With the help of number of papers we have been able to found four problems ensure potential of HFE is underexploited.

- Stakeholder (intern of management and design) not aware of HFE, so there problem continues.

- Enough demand of high quality HFE in design for e.g. ergonomic product in product marketing, but HFE is lacking its application i.e. limited scope.

- This field is unlimited in size contradictory to design aspect like psychology and engineering so often united with this subject field without definite reference to HFE subject field.

- HFE, multi subject field base which itself is a weakness, diversity of views topic and practices, so tough to pass clear message to external world

In order to plan scheme of HFE profession and discipline we talked about cardinal characteristics, development required in modern world key for HFE, develop values of HFE for stakeholders in terms of system design & possible strategic action for HFE community. Other than that significance role of ergonomics in terms of preservation is been studied. This paper is also a review to recent approaches to preservation. REASON & HOBBYS (2003) reexamined types of error, violation and condition that provoke them and set out the wide image, explained by examples about system failure.

Numbers of publication were studied to have wider knowledge & to comprehensively analyze human factor in presentation from different viewpoint.
2. FUNDAMENTAL CHARACTERISTICS
The basic motto of system of HFE is to make interaction of human with their environment. The surrounding is intricate and consist of physical system, organizational environment i.e. the way they are disciplined and been organized. The system can be a work system or a product/service system. Our primary focus through this paper is to improve performance and where the merchandise is used to enhance the well-being by designing with reference to HFE. HFE prioritizes environmental design to fit an individual and not the other way round, by this human more efficiently will be able to contribute in execution of performance. The Human factor ergonomics community over 50 years endeavor to develop and file a document for considerable body of cognition and accomplishment regarding interaction between human and there surrounding and way for designing and analysis system. Cardinal characteristics of Human factor ergonomics is 1. System approach, 2. Design driven approach, 3. Performance & Well being

2.1 System Approach
A system is a set of reciprocal action and related components that form a fully integrated whole. HFE mainly concentrates on goal-oriented and determined systems consisting of humans and their environment. The environment can be any man-made antique e.g. (tools, technical processes, hardware, software, buildings, organization etc.) HFE contemplate various features of the human (physical, psychological and social) and divergent features of the environment. It address problems on the different system levels from micro level (man using tools to working on single tasks) to macro level (for e.g. man as part of organization’s) and to macro level. When discussing on the problems and solving the solutions then the system dimensions are defined, and main focus of HFE will be on the aspects of people, working environment but the wide context of the man within respect to the environment is always taken in to main account. This wide context of the HFE is referred as a systems approach. The system approach of HFE and its vast context for application separates it from other straitened disciplines such as human movement and affective psychology. These systematic method may share a human vision with HFE, but not a broad view.

2.2 Design Driven Approach
This is a type of approach which is used to enhance public presentation and well-being by the system design. Examine and assessments of results in testimonial and action for design. Human factor ergonomics can be concerned in different stages as like Design, evaluation, implementation, redesign, maintenance and uninterrupted improvement of system [Japan Ergonomics Society 2006]. These stages are algorithmic, mutually dependent, and dynamic however design is the heart of them. Decision at certain situation may affect or situation may be affected at different stages. Human factor ergonomics expert can be progressive participant in design process, they can have different functions to perform as like they can act as specialist of Human component (covering individual, collective and social aspect from mini to macro level). They have competency for analyzing situation, method of design and evaluate technical & organizational surrounding, method to coordinate and manage participatory approach and redesign then continuously improving system (Woods and Dekker 2000), even they can act as decision makers. These expert used to analyze, solve issues in partnership with others contribute to design (Nov 1995, Rasmussen 2000)

2.3 Related Outcome: Performance & Well-Being
By providing appreciable surrounding to the human, two types of outcomes can be achieved, first one is Well-being (personal development, satisfaction, safety, pleasure, health) and other one is Performance (efficiency, quality, productivity, flexibility, sustainability etc.) both these terms can influence each other (long and short term). Both are intertwined. Both can be reduced if there is lack of coordination between surrounding and human aspirations and capabilities.
4. SIGNIFICANCE OF HFE FOR STAKEHOLDERS

The offering of HFE to system design i.e. supply is directly proportional to demand of HFE by stakeholders engaged with system design demand depends on perceived value of HFE by parties (directly/indirectly) for supply, importance of HFE must be shown to these parties, so that they can have demanded and reputable partner. Now we are going to discuss various types how HFE in system design could affect stakeholders System design- Stakeholders/Partners As we mentioned in introduction, it can be subdivided into four groups which need to be identified:-

1) **SYSTEM PERFORMER** (actor) i.e. consumers and employees, who are part of system being directly or indirectly affect performance and affected by decision

2) **SYSTEM SPECIALIST** i.e. psychological and engineer they design system based on ad-hoc professional framework. HFE specialist uses system framework and focuses on above mentioned outcomes by fitting environment to human (earlier mentioned)

3) **SYSTEM DESIGN SHAPER** i.e. plan makers like Managers about system design about leverage of system, its execution and its application

4) **SYSTEM INFLUENCER** regulator, media, standard institute, government, organization who used to have general public interest in product design and work system design

We have discussed about stakeholders from broader to narrower level i.e. from country to company. Value for HFE for Stakeholders

4.1 System Performer

We have subdivided this into work system (workers, staff) and performance of service/product system (customers). How workers, employees and staff receive beneficial from HFE in work system are mentioned below:-

- Better physical, psychological, physiological and societal well-being (example: optimization of work surrounding)
- High job satisfaction, growth and motivation (room to grow and learn, independence to act)
- Quality performance (security intrinsic and extrinsic reward)

How HFE used to benefit service/product system by ensuring well-being and performance:-

- Improved experience
- Less time consumption of familiarization
- Improved fitting of service/ product to individual needs
- Fewer fault would take place
- Higher efficiency

4.2 System Specialist

Stakeholders include variety of engineers, psychologist etc. to involve in system design eg. HR management, Industrial Engineer, IT, consultancy etc. their aim is to design a structure that act well accordingly to standard of respective profession. For this, HFE can be favorable because it ensures:-

- Great performance
- Better development process
- High performance
- Best fit with norms (professional ethics, safety, health etc.)
4.3 System Design Shaper
Stakeholders or parties group comprises of decision makers (eg. Managers) who used to decide design of 2 different system mentioned above (i.e. work & service/product). Management aims to achieve overwhelming performance of work system with lower degree of capital.

| Table 1. Examples of stakeholders in the main stakeholder groups that are directly or indirectly involved in the design of systems, and their role and stake in the system. |
|---|---|---|---|
| Stakeholder group | Level of stakeholders | Organisations representing individuals in the company | Organisations representing individuals in the country/region | Organisations representing individuals in the world |
| System actors | Individual | Actors of work systems: Employees | National/regional trade unions (work systems) | International trade unions (work systems) |
| Are parts of the system | Actors of product systems: Product users | National/regional organisation of OHS services (work systems) | International government/ OHS legislation |
| Are directly or indirectly affected by its design | Actors of service systems: Service receivers | National/regional consumer organisations (products/services) | ILO |
| Affect directly or indirectly performance | Professionals from the technical and social sciences; e.g., (industrial) engineering, information technology, computer science, user experience specialists, psychology, management consultancy, design, facility management, operations management, human resource management, interior design, architecture) | National/regional government/ OHS legislation/consumer safety legislation | WHO |
| System experts | Professional colleagues | National/regional user groups (e.g. patient associations) | National/regional organisations (universities, research funding organisations) |
| Are designers of the system based on their specific professional backgrounds and the nature of the system | HFE SPECIALIST (one of the system designers) | National/regional HFE organisations (e.g. IEA federated societies, IEA networks, national/regional certification organisations) | HFE SPECIALIST International HFE organisations (IEA) |
| HFE SPECIALIST | Other professionals who support HFE | | |
| Are designers of the system based on their specific professional background in HFE: design by fitting environment to human, systems approach, dual goal (performance and Design shaper about work system can benefit HFE as it guarantees performance:-
- High Productivity, by reducing time consumption (optimize work consumption)
- Great Quality & Reliability (operating instruction & worker qualification)
- Reduced Operating Cost, as there will be less health issues accidents and absenteeism
- Better Design Making as more authentic and logical information availability will be there related to outcomes of system design on employees
Now we will talk about the beneficial in case of service/product system:-
- Great Market Staging/Performance
- Improved Decision Making
- Good Profit Making
- Less redesign due to less synergy issues after market

4.4 System Influence
In terms of product and services and work system we have general public interest with reference to their outcomes for which Human Factor Ergonomics can contribute simultaneously two generic aim (In relation with single entity or society of all people)
- Social Wealth (by well-being result of HFE design system)
- Economic Wealth (through production sequel of HFE system design)
HFE ensures public safety during work in any system

5. SCHEME FOR FUTURE
Earlier in above section we have discussed that we aren't able to take full advantages of HFE uptil date later we also taken fundamental character of HFE into consideration so, according to this deadly combination is quite unique in differentiating with respect to other disciplinary.
After that we have also discussed about the fact that system are changing and its quite obvious that it will continue to change as it is the necessity or need of a hour for product development quality improvement and in accordance to health and safety point of view all this can be ensured with help of HFE as it can help in designing system that can endeavor people so that performance and well-being results can be achieved in future system. Keeping in mind about the fact of exploit HFE we also discussed about stakeholders in other section other than that we all are aware of this fact that HFE has certain boundaries i.e. Limited in nature, so we discussed the way how it can widen its arm to reach system experts/specialist and system design shaper.

So here suggest different scheme for future scheme:
1. Enhancing the demand of utmost quality HFE by raising awareness of parties by:
   - Communication
   - Building Partnership
   - Educating Stakeholders

2. Enhancing usage of High quality HFE in various sectors by:
   - Promoting Education
   - Availability of High quality standard
   - Boosting HFE Research existence e.g. Universities

Above mentioned schemes are interrelated. Now coming on to figure which reveals “HFE demand development cycle” corresponding main scheme, cycle combines three element as parties demand high quality HFE which can nurture parties awareness of needs, Which may lead to enhancement of demand in terms of high quality of HFE. Human Factor Ergonomics member can promote or supercharge this cycle by stressing on pull and push (both approach). It can be increase stakeholders consciousness regarding its need i.e. High quality HFE by the process of communicating, building partnership and enhancing education among stakeholders.

6. EXECUTION OF STRATEGIES
From the above schemes of future we noticed that the main strategic regulation is “to strengthen the demand of HFE & application of better quality HFE”. The application of these strategies is a necessary but interconnected attempt that needs further evolution. We mainly study about only two topics, 1) progress an action plan by changing the strategy in to actionable jobs, 2) managing the progress and application of the action plan. We can increase strengthening of HFE by enhancing the stake holders by communicating and showing them examples of success by using the better quality of HFE and negativity of absence of the HFE. Providing high quality standards of HFE implementations and HFE specialists by developing high-quality HFE in all activities of HFE societies and HFE practitioners’, and by safe guarding the implementation of high-quality HFE Standards by qualification and certification bodies. Sponsoring HFE research excellence at universities and other organization’s by encouraging research and Publications on high-quality HFE. We can also execute these strategies by using

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the leadership of INTERNATIONAL ERGONOMIC ASSOCIATION (IEA) by encouraging the IEA allied societies and networks to set up their own plans, each taking to their particular context.

7. PRESERVATION: LITERATURE REVIEW

The importance of human aspects in maintenance is studied from different prospective. Several publications are analyzed in this review. We analyze human errors and human factors by two methodology first one are “Human Factors Fieldand Domain” and second one is “Swiss Cheese Model”. Krulak (2004) investigated 1016 aircraft accident which were caused by human factors involved in maintenance by using statistical frequency analysis. The essential factors which were an outcome of the study included insufficient supervision judgmental errors and lack in paying attention. Hackworth et al. (2007) analyzed status of programs focusing on human factors in maintenance and Repair Company and the study showed that use of analytics for error tracking is the best technique for improvement. Hobbs (2004) studied maintenance system in aviation industry and mentioned that errors by maintenance personnel remain unnoticed. Chang and Wang (2010) studied and grouped risk factors using a quantitative approach work culture and worker related factors were most important. Antonovsky (2010) analyzed effect of human factors in petroleum industry and noted that faults in decision making were the prime cause for error.

With Respect to Organization Condition:

Norjte and Visser studied showed that there were not any multiple defense mechanisms to prevent human errors and accident. Human errors are responsibility of senior management in the organization (Collins and Keeley, 2003; Anderson, 2004). Hobbs (2004) studied that the major problems are not technical in nature but rather negligence in reporting incidents. Cherry (1999, European agency for safety and health at work) noted that MSD account for majority of work related disorders in developed countries. Shelerud (2006) studied that lower pain is increasing at very high rate and is becoming unavoidable for workers in industries. Anderson, Haahr, and Frost (2007) studied that very small part (7.7%) of their sample strength (N=4006), had been free of any MSD related pain. Clyn et al. (2007) showed that very small problem which is a major MSD related pain have prevalence rate of 49.9% in women and 38.8% in men. Leino and Hanninen (1995) stated that demographic variables are related to MSD’s and may thus increase complexity of working conditions and factors.

8. INDUSTRIES: CONSEQUENCES AND PRESERVATION

Market competitiveness and the need for higher productivity highlights the requirement for focusing on ergonomical aspects in industries tasks today involve:-

- Pushing, pulling, lifting and carrying loads
- Higher working hours
- Higher efficiency

These can lead to physical stresses on the workers and hence the need to give due consideration to ergonomically aspects. The steep rise in the rate of MSD’s over the years is depicted below. Not paying attention to human factor ergonomics aspects may lead to risking the physical health of workers, hence the requirement for anticipating such risks.

What is MSD?

Disorders dealing with soft tissues (muscles, tendons, ligaments, cartilages) they affect nerves also these disorders develop progressively over a period of few weeks to years and affects the arm, fingers, neck, back, wrists, hands, necks, and shoulders. Serious disorders include carpel tunnel syndrome, herniated disks or tendinitis. Continued exposure to ergonomic risks is injurious to workers health the causes include:-

- Applying disproportionate forces repetitive movements which increase pressure
- Static positions
- Irregular motion of the body and parts
- Inadequate breaks and insufficient recovery time
- Body vibrations

Signs of MSD’s involve insensitivity in fingers, thighs, pain in back and problems in movement of fingers. Parts of bodies affected by MSD’s are tissues in human body, nerves, arms, and back, carpel tunnel syndrome and tenosynovitis are frequent muscular disorder with arms. Tendon problem in joints where tendon frequently burst against ligaments and bones carpel tunnel syndrome affects hands and wrists and is a result of repetitive motion. Now the question arises that how can consideration to ergonomical aspects improve working conditions:-

- Reduce MSD’s rates (reference data)
- Increase efficiency
- Improve worker attitude
- Improve labor safety.

Ways to prevent accidents are proper training of employees, job analysis with detailed breakdown of tasks, establishing controlled working environment and effective feedback mechanism.

9. HFE IN RELATION WITH MATERIAL HANDLING

The conditions related to injuries originating from manual material handling are

- Uncoordinated postures
- Repetitive motion
- Exertion beyond body limits
- Static position
- High stresses on pressure points

The above thus emphasize the need to improve workplace condition by

- Preventing injuries
- Reducing labor effort
- Decreasing risks of MSD’s
- Improving quality of product service
- Eliminating worker grievances

The broader aspects for improvements from ergonomics point of view are:-

- Rearrangement of equipment’s, storage materials and tools, machines, and packaging goods it also includes organizing tasks schedules analyzing work practices work rotation and shifts organization.

10. CASE STUDY: ASSEMBLY STATION

The performance of the handler is studied using an ergonomically served assembly workstation which can be modified while performing an assembly. On the basis of three different case conditions, 10 students are assigned.
Adjustable, modifiable table
Adjustable modifiable chair
Sex

They have to perform an assembly and the work done by them is to be judged on the basis of number of products assembled per hour.

The task given to them is to fix electrical switches consisting of eight components. The participants include 5 girls & 5 boys average age (21 years)

An adjustable workstation was made keeping in mind all the aspects of ergonomics. The workstation consisted of a table frame with rotary motion allowances. A table which both transformable property of adjusting both sitting and standing posture. Height adjuster which can be pneumatically controlled

Before they could begin assembly they were trained for fifteen minutes and shown what and how they have to perform the given task. While examining them three basic human ergonomic factors which could impact the performance where taken into consideration these were adjustable height level of chair, gender, and adjustable height of table, a significant no of observations were taken at different permutations and combination and at different point of time with boys performing at different time than girls. On the basis of the observations few conclusions were drawn such as workers could adjust according to the needs and comfort. A marked increase in productivity was noted. Productivity of female was higher than their male counter parts.

REFERENCES

32. OSHA 3125 2000 (Revised), Ergonomics: The Study of Work, U.S. Department of Labor Occupational Safety & Health Administration
36. Jeffrey E. Fernandez, PhD, PE, CPE Michael Goodman, MD, MPH, Ergonomics in the Workplace

AUTHORS
Abhishek Shukla, Shivam Yadav, Sarthak Das, Narendra Babu, Nikhil Kumar & Sanjay Mohan Sharma, School of Mechanical Engineering, College of Engineering, Shri Mata Vaishno Devi University, Katra, Jammu & Kashmir, India