2025 Volume: 01 Issue: 04 www.ijrpa.com Review Article

International Journal Research Publication Analysis

Page: 01-12

INTEGRATING HUMAN FACTORS INTO INDUSTRIAL ENGINEERING: ENHANCING OPERATIONS AND MANAGEMENT

Chinedu James Ujam*

Department of Mechatronics Engineering, Federal University Otuoke, Bayelsa State, Nigeria.

Article Received: 02 August 2025
Article Revised: 22 August 2025
Published on: 12 September 2025

***Corresponding Author: Chinedu James Ujam**
Department of Mechatronics Engineering, Federal University Otuoke, Bayelsa State, Nigeria. **Email ID:** ujamism@gmail.com,

DOI Link: https://doi-doi.org/101555/ijrpa.6732

ABSTRACT

Human factors engineering is currently of interest because technological advancements have brought attention to the necessity of taking into account people and how they interact with machines, materials, information, processes, and environments when developing new technologies and when designing technological systems. The goal is to make sure that technology and people coexist peacefully, with tasks and equipment that are in line with human traits. In order to create the most effective and efficient working and operating environment possible, industrial engineering combines and applies scientific principles to the analysis, design, installation, and enhancement of integrated systems of people, materials, equipment, and information**.** In order to address this issue, this analytical paper examines pertinent data regarding the specifics of human factors, their interdisciplinary nature, and their implications for industrial engineering and design. Additionally, it explains the fundamental connection between industrial engineering and human factors engineering as well as the value of studying human factors for industrial engineers. An industrial engineer with a background in human factors is ideal because he can evaluate various machinery and process design options, make trade-offs when choosing equipment, and come up with a better solution.

KEYWORDS: Human Factor, Industrial Engineering, Work Station Design, Production Engineering, Optimization.

INTRODUCTION

A key component of increasing productivity and guaranteeing worker safety in the fields of industrial engineering and management is the design and optimization of operating environments.[1-2] Optimizing industrial operating environments requires human factors engineering, the field that takes into account human capabilities and limitations when designing systems.[3–4] In order to improve system design by comprehending human behavior and capabilities, human factors engineering focuses on matching human physiological and psychological characteristics with the work environment. In industrial environments, this includes workstation design, equipment operation, workflow arrangement, and other aspects that have a direct impact on employee well-being and work efficiency [5,7]. The application of human factors engineering principles to industrial engineering and management is crucial for the creation of a highly efficient and humane operating environment because in many industrial enterprises, the design of operating environments tends to focus more on production efficiency and cost control than on the physiological and psychological needs of employees, which can result in lower work efficiency, lower employee satisfaction, and even health issues and safety accidents.[8] The main methods of optimizing the operating environments based on human factors engineering include the design of workstations, the optimization of equipment layout, the adjustment of environmental factors, the optimization of human-computer interaction, and the optimization of equipment layout.

The main methods of human factors engineering-based work environment optimization are workstation design, equipment layout optimization, environmental factor adjustment, human-computer interaction optimization.[9–11] Businesses may encounter issues with cost and investment, employee training and adaptability, and technology and methodology updates when implementing industrial engineering and management work environment optimization based on human factors engineering. Industrial engineering and management work environment analysis and optimization based on human factors engineering will give greater consideration to employee experience and technological innovation. Using human factors engineering in industrial engineering and management work environment analysis and optimization The use of human factors engineering in industrial engineering and management work environment analysis and optimization is crucial for increasing production efficiency, protecting employee safety and health, and boosting the competitiveness of businesses.[14,15] As intelligent technology, such as artificial intelligence, advances, big data analysis in work environment optimization will start to gain popularity.[12–13] At the same time, the health and well-being of employees should become increasingly important to the business.

In order to study and investigate the industrial engineering production plant's operations regarding personnel and machine configuration as well as the improvement of the production site environment, human factors engineering is primarily applied in the field improvement in this paper. gathering and evaluating data on operation efficiency in industrial engineering, as well as applying the operation time measurement method. Determine the factors that affect production efficiency and make improvements to them in order to reduce the workstation operation time while maintaining a standard of product quality. This can be done by specifically analyzing the operator's work and analyzing the operation method, operation load, labor intensity, and operation time Operation analysis mainly studies a production process, workplace man-machine operation, or man-alone operation situation.

Objectives of Human factors

There are two main goals of human factors engineering. The primary objective is to improve the efficiency and efficacy of work and other activities. This covers things like improved usability, decreased mistakes, and heightened efficiency. Enhancing certain desirable human values, such as increased safety, decreased stress and fatigue, increased comfort, increased user acceptance, increased job satisfaction, and enhanced quality of life, is the second goal. Ergonomics is crucial for creating the best possible working conditions for employees, lowering physiological expenses, increasing productivity, making handling instruments easier, maximizing operational and production system efficiency, and minimizing human error.

Industrial engineering

Analysis, design, and control of productive systems are the focus of industrial engineering. Any system that generates a product or a service is considered productive. In order to operate productive systems efficiently, industrial engineering explains how to analyze and design them as well as control procedures (i.e., directing human effort).

The goal of industrial engineering is to create an effective production system that generates the necessary number of goods at a reasonable cost and quality. It blends ideas of engineering process and analysis with human behavior principles.[14] The skills of an engineer and a manager are combined in industrial engineering. This calls for aptitude in economics, statistics, and mathematics as well as a basic understanding of engineering sciences, an interest in a variety of occupations, a fascination with machinery and people who manufacture goods, and the capacity to synthesize, analyze, and integrate technical knowledge in real-world contexts. To put it succinctly, industrial engineering is the study of the technical aspects of each production process in a productive system and the integration of all the components of a production system (workers, materials, equipment, information, management, etc.) in order to produce a high-quality product at the right time and at the right cost.[14]

Specialties of Industrial Engineering

Most people consider industrial engineering to be a synthesis of four main fields. The first is "operations research," which covers the general analysis and design of integrated systems of people, machines, materials, money, and management through the application of scientific methods. Optimization, decision-making science, stochastic processes, and simulation modeling are all included in operation research (OR). Economic analysis, production planning and control, quality control, facility design, and other facets of top-tier manufacturing are typically included in the "production/operations function." "Manufacturing processes and systems" comes in third. Manufacturing processes, such as chip-less and chip-forming procedures, and materials removal techniques like material forming, cutting, shaping, and planning, are directly related to machining science. The integration of manufacturing processes is the main goal of manufacturing systems, which are typically accomplished through computer control and communications (such as CIM and CIE). The manufacturing function is a collection of technical expertise and knowledge that keeps all production processes under control in a system that is productive. In essence, human factors are concerned with people. Informational human factors study the cognitive aspects of human formation processes, whereas physical human factors consider the human as a biomechanical device.

Weaknesses of Production Engineer

The typical weaknesses of production/ manufacturing system engineer (PE) identified include, among others

- Lack of proper knowledge in human factors causes problems to PE’s in today’s environment of productivity management, operations management and continuous productivity improvement approach.
- Many companies are seeing this weakness and are providing human factors engineering training to PE’s.

- There is a major effort in manufacturing to improve health and safety, reduce injuries and workers physiological costs, which is foreign to traditional PE's. This can be affected by implementing human factors in production design and planning.
- Many companies are demanding industrial engineers with proper knowledge of human factors application in the design of products and equipment, workstations and working environment, systems and methods of operation. Ergonomics or Human factors will give industrial engineers an edge over traditional PE's with high potential for job and work experience.

Effect of poor Human Factors Application in Manufacturing

- Less production output
- Increased lost time
- Higher physiological cost
- Higher material cost
- Increased absenteeism
- Increased risk of accidents
- Higher employee turnover
- Low employee morale
- Increased fatigue and injury rate
- Increased risk of errors

Indicators of Human Factors Weakness

Industrial and manufacturing system engineering where there is no application of human factors indicates the following drawbacks:

- High material waste, scrap and rework
- Operators doing frequent mistakes
- High number of employee complaints
- High absenteeism and turnover
- Incidents of near-misses of accidents
- Employees taking frequent breaks
- Supervisor constantly missing schedule
- Employees requesting frequent job transfer
- Workers complaining about aches & pains

- Large number of employees wasting time

Industrial Engineering approach Vs Human Factors approach

Fredrick Taylor's scientific management concepts and methods form the foundation of the industrial engineering approach. Its foundation is the use of the method-time-motion study on task elements to analyze operations. While the ergonomics/human factors approach uses physiology and biomechanics to identify fatigue factors that are neutralized by engineering and administrative controls, the standard allowance provides the fatigue factor to develop the production rate.[6] The methodical application of pertinent data regarding human capabilities, limitations, traits, behavior, and motivation to the design of objects and processes people use as well as the surroundings in which they use them is known as the human factors approach.[7] This entails conducting scientific research to find pertinent data regarding people and how they react to objects, machinery, processes, workplaces, etc. Evaluating the products to make sure they meet their intended goals is another aspect of the human factors approach.[16–17]

Implications of Human factors in Industrial engineering design

Human factors has a wide application in everyday living and domestic situations, however there are even more significant implications for efficiency, productivity, safety, health, and comfort in work settings. Among the many important roles identified, human factors engineering plays the following basic functional roles:

- Methods and operation design
- System and interface design
- Product and equipment design
- Task and job design
- Workstation, work arrangement and working environment design
- Information design

Workstation Design Guidelines

Work systems place a strong emphasis on how well people and the process environment mesh. A workstation system that combines comfort and efficiency enables task-focused and operator-specific setup and adjustments. Manufacturers can create a work environment that meets the needs of the business and its employees thanks to a flexible base design that is supported by a range of modular components..

Depending on the operator, different workstation heights are advised. Males and females have different standing work postures, and when it comes to designing workstations, males and females have different seated work postures. The size of the object being worked on and the worker's position during the task—whether seated, standing, or a combination of both—should be taken into consideration when determining the ideal level.

Setting the height a little lower than the suggested level is advised if the object being worked on is large. This puts the object's center at a height that the operator can reach more easily..

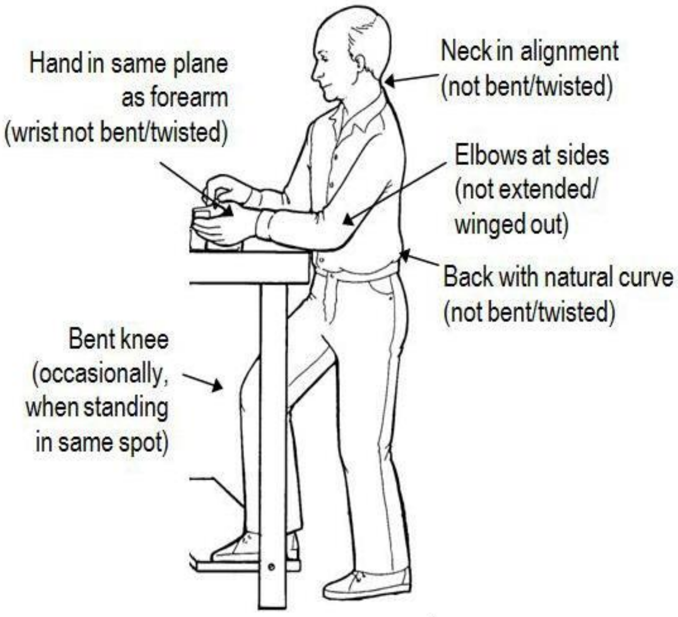

Fig. 1: Workability of a worker in Optimal Position.

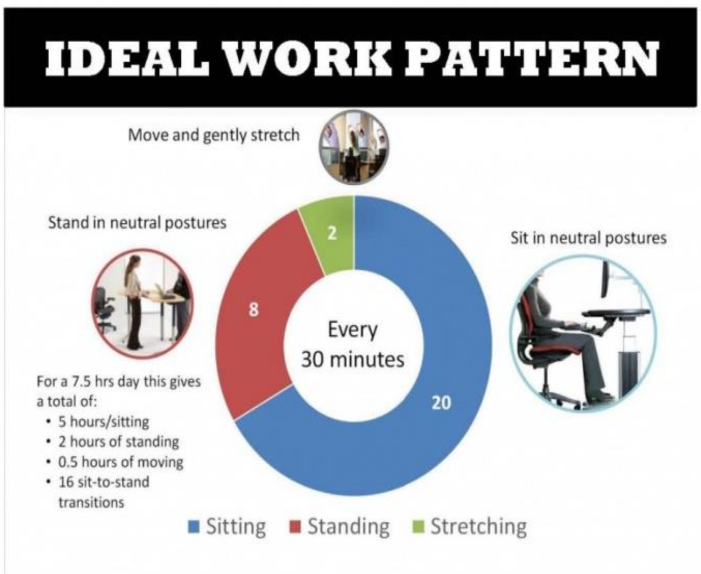

Fig. 2: Ideal work Pattern Positions.

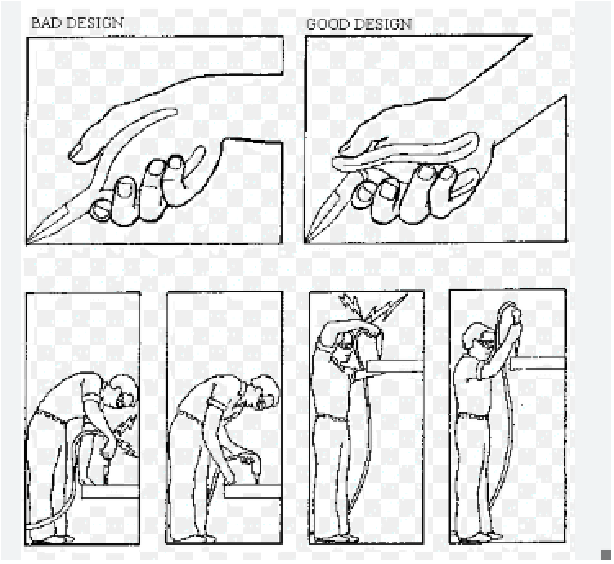

Fig. 3: Shows the reachability of workers hand during working period.

Designing jobs to fit people is one of human factors' objectives. This entails accounting for variations in size, strength, and capacity to manage data for a variety of users. These differences are then taken into consideration when designing the tasks, workspace, and tools. Increased productivity, quality, and job satisfaction are the desired outcomes. Increased error rates and physical exhaustion, or worse, are the costs of failure.

Product design: If a product is poorly designed, even the most straightforward ones can be a nightmare to use. These days, product designers are frequently separated from end users, so it's critical to take an ergonomic, user-centered approach to design. This includes asking people to test items, talking to them, and observing how they use equipment. This is particularly crucial when it comes to "inclusive design," which involves designing commonplace items with older and disabled users in mind.

Current industrial practices and standards in Human Factor Environment (HFE)

There are several standards available to support industrial practitioners.[20] Where appropriate, the standards may mandate that the operator's tasks, the tools they will use to perform them, and the environment in which they are performed be considered in terms of physical and cognitive ergonomic assessments. However, the standards must be sufficiently general to prevent being customized for any particular design process; consequently, more detailed guidelines for various domains are required to provide designers, operators, risk assessors, and project planners with specific guidance. To give more detailed instructions on

HFE assessment and safety by design issues, safety-critical industries like the nuclear or aviation sectors have frequently created their own internal standards. The purpose of this section is to give a concise summary of the most widely used HFE standards. The following components must be considered when designing a work system: (a) work organization design; (b) work task design; (c) job design; (d) work environment design; (e) work equipment, hardware, and software design; and (f) workspace and workstation design, according to ISO: 6385—Ergonomic Principles in the Design of Work Systems [21]. The relevant ergonomic principles and techniques for every design stage are listed along with a description of each stage. Although ISO 6385 is meant to serve as a menu to help guide future decisions, it needs to be updated to offer a more thorough and organized list of available practices. For instance, it makes no mention of the standard ISO 11064, which is known as the Ergonomic Design of Control Centers.[22] This standard provides guidance on particular aspects of control room design, such as layout, workstation design, controls and displays, and environmental requirements, as well as nine principles for the ergonomic design of control centers. The standard ISO 12100-Safety of Machinery.[23] is another cross-reference that is not included in ISO 6385. It proposes a five-step methodology to conduct risk assessment at the design stage and the overall strategy to take into account machinery safety throughout its life cycle, taking usability, maintainability, and cost efficiency into consideration. The EEMUA 191 is not part of the ISO group. In order to support the design of alarm systems that take into consideration the needs of the human operator receiving and responding to those alarms, the Engineering Equipment and Materials Users' Association developed the.[22] industrial standard. Meanwhile, EEMUA 201.[23] focuses on the design of the Human Machine Interface (HMI) and provides guidance on topics like display hierarchies, screen formats, and environmental characteristics that may impact the use of the HMI. Although these standards specify minimum requirements, their methodical approach is rather generic and does not offer designers technical support. They don't provide any instructions on how to go about doing this verification. Participatory methods and rapid prototyping are increasingly being used in design reviews.[18] The final users are frequently involved in the use of 3D models for reviews. Because the 3D model is a more realistic representation and eliminates the need to decode 2D technical drawings, it makes it easier for the operator to spot possible problems with the suggested design. This method is a more reliable place for the designers to start when creating a safer design and can be regarded as a tangible illustration of human-centered participatory design. It is important to facilitate these participatory design reviews as soon as feasible. Although the aforementioned standards can be used in conjunction with 3D participatory review, none of them provide a clear explanation or outline of the procedure. Therefore, even though ISO 9241-210,[23] Ergonomics of Human-System Interaction, calls for human-centered, participatory approaches, it does not offer technical information about which particular factors should be taken into account or how to actually implement such a process; furthermore, it does not even make reference to more specialized standards like ISO 11064,[22] for the Ergonomic Design of Control Centers or ISO 12100,[23] on Safety of Machinery. Assimilation may be accomplished by incorporating HFE principles into more general technical engineering and design standards. Too frequently, the existence of HFE standards and the underlying principles are unknown to anyone outside of the human factors field. In order to prevent designers from receiving contradictory instructions, it is also critical to make sure that the HFE standards are in line with the pertinent engineering standards. Furthermore, it is important to emphasize that the primary HFE best practice is to incorporate end users' actual needs into all design stages as much as possible in order to introduce a life-cycle perspective.

DISCUSSION

The most obvious person to design and analyze workstations, as well as to design controls and displays for VDTs in any human-machine system, is an industrial engineer who understands the field of human factors engineering and is able to apply concepts, techniques, and principles of human factors.

Human factors will surely become more significant in industrial engineering, production system design, planning and control, and industrial health and safety as technology advances. In order to create the most effective and efficient working and operating environment possible, industrial engineering combines and applies scientific principles to the analysis, design, installation, and enhancement of integrated systems of people, materials, equipment, and management. Additionally, human factors engineering contributes to a productive, user-friendly, comfortable, and convenient workplace. Therefore, human factors in industrial engineering and design are crucial for increased system efficiency, productivity, job satisfaction, and quality of life.

CONCLUSION

The multi-disciplinary nature of human factors is immediately obvious. The ergonomist / human factors engineer works in a team, which may be composed of variety of other professionals namely, design engineers, industrial engineers, manufacturing engineers, computer analysts, industrial physicians, health and safety practitioners, and specialists in human resources. The overall aim is to ensure that the knowledge of human characteristics and limitations is brought to bear on practical problems of human beings at work and the environment in which they work. This analytical article has explored the relevant information on details of human factors and the interdisciplinary nature of human factors as well as the implications of human factors in industrial engineering and design. The core part of the paper has presented a workstation design guidelines in details in addition to a case-study analysis of Human-machine interface at a Computer workstation.

The increased rate of technological development of recent decades has created the need to consider human factors early in the design and development phase, and in a systematic manner. Because of the complexity of many new and modified systems, it frequently is impractical to make changes after they are actually produced. The cost of retrofitting frequently is exorbitant. Thus, the initial designs of systems, products, equipment, and environment must be as satisfactory as possible in terms of human factors consideration.

REFERENCES

1. Drogoul, F., Kinnersly, Roelen A, Kirwan, B. (2007). Safety in design. Can one industry learn from another? Safety Science 45,129–153.
2. HSE 1999, Offshore technology report 0992, Human Factors assessment of safety critical task, health and safety executive, UK
3. Kletz, T. (1996). Inherently safer design: The growth of an idea. Process Safety Progress, (15), 5–8.
4. Leveson, N. G. (2011). Engineering a Safer world. Massachusetts: The MIT Press.
5. Lindgaard, G., Dillon, R., Trbovich, P., White, R., Fernandes, G., Lundahl, S., & Pinnamaneni, A. (2006). User Needs Analysis and requirements engineering: Theory and practice. Interacting with Computers, 18(1), 47–70.
6. M. Helander, "A guide to the Ergonomics of manufacturing", *East-West Press edition,* 1995.
7. M. Iqbal, "Ergonomics/Human Factors: The concept", *18th Annual Science Conference* of Bangladesh Association for the Advancement of Science (BAAS), Bangladesh Agricultural University (BAU), Mymensingh, June 22-24, 1994.
8. M. S. Sanders and E. J. McCormick, "Human factors in engineering and design", *McGraw-Hill, Inc*., 7th edition, 1992.

9. Maguire, M. (2001). Methods to support human-centred design. International Journal of Human-Computer Studies, 55(4), 587–634.
10. M*cGraw-Hill, Inc*., International editions, 1995.
11. Naghdali F., Leva M. C., Balfe N., Cromie S. , 2014, Human Factors Engineering at Design Stage: Is There a Need for More Structured Guidelines and Standards? Chemical Engineering Transactions Vol. 36, 2014.
12. OGP, 2011, Human factors engineering in projects, International Association of Oil and Gas Producers, Report No. 454, International Association of Oil and Gas Producers, London,
13. Øwre F., 2001, Role of the man–machine interface in accident management strategies, Nuclear Engineering and Design, 209, 1-3, 201–210.
14. P. H. Hicks, "Industrial engineering and management – a new perspective", *McGraw-Hill, Inc.*, International editions, 1994.
15. R. Bailey, "Human performance engineering: A guide for systems designers", *NJ: Prentice-Hall*, 1982.
16. R. S. Bridger, 1987 "Introduction to Ergonomics",
17. Rasmussen, J. (1983). Skills, rules, knowledge; signals, signs, and symbols, and other distinctions in human performance models. IEEE Transactions on Systems, Man and Cybernetics, 13, 257-266
18. Taylor J.R., (2013). Incorporating Human Error Analysis into Process Plant Safety Analysis CHEMICAL ENGINEERING TRANSACTIONS VOL. 31, 2013 301-306.
19. Tendjaoui, M., Kolski, C., & Millot, P. (1991). An approach towards the design of intelligent man-machine interfaces used in process control. International Journal of Industrial of Industrial Ergonomics 8, 345–361
20. Vicente, K. J. (2001). Cognitive engineering research at Risø from 1962-1979. In E. Salas (Ed.), Advances in Human Performance and Cognitive Engineering Research, Volume 1 (pp. 1-57), Elsevier.
21. Widdowson, A., & Carr, D. (2002). Human factors integration : Implementation in the onshore Human factors integration : and offshore industries. Camberley
22. Wilson J. R., Corlett N., (2005) Evaluation of Human Work, 3rd ed., 83–111, Taylor and Francis Group, Boca Raton, USA.