Industrial Engineering Letters
ISSN 2224-6096 (Paper) ISSN 2225-0581 (online)
Vol.3, No.12, 2013

Review of Human Factors Engineering: Its Contributions to the Performance Efficiency of Manufacturing Workers in Industries.

Nwosu M. C.
Nwosu, M. C., senior lecturer in the dept. of Industrial and Production Engineering, Unizik, Awka, Nigeria

ABSTRACT
Human factor engineering(HFE), the ability of human to perform physical work, focusing on the size of the force and convenience required to do a particular movement or work effectively .This except reviews the principles of work , location and posture, control, comfort, convenience and performance of the operators of mechanisms, devices and machines. More so, the various aspects of contributions of HFE in engineering and technology are discussed of the principles and applications of different organization immense contribution, such as the Society of Automotive Engineering (SAE), International Standard Organization (ISO), Air force system command (AFSC), and so on. The integration of these organizational research findings in technology and the extent to which they are applied has increased the performance and efficiency in industrial, social and military activities. Hence human factors engineering has greatly improved technological operations and the comfort of human life and the society.
Keyword: Man, machine, work station, human factors, environment, organization, principles and performance.

INTRODUCTION

The intention of this compilation is to review in order to bring to light the immense contributions of this new field of engineering called the human factors (HF) engineering or ergonomics, and to show its vital influences and applications to Production Engineering and Operations. Based on these facts, the entire spheres where their attributes affect lives are to be enunciated as well as showing their relevance and effects in engineering technology. Moreover, the development and advancement of human factors engineering have caused a lot of improvement in the performance, reliability and efficiency of systems in which human operators operate or control.

Background Information:

The dynamics of psychomotor skill development and its negative, poor performance and emergence of errors, is a pervasive consideration in man- machine system design and control. The highest level of psychomotor skill is attained by a process of successive organization of perception (SOP), whereby operators fully familiarized with the dynamics of the machines under their control and the appropriate responses to the input signals can reorganize the system, adapt their behavior to create a repertory of special respoanses, and then select from this repertory the appropriate response for the system performance.

Human factors engineering and ergonomics is a new engineering technology developed to improve the performance, reliability and efficiency of systems (machine tools, working-place, product design, industrial process control, quality control, office design, etc) in which human operates in concert with machines (man/machines/ systems). This discipline was developed during and after World War II. During this period, the life or death stake and advances in military technology made even minor improvement in military system highly desirable and major improvements essential. Subsequently, the risks of accidents and the complexity and costs of military hardware, manned space exploration, nuclear power plants, vehicular control and civil air transportation were behind the continued development of human factors or ergonomics as an engineering discipline. It received wide attention in the late 1970s and the '80s when the safety of nuclear reactors was questioned following serious accidents that were caused by operator errors, design failures, and malfunctioning equipment. Human-factors engineering seeks to establish criteria for the efficient, human-centered design of, among other things, the large, complicated control panels that monitor and govern nuclear reactor operations.

The term is perhaps not well chosen, for what is meant is engineering for human use, not engineering the human. Human factors engineering can be defined as *"the determination and application of scientific principles of human physical and psychological characteristics to the design of equipment, so as to increase speed and precision of operation, provide maximum maintenance efficiency, reduce fatigue, and simplify operational requirements"*. The aim is to make the best use of human abilities and limitations in equipment and systems design and so decrease, if possible, the amount of specialized skill required of operating and maintenance personnel.

The professional personnel conducting studies in this field of human factors engineering, supplied data, and applying it to practical engineering design problems are known commonly as human engineers or human factors specialists or human factors engineers or engineering psychologists.

Commercial applications of human factors engineering are in: product design, industrial process control, quality control, health-care technology, computers and office design and these have expanded development of human factors engineering which interact with the theories and data of many diverse disciplines: psychology, physiology, and applied physical anthropology, aeronautical, electrical, industrial, mechanical, and system engineering and cognitive science.

Human beings operate as sensors, information processors, actuators, and decision makers. The model used to determine these operations are determined by the man-machine-systems (MMS).

Today, human factors engineering is generally viewed as the science of fitting the job to the worker, and concerns the field of the human operator and his working environment. It can be seen that it covers a very wide field of technology and may be applied at the early stage of design when production lines and workplace are being laid down, and sometimes have to be applied to improve the existing layout.

Human factors engineering is an activity which has developed from the work study and the aim is to improve the working environment such that the operator's fatigue and strain are reduced and the efficiency of the manufacturing organization is increased.

The human-factors engineers when studying the job with a view to keeping it within human limitations, and in order to make the best use of human abilities, will arrange the things that must be considered into these three groups: instrument controls, workplace and working environment.

Nature of human factors contributions to production efficiency in industries:

It has been widely accepted that the main purpose of human factors engineering is to improve the performance, reliability and efficiency of production systems that are used or operated by human operators. In industries, there are machines, equipment, work place, materials utilization, instruments and controls, and working environment which human manipulates, controls and uses. These have to be used to the advantages and efficiency of production workers as will subsequently discussed below.

Instruments and controls Applications in manufacturing Industries:

i) Human factors Engineering in Instruments design

In the use of machines and other equipment in industries, two actions are made, which are: to apply control and to look at or listen to the display. Display is the instrument or equipment parts which operator must looked at or listen to (e.g. electronic visual display units, metering instruments, scales of measuring devices), whereas the control device is that part of machines or equipment on which operator exert muscular force in order to change the state of the process or operation (Knobs, levers, hand wheels, pedals, switch and rotary selector switch, cranks, pushbuttons, and joysticks).

In the design of instrument, the information expected of the
Instrument to contain or provide must be displayed to operators vividly and in the simplest form. This display is grouped into three types depending upon the information to be conveyed, and they are: qualitative, quantitative, and representational displays.

The quantitative displays are the analogue and digital. But the first form to be in use is the Analogue form of instrument which found to present the problem of accurate read-out of measured quantities. This problem imposed actually inspired the human-factors engineers to develop a new method of reading a display, which is the digital display. The improvement of display through digital process offers the operators the advantage of using the digital indicators to show the required information directly and quickly as a number from the measuring devices meter (a quick approximate reading at a glance), but the analogue version gives the best results. As a result of these advantages, there is possibility of combining the two types of indicators in an instrument display.

The important features of the scale for adaptability for use are legibility.
Aesthetically, the design of black colour numerals on white background gives clearer print in combining Analogue and Digital instruments.

Operators using display equipment to display information expected the metering system designer to incorporate the qualities of simple to read, bolder to perceive and legible to sight.

The meter graduation is characterized in such a way that the numerals are made long, and upright enough, good accuracy and efficiency of the display read-out by the operators or manufacturing workers.

There are many configurations that are be adopted for different instrument design, these are commonly presented as: numbers increase clockwise, numbers increases from left to right on horizontal scale, and numbers increase upward on.

In multi-instrument display panels such as in electric arc melting furnace, instruments are located in a logical order or pattern such that dials and points are shown to the users (operators) and that the pointers are set in the same instrument positional direction.

ii) Human-Factors Engineering Attributes in Machine Control

Certain controlling elements such as: Knobs, levers, hand wheels, pedals, switch, rotary selector switch, cranks, push-buttons and joysticks are common components found used in machines by operators, to offer some degree of mechanical advantage at use. These components are positioned such that the operators can manipulate them with the least change in the body position and with the greatest mechanical advantage. It is necessary to ensure that the operator needs not to leave his normal working position in order to reach a machine control as well as need not to bend or twist to reach these control elements of a machine. It is ideal that a machine is designed for a general use to suit an average human being and information on anthropological studies and anatomical dimensions are available to help to do this. Proper consideration during the design stage of a machine will be made with regards to the location and position of the control elements for offering easy manipulation of machines.

The application of these elements are configured in a logical order or pattern of turning, such that positive turn (PT) or negative (NT) confines to a common defined direction of increasing magnitudes gives a positive turn (PT) and a decreasing magnitudes give a negative turn (NT). This will give a definite concept in control of these control elements and improves performance of the operators in terms of force application, speed and accuracy designed into a machine.

iii) Control Elements Features Design and Applications

The following observations are to be made in respect of control elements design in machine systems for ease of manipulation:

1. Smaller hand controls such as switches and knobs used for instrument control elements. Larger diameter switches or knobs are most suitable for fine and sensitive control, and small diameter knobs are used for coarse adjustment.

2. Switches operating power are best designed with red indicator knobs or light which shows power or power on respectively.

3. Pointer shapes should be used on knobs which are designed to indicate some values.

4. Knobs are distinguished by shape so that the control can be recognized by feeling alone.

5. The control switches accepted conventions for ON or OFF controls should strictly adhered to with switches pressing downwards as ON and upward OFF and with rotary switches turning clockwise is ON (sometimes with increase values) and turning anti-clockwise is OFF (with a decreasing values).

6. Designers must conform to general standards for ease of use by operators.

iv) Human-factors Engineering Applied To A Workplace Layout:

Most of the commonly encountered problems in the human-factors engineering designs of machines and controls are found in the design of workplace layouts. The workplace is a space in a factory where machines, semi-finished or finished products, materials or vehicles are accommodated as well as operators, who may be sitting or standing. The efficiency of the operator at work depends upon design comfortability of the workplace. Usually, a workplace should be custom built for the use if the person whose anatomical dimensions are known. Therefore, the human-factors engineers should utilized the knowledge of the science of anatomy and anthropometry (measurement of people) in the design of a workplace layout, and proper consideration of the various elements as sex, seated or standing at a workplace and the design should be for the average person some times adjustment may be provide such as the case of seat heights in vehicles.

In considering working areas, according to BS 3138:1969, specified two aspects of the working areas, which are known and defined as:-

1. Normal working area is the within which a seated or standing work can reach and sue tools, materials and equipment when his elbow fall naturally by the side of the body.

2. Maximum working area is the space over which a seated or standard worker has to make full length arm of human factors engineering design of bench, seats and seating arrangements. Movement (i.e. from the shoulder) in order to reach and use tools materials and equipment. Note that the same considerations are made when using legs.

v) **Human Factors Engineering Considerations in Benches, Seats and Seating Arrangements**

Detailed anthropometric information is available for the different sexes, but simpler information could be obtained once the group of persons liable, to use the work place (or series of work place).

The anthropometric information for sitting position and standing position as well as bench and seat height are engineering presented in diagram as shown by SAE (1989).

The body dimensions given in the sample must be the smallest dimensions in the group in order that all can reach the equipment.

In respect of the case of bench height and seat height, the seat can be adjustable and bench or work top usually kept fixed at the value 712mm to 762mm (the best compromise dimensions). For fixed bench heights, the seat should be adjusted for height and rake angle.

There is usually occasions for using, items such as tote box, bin, loose or portable tools etc, it is necessary to locate them in a definite position within the working area, hence the operator can develop habitual, confident movements to collect the equipment or tools without any need for eyes to direct the hands, thereby reducing the mental efforts and strain

vi) Human Factors Engineering Applied To Noise and Its Control

In most engineering factories (especially in the machine tools), noise is highly generated which is not desirable to operators and other factory people, because it tends to be annoying and sometimes distracting, thereby leading to less efficiency of work and in some occasions it can lead to increase in accident risks. Noise bothers some people more than others. Noise can be defined as an unorganized sound generated with varying frequencies and intensities.

From the research findings, noise is generally believed to be causing a decrease in the health of most people who are exposed to a high noise level especially, it can cause damage of hearing and even cause deafness, and worst still noises may not necessarily be the loudest or the most annoying. Therefore noise can reduce efficiency of work by an operator and damage hearing. It is worthwhile to consider how the situation of industrial noise can be improved.

Noise is generated in industry, by the operators of industrial process machines which often cause undue vibration and noise. The vibration causes a rapid rise and fall of the pressure of the surrounding air. These pressure charges travel through the air in the form of waves and strikes the ears of a person. Whether a person hears the sound or not depends upon the amplitude of the sound waves and its speed of the sound from its source. A human being will hear sounds between values of 20 and 1500Hz, e.g. ultra sound of the order of 3MHz is not audible to the human hears. In some industrial operations, noises are of the order of 140dB (decibels). Noise is measured in frequency (Hz) and intensity (dB).

Noise preventions in working place.

a. Ensure that there is an adequate improved maintenance procedure and machines which give rise to vibration should be mounted on properly designed anti-vibration mountings to prevent vibration transmission through the base.

b. Compressed air operated mechanisms are particular noisy, and so exhaust parts should be connected to silencers. Sometimes, the level of noise here will still be intolerable.

c. Where possible, enclose all or part of a machine in a sound proof booth**.** The sound proofing materials to use are of two types, and are different in both physical character and design purpose, they are dense and non-porous (reflecting) e.g. stone and metal; and light and porous (absorbent) e.g. cork and felt. They are used to design most of the acoustic enclosures.

   Workers must be ensured to put on ear protectors (ear muffler).

d. According to Hazlehurst, it is necessary that people working in high noise level occupations should be given a hearing test at frequent intervals, so that where hearing is affected it can be detected in a good time and the operator moved to another job as a remedy.

Human Factors Engineering Applied in Maintaining Standard Industrial Comforts:

The intention of this consideration is to find out ways of improving standard industrial comforts during working. The climatic and environmental factors such as brightness, air temperature, radiant temperature, air humidity and rate of air movement will be looked into to validate their influences in the improvement of operators working efficiency.

1. **Air Temperature**: It is recommended that a reasonable temperature must be maintained in each work room. In rooms in which a substantial proportion of the work is done sitting and does not involve serious physical effort, the temperature must not be less than 18^0C, but a satisfactory of 18.3^0C conceded. Other recommendations are:-

   Workers engaged upon heavy tasks: 12.80 C to 15.6^0C
   Workers engaged upon light tasks: 15.6^0C to 20^0C.
   Workers engaged upon sedentary (nonmoving) occupation: 19.4^0C to 22.8^0C
   The effect of a process in the workroom such as a furnace, giving off radiant heat, can be accounted for.
2. **Radiant Temperature:** The **globe thermometer** is used to measure and record the mean radiant temperature. The desirable standards temperature is that of the air at standard temperature, 293**K** and pressure of one atmosphere.

3. **Air Humidity:** Humidity is the existence of moisture in the air and is measured with hygrometer. Absolute humidity which is unaffected by temperature is a measure of the actual moisture content in a given weight of air. Relative humidity is a commonly used measurement. Relative humidity is ***the ratio of the actual moisture content of the air to that which would exist if the air were saturated at the same temperature.*** The standard relative humidity value that should be allowed if personnel comfort is to be maintained and expressed as a percentage as 65%. Humidity varies with temperature changes. As the temperature falls so humidity may cause discomfort through a dryness of the nose and throat; and high humidity may cause discomfort through a feeling of stuffiness and closeness. As ordinary working temperatures (e.g. 18^0C) humidity has little effect.

4 Rate of Air Movement Required in a typical Shop

Breeze is highly admired especially workers. The speed at which air moves through a workroom can affect the comfort of the staff. At say 0.5m/sec draughts resulted and at 0.1m/sec the atmospheric air is less. The recommended value of rate of air movement is given as 0.15 m/sec (breeze). It is important to note that at temperatures above the standard values (e.g. 25^0C) an increase in rate of air movement will be required, say 0.25m/sec.

5 Lighting of the work Environment:

This an important factor to be considered in human factors engineering because brightness in factory shop increases efficiency of work especially during night work. If light is controlled at a desirable level, satisfactory and comfortable to the working staff, efficiency will be high, productivity will be higher, health will be improved, and less accident should occur. The unit of light (luminous flux) is the lumen and is defined as- the amount of light emitted by a point source having a uniform intensity of one candela (intensity of one candle). The S I unit of illumination is ***lux,*** which is **an illumination of one lumen per square meter.**

The factory Act states that "there must be sufficient and suitable lighting in every part of the factory in which persons are working or passing, and requires at least a minimum of 65 lux (40W tungsten wire bulb intensity at 220-240 voltage capacity). The illuminating Engineering Society of Great Britain Published a Code of good interior Lighting practice (1961): that a lighting level of 160 Lux should be regarded as minimum in all work places as a general amenity.

Other recommended lighting levels for specific visual work are shown in appendix.

CONCLUSION:

It is generally observed that factors such as instruments design, proper ergonomics consideration in the design of machine and control elements, design of work place layout, bench and seat arrangements, Noise and lighting are responsible for the performance efficiency of operators or workers in manufacturing industries. The control elements of machines standard configuration will aid users to be efficient in handling and manipulating control with a hand wheel, it is efficient to use big wheel than small diameter wheel if one is controlling. It can give quick and high precision value instead, and there is no longer a time delay in an attempt to obtain accurate values. The evolution of the human factors engineering elements in manufacturing industries application offers ease of operation, speed, accuracy, stress and strain decrease, improvement in health and better performance efficiency of manufacturing workers.

The importance of using standard recommended lighting level cannot over emphasized because during night shift, a good lighting is necessary for a good vision to the tools and work piece and less straining of the eyes during manufacturing operations. It is recommended by IFS (1961) that a lighting level of 160 lux should be regarded as minimum in all work places a general amenity. If the standard giving in this review work on the human factors engineers contributions for a way out for improvement for performance efficiency of manufacturing industries will experience a tremendous increase in production output as workers efficiency is greatly improved.

Recommendations

1. As a matter of necessity, every manufacturing industry must try to comply with the standard design features as stipulated in the various sections of this compilation as it will give a sense of direction to the manufacturing engineering design of work environment.

2. All the information provided are necessary and if well applied will promote the company's good will and co-operation between workers (employees) and employers increased. It also shows the company's great regards for its workers good health, and this will increase the morale of the workers and hence increase in productivity.

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APPENDICES

The code specific recommendations for a few are:-

VISUAL TASK		**RECOMMENDED ILLUMINATION (LUX)**
1	Rough assembly and inspection work	160
2	Very fine assembly and inspection work	1600
3	Weaving light cloth	320
4	Weaving dark cloth	750
5	Sheet metal work	220
6	Planning wood at machine or bench	220