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ERGONOMICS – AN INDUSTRIAL PERSPECTIVE: A REVIEW

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ABSTRACT

Ergonomics scopes the bridge between design parameters and human compatibility factors. In this paper, need of ergonomics, domains of ergonomics, benefits of ergonomics, application areas and a prospective epidemiologic case study was conducted. This case study identifies that, the controls being used in tractors are consistent with the published design recommendations for controls. This paper describes the development of an ergonomic facility for improvement of tractor design.

KEY WORDS: ERGONOMICS, COMFORT, CONTROL, DISPLAY, TRACTORS

SUB AREA: INDUSTRIAL ENGINEERING

BROAD AREA: MECHANICAL ENGINEERING

1. WHAT IS ERGONOMICS?

The word Ergonomic is derived from two Greek words "ergon" and "nomos", which together mean, "the laws of works" [2]. Ergonomics is a science concerned with the 'fit' between people and their work [1]. It puts people first, taking account of their capabilities and limitations. Ergonomics aims to make sure that tasks, equipment, information and the environment suit each worker.

2. NEED FOR ERGONOMICS [2]

Traditionally, tools and machines were made by their eventual users: the craftsman would design and make tools that suited his exact purposes, rather than acquiring tools from a specialist maker. This allowed the tool to fit its user exactly. More recently, design and manufacture of tools and machines has developed to specialists, and we have seen rapid development in the engineering sciences and technologies as a reflection of this. One consequence of this development, however, is that the maker and user of a tool are no longer the same person, and the maker must make assumptions about the user's characteristics in an attempt to achieve a satisfactory fit between user and product.

For many years a measure of common sense on the part of the engineer and designer was sufficient to fit user and tool in an acceptable manner: as long as the tool was relatively simple, and as long as the consequences of poor fit were not severe, the problem was not a difficult one to solve. In recent years, however, Man has used tools and machines of increasing complexity, and users may be placed in increasingly hazardous environment as a result; aircraft provide rich example of this, where a complex machine (the aircraft itself) is used to transport the user through a very dangerous environment where the consequences of a failure or inadequacy of the machine are life threatening.

As more and more products compete in a fiercely competitive market, it is becoming essential that a given product surpass its rival in every respect. One such respect is its usability, complementing others such as engineering excellence, cost, and aesthetics. Related to this is the need for mass-produced articles to be correctly designed at the outset, rather than passing through long and expense series of modifications.

Finally, because of better health care and improved living conditions, people may now expect to live longer than previously, and the population contains many people with various degrees of physical and mental impairment who may not have survived in past times. As a result, the designer of tools and machines must now cater for a market containing extremes of age, health, and physical and mental ability; that is, one whose members are much more variable than they used to be.

3. DOMAINS OF ERGONOMICS [3]

(3.1) Hardware Ergonomics:

The human machine interface, it deals with:

- Control design and location parameters and functional aspects for communication and easy operation.
- Visual displays, codes, scales and markings Anatomical and anthropometric (static & dynamic) match establishment.
- Working posture, body supportive devices match along with context fit and workstation.
- Range of body movement characteristics and thus limitations of man.

(3.2) Environmental Ergonomics:

Human environment interface concerning human capabilities and limitations with respect to the demands imposed by various environmental modalities and relevant applications. Physiological and performance effect in occupational settings pertaining to:

- Ventilation and pollutants
- Heat stress and Humidity
- Illumination and glare etc.
- Psychophysical quantification of sound level
- Vibration full and partial, self and / or work items

(3.3) Cognitive Ergonomics:

- Human perception and information processing to reduce error, and system mismatch to increase usability, functional reliability and safety (stereotype behaviour)
- Cognitive task analysis, qualitative and quantitative perspective to human system reliability analysis
- User's behavioral demands in designing consumer products
- Stimuli and effect reaction
- Influence of cognitive demands on performance
- User-centered interface-computer simulation
- Effect of psychological stressors on human performance; etc.

(3.4) Macro Ergonomics:

It is Human Organization. Interface technology, and covers application of ergonomics principles in organized sectors for better productivity and safe operation, and office and corporate ergonomics and its cost effectiveness.

It deals with specific aspects of:

- Workstation design [4]
- Work process design
- Work organization
- Shift work
- Machine and tool design for multiple function
- Job design and work methods Management of occupation related stress, safety and health hazards
- Design of public places

4. BENEFITS OF GOOD ERGONOMIC PRACTICES

Effective workplace ergonomic practices help to:

- reduce the risk of workplace injuries
- reduce pain and discomfort [5]
- reduce absenteeism
- improve employee morale
- improve productivity [6]

5. ERGONOMICS APPLICATIONS [3]

Applications are mostly in

(5.1) Occupational stress, health hazards and safety:

Application areas specific to *Occupational stress, health hazards and safety* are*:* Occupational risk management, Work schedule and sustained performance, Psychosocial approach occupational health, Manual material handling, Work related musculoskeletal disorders, Warning and risk perception, Safe design, etc.

(5.2) Management:

Applications in *management* are*:* Work process management, Productivity and human resource utilization, Work study and time study, Management of work/rest cycle, Personnel deployment and Shift work, Human cost of work and cost benefit effects for the modifications done, Work ambient environment monitoring, Human work and efficiency.

(5.3) Design:

During and after the Second World War, ergonomics developed into a recognized science, which uses knowledge of human abilities and limitations to design systems, machines, tools, and products for safe, efficient, and comfortable human use[7].Product/space is based on data such as human dimensions and human ability provided by ergonomist.

6. CASE STUDY [8]

In the cab of a tractor, the driver communicates information to the tractor using various control types (i.e., rotary switches, toggle switches, rocker switches, knobs, push buttons, hand–levers, and steering wheels). The published literature documents numerous design and ergonomic considerations that should be followed to maximize the operator's interaction with machine controls. This case study reviews the published literature and identifies guidelines related to seven types of controls, control placement, control labeling, and functional reach. Six agricultural tractor workstations, with manufacturing dates between 2003 and 2005, were analyzed to determine the degree to which tractor manufacturers comply with these published recommendations.

(6.1) Results:

Table 1. Criteria used to evaluate three human factors characteristics of control panels in agricultural tractors

Human Factors Characteristic	How human factors characteristic was assessed
Placement of Controls	Each tractor cab was reviewed to determine the number of controls that were located on the right-hand side of the operator. The right-hand side was identified using a line joining the mid point of the seat and the centre of the steering wheel.
Control Labelling	Each tractor cab was reviewed to determine the number of controls that had an associated label or symbol. Labels or symbols that were located beneath the control were considered to not exit. For labels, the text height had to be at least 2.5 mm to be counted. For symbols, to be counted, they had to consistent with standard symbols for agricultural equipment described in ASABE S304.7 (2000).
Functional Reach	Each tractor cab was reviewed to determine the number of controls located within 750 mm (covering a 180^o reach envelope) from the seat reference point.

Table 2. Measurement details related to the specific dimensions of controls

Dimension	Control type	How dimension was measured
Length	Rotary switch	Distance of the switch from the top to the edge
	Rocker switch	Half the distance of the total length
Width	Rotary and Rocker switch	Thickness of the switch based on its front surface
Height	Rotary switch	Depth of the switch based on its side surface
	Knob	The vertical length of the knob
Separation	Rocker switch	Distances between the centers
	All other types	The minimum distance between two controls of the same type
Arm length	Toggle switch	Vertical length from the base to the top of the switch
Diameter	Knob, Push button, Steering wheel	For Knob and push button, outside diameter of the control was measured. For steering wheel, diameter was measured from the inside of the rim.
Displacement	Hand-lever	Maximum travel distance through its range of motion
Activation Force	Hand-lever	Maximum force recorded by dynamometer during movement of the lever through its range of motion
Rim thickness	Steering wheel	Maximum vertical thickness
Tilt angle	Steering wheel	Not measured; taken directly from the specifications for the tractor

Table 3. Values recommended from the literature for seven different types of controls (top of half table); mean and standard deviation dimension values for seven different types of controls (bottom half of table)

Dimension	Rotary switch	Toggle switch	Rocker switch	Knob	Push button	Hand lever	Steering wheel
Recommended values							
Length(mm)	25-76		≥ 12				
Width(mm)	≤ 25		≥ 6				
Height(mm)	12-75			12-25			
Separation(mm)	≥ 25	≥ 50	≥ 19	≥ 50	≥ 50	≥ 100	
Arm length(mm)		12-50					
Diameter(mm)				12-100	12-25		400-510

Dimension	Rotary switch	Toggle switch	Rocker switch	Knob	Push button	Hand lever	Steering wheel
Displacement(mm)						≤ 355	
Activation Force(kg)						≤ 16	
Rim thickness(mm)							19-32
Tilt angle(°)							40-60
Measured values							
Length(mm)	47 ± 0		20 ± 5				
Width(mm)	11 ± 0		18 ± 3				
Height(mm)	10 ± 0			15 ± 5			
Separation(mm)	42 ± 0	35 ± 22	41 ± 47	34±17	18 ± 45	104±91	
Arm length(mm)		23 ± 9					
Diameter(mm)				31±14	19 ±5		398 ± 8
Displacement(mm)						76 ± 38	
Activation Force(kg)						1 ± 2	
Rim thickness(mm)							29 ± 2
Tilt angle(°)							63 ± 21

Table 4. Proportion of controls that met the published design recommendations

Dimension	Rotary switch	Toggle switch	Rocker switch	Knob	Push button	Hand lever	Steering wheel
Length(mm)	2/2		66/73				
Width(mm)	2/2		72/73				
Height(mm)	0/2			39/51			
Separation(mm)	2/2	13/30	43/73	11/51	16/167	9/21	
Arm length(mm)		28/30					
Diameter(mm)				51/51	147/167		4/6
Displacement(mm)							
Activation Force(kg)						21/21	
Rim thickness(mm)						21/21	6/6
Tilt angle(°)							4/6

Table 5. Criteria used to evaluate control labeling – Sample analysis for Fendt tractor workstation

Control	Was text label above control?	Was symbol above control?	Was text > 2.5 cm in height?	Was symbol consistent with ASABE S304.7?	Was label acceptable?
PTO Engagement	No text label	Yes	No text label	Yes	Yes
Throttle	No text label	Yes	No text label	Yes	Yes
Cigarette lighter	No text label	No	No text label	Yes	No
3-point hitch	No text label	Yes	No text label	Yes	Yes
Differential lock	No text label	Yes	No text label	Yes	Yes
Windshield Wipers	No text label	Yes	No text label	Yes	Yes
Headlights	No text label	Yes	No text label	Yes	Yes
Fan speed	Yes	No symbol	Yes	No symbol	Yes
Seat back adjustment	No text label	No	No text label	Yes	No

(6.2) Discussion:

Following discussions were derived from this case study:

1.) There is sufficient evidence to conclude that the controls being used in tractors are consistent with the published design recommendations for controls.
2.) Of the recommendations used for various control dimensions, the least conservative values were chosen for separation distance. Perhaps this is an indication that space is a premium inside a tractor cab.
3.) As recommended, most controls (89%) are located so that they can be operated by the driver's right hand.
4.) Designers of agricultural tractors tend to use symbols rather than text labels. The majority of controls (95 %) are labelled using either a symbol or text.
5.) Only 75% of controls were located within the functional reach envelope (i.e., 750 mm from the seat reference point). It is speculated that space may be a limiting factor due to the large number of controls required to operate modern agricultural equipment.

7. CONCLUSION

Ergonomics make design more successful for user's acceptance. It is not only product- user relationship, but design ergonomics (e.g., design for functional consistency, users' compatibility and feedback) is also an advancement in its journey crossing the concept of user, product and function, to look at user, product and relationship in totality. It should look beyond usability. Man is not a physical and cognitive processor; his needs are to be addressed in tune with his emotions, values, hopes, fears, and anxiety over new adaptations in life. More research work is necessary to achieve higher levels of comfort.

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