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Automotive seating based on Human factors and Ergonomics.

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ABSTRACT

Human factors and ergonomics (HF&E), also known as comfort design, functional design, and user-friendly systems is the practice of designing products, systems or processes to take proper account of the interaction. It is a multidisciplinary field incorporating form psychology, engineering, biomechanics, industrial design, physiology and anthropometry. In essence it is the study of designing equipment and devices that fit the human body and its cognitive abilities. The two terms "human factors" and "ergonomics" are essentially synonymous. HF&E is employed to fulfill the goals of occupational safety, health and productivity. It is relevant in the design of such things as safe furniture and easy-to-use interfaces to machines and equipment. Proper ergonomic design is necessary to prevent repetitive strain injuries and other musculoskeletal disorders, which can develop over time and can lead to long-term disability. Human factors and ergonomics are concerned with the "fit" between the user, equipment and their environments. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, functions, information and the environment suit each user.

Keywords- **Anthropometry, Ergonomics, Human factors, Industrial design, Physiology**

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I. INTRODUCTION

Automotive seat design has been always challenge in design parameters because automotive seats are more complex in design. Three basic design objectives, to be satisfied simultaneously are comfort, safety, and health.

(i) For comfort, in various ergonomic and human factors considerations are discussed ranging from seat dimensions and adjustments to cushioning and occupant perceptions of comfort.

(ii) For safety, the principal consideration is the effectiveness of the seat in providing spinal support during accidents-particularly in rear end collisions. An additional safety consideration is the ability of the seat to keep an occupant “in position” during an accident. Finally,

(iii) For health concerns, the focus is upon maintenance of spinal stability, seat ergonomics, and road induced vibration attenuation.

II. DESIGN CRITERIA

Seat means a structure, which may or may not be integral with the vehicle and the structure complete with trim, intended to seat. The term covers both an individual seat and part of a bench seat intended to seat one person. The function of automotive seating is to protect support and to provide comfortable seating posture to its occupants.fig:1 shows the different types of seats. Three different occupants in the automotive car [5] : i) Driver, ii) Front seat passenger and iii) Rear seat passenger.

The four design criteria’s for the driver seat: [1]

1. It should position the driver with un-obstructive vision and within reach of all vehicle control.
2. It must accommodate the driver’s size and shape.
3. It should be comfortable for extended periods.
4. It should provide a safe zone for the driver in case of a crash.

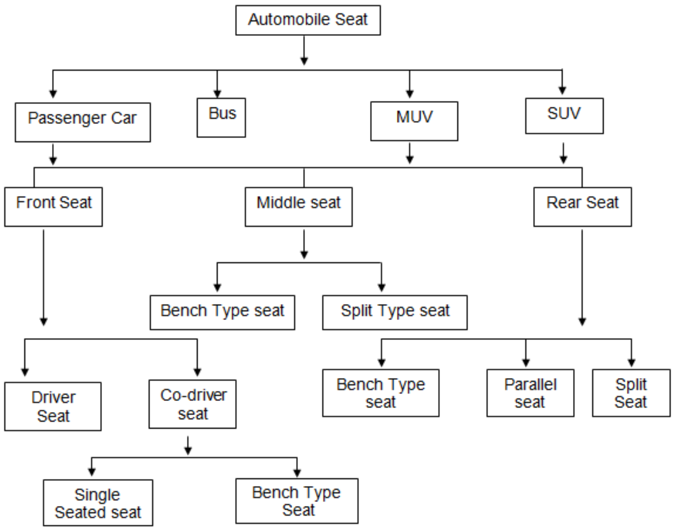

Fig:1- automobile seats

II. SEAT PARAMETERS.

1. Hip point: A point, which simulates the pivot center of the human torso and thigh and provides the guidelines on where a passenger sits on the seat [5].
2. Back angle: Angle between the torso line and vertical axis through hip point [5].
3. Hip angle: Angle between the torso line and the thigh axis.
4. Knee angle: Angle between the thigh axis and lower leg axis [5].
5. Foot angle: Angle between the lower leg axis and paddle plane [5].
6. Thigh angle: Angle between thigh axis and horizontal [5].

III. . CONCEPT DESIGN

The design of seat based on the following concepts [6].

1) Concept design of PU pads.
2) Contours & Profiles & Aesthetics.
3) Concept design of Seat Trim.
4) Concept design of Suspension- Spring Type, Mat Type and Pan Type
5) Concept design of frames- Sheet Metal structure, Tubular structure and U – Section structure
6) Concept design of Anchorage methods.
7) Concept design of Height Adjusters.-Mechanical and Push button / Automatic
8) Concept design of Recliners.
9) Concept design of Adjusters (Sliders).
10) Concept design of Head Restraint. -Integral, Detachable and Adjustable
11) Concept design for other specific requirement.

Seat Assembly [5]

Automotive seat basically consists of the following parts are shown in fig.2 below,

1) Cushion Assembly
2) Back Assembly
3) Head Restraint Assembly

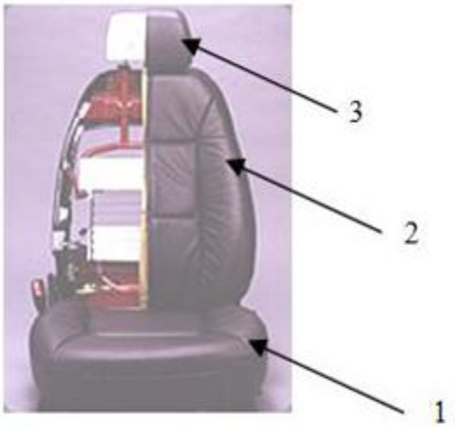

Fig 2 Seat Assembly

A) Cushion Assembly [5]

Cushion Assembly is a part on which the Passenger sits. Sub components of cushion assembly are as follows (Front Seat):

(a) Frame complete seat cushion
(1) Spring Type Cushion Frame.
(2) Mat type Cushion Frame.
(3) Pan Type Cushion Frame.

(b) Pad complete seat cushion:
i) PU pad: To the passenger give comfort and to provide aesthetic looks to the seat.
ii) Insert wire seat cushion: It is used to hold the Trim with the Pad at a particular profile.

(c) Trim complete seat cushion:
i) Trim: is the seat cover assembled on the PU Foam.
ii) PVC pocket: to hold the trim wire inside which is joined with the insert wire of Pad by C-rings.
iii) Wire Trim: It is used to hold the Trim with the Pad at a particular profile. Different fabrics used for the seat cover Trims.

(d)Recliner: are used for the angular adjustment of the seat back as desired by the passenger sitting.

(e) Adjuster set: are used to move the seat position in front and back in horizontal direction.

2). *General parameters to be kept in consideration while designing Seat Cushion:*

1) Cushion Length: Cushion size accommodates the seated occupant's buttock and thigh dimensions. The distance from buttock to popliteal region delimits the loaded cushion back from seat back to waterfall line. The length of 5th percentile female is 440 mm and 95th percentile male is 545 mm.

2) Cushion Width: Lateral space is important for physical & psychological comfort. In a bucket seat, bolstering and lateral contours must accommodate the physical dimensions of large torso. Female hip breadth is greater tale hip breadth. Thus, the 95th percentile female hip breadth determines cushion breadth. The 5th percentile width is 432 mm, however 480 mm has been recommended for margins considering clothing and leg play.

B) Seat Back Assembly [5]

The function is to back support to passenger. Sub Components of Back Assembly are,

(A) Frame complete seat back

(1) Main Pipe (2) Holders (3) Cross Plate (4) Recliner Bracket (5) Stay Bracket (6) Springs / FB Mat (7) Hook springs

(B) Guide H/R Set: is fixed in the holder, which is welded on the pipe frame.

(C) Trim complete seat back

(1) Main fabric: To prevent damage to PU foam and to give good appearance and comfort.

(2) PVC pocket: Hold the trim wire inside which is joined with the insert wire of pad by C- rings.

(3) Trim wire: Used to hold trim with the pad maintaining a certain profile, Costly to main fabric.

(D) Pad complete seat back

(1) PU Pad: Is used to give comfort to passenger and to provide looks to the seat.

(2) Insert wire seat back: To fix the trim with the pad at a particular profile.

2) General parameters to be kept in consideration while designing seat back:

1) Seat back height: Seat back supports the trunk while sitting, but it also is considered a barrier to arm reach and vision. Small female sitting shoulder height therefore determines seat back height. Accordingly, 509 mm is recommended.

2) Seat back width: Seat back width may be divided into lower and upper regions. Large torso width at the hip waist and chest determine the lower space requirement. The lower region must accommodate a tapered shape from 432 mm at the hip to 367 at the chest.

V. HUMAN FACTORS.

Definition: Human Factors is a discipline of study that deals with human-machine interface. Human Factors deals with the psychological, social, physical, and biological and safety characteristics of a user and the system the user is

A) *The Elements of Human Factors* [4]

1) Anthropometry- Anthropometry means the "measure of man". In Anthropometry measures all physical aspects of human body, simple measurements include height and width. But a more thorough body of measurements is usually needed for Human Factors work.

2) Body Mechanics - To understand body mechanics must know a little bit about human's own physiology and anatomy. But use a simplified model for testing purpose. In modern Human Factors analysis computer generated manikins that can mimic the body's complex mechanics are used within a CAD environment to represent the body mechanics aspect of Human Factors.

3). Human Performance-Body mechanics tells us how people move. Human performance uses that and tells us what the body is capable of and how efficient it is at it. It is divided into two main categories. (i) That of human limitations, both absolute and restrictive and (ii) the other category is that of training and skill level. The skill and training level of the subject plays a major role in their performance capability.

4). Human's Cognitive Capability-. The Cognition refers to higher level brain functions such as perception, planning, problem solving and using language. A person's cognitive capability is an important factor when evaluating a human-machine interface.

5). Human's Psychological Makeup for Human Factors- The two main psychological elements in Human Factors are –

(i) The physical- those physical means make up part of the human-machine interface, or even the human-environments interface. What they play and how they can affect both human performance and behavior are important when analyzing those human factors.

(ii) The behavioral - The behavioral aspect of a person's psychological makeup relate to elements that motivate actions or cause reactions.

VI. ERGONOMICS

Ergonomics 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.

TABLE;1
FACTORS OF COMFORT AND DISCOMFORT

Discomfort related factors	Comfort related factors
Fatigue	luxury
Pain	safe
Posture	refreshment
Stiffness	Well-being
Heavy legs	relaxation

B) Comfort and discomfort division [4]

1). Comfort- The Comfort is one of the greatest aspects of a design's effectiveness. In Table-1 shows the factors of comforts and discomfort. The Comfort in the human-machine interface and the mental aspects of the product are a primary ergonomic design concern. The comfort in the human-machine interface is usually noticed first. The Physical comfort in how an item feels is pleasing to the user and the mental aspect of comfort in the human-machine interface is found in feedback [2] fig-3 shows the relationship between comfort and discomfort considering HFE.

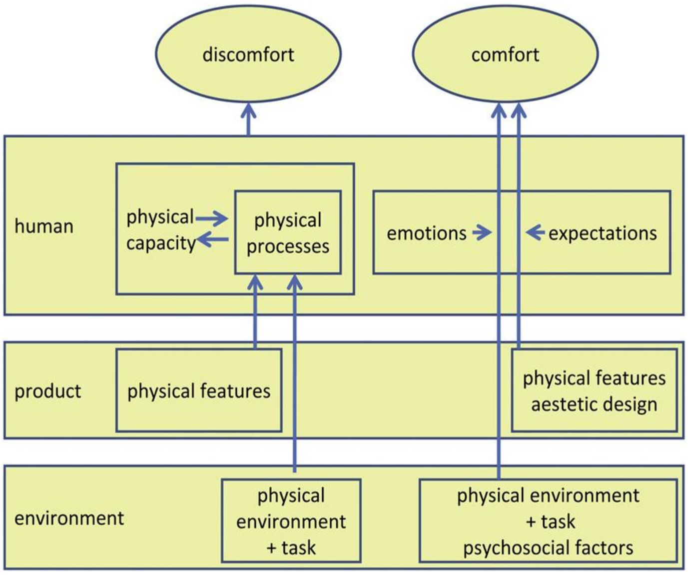

Fig: 3-Division of comfort and discomfort related to HFE

Seat comfort can be measured both on static & dynamic conditions. Hardness of the cushion, back and contour primarily determines static & dynamic seat comfort. Adjustments by occupants to change position also contribute to the comfort. Cushion hardness affects the vibrations transmitted to the occupants and pressure distribution in the seat. As hardness of the seat increases, higher frequencies are transmitted. As hardness of the seat decreases, pressure is distributed over a greater area. Thus, the occupant's evaluation of dynamic and static comfort is affected by cushion hardness. [1]

2) Discomfort –The discomfort is related to physical loading: the several clear relationships between discomfort and posture holding time, maximal holding time, torque at joints, lifting index and different discomfort factors showing in the table-1. Discomfort scales are typically less time consuming in their use than the objective measures that have used. Thus, discomfort scales are very valuable of products in development; however, the discomfort scale was better for high force levels (>65% MVC) than the comfort scale. That discomfort measurements are more useful in long-term measurements than pressure recordings as it is related to fatigue. In longer than 2 h driving, comfort and pressure recordings gave input for a seat which adapts itself to the "ideal" pressure distribution by recording pressure and adapting the form, showing that for low physical loads, comfort may be a function and related with the time[6].

VII. DISCOMFORT OF SEATED UNDER THE OSCILLATION.

In the seat different causes are create discomfort. For study considering the discomfort caused by roll oscillation, lateral oscillation, and fully roll-compensated lateral oscillation has been finding between 0.25 and 1.0 Hz frequencies at the time of sitting on a rigid seat and when sitting on a compliant cushion both without a backrest.

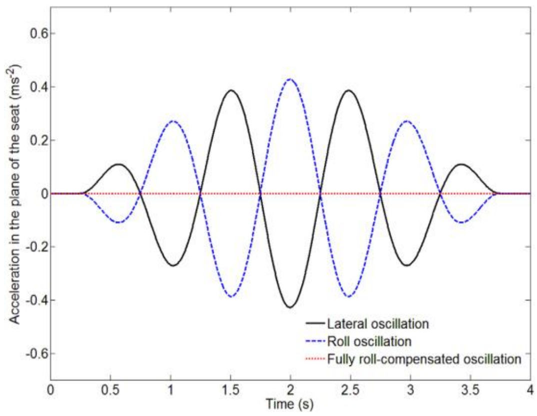

Fig. 4. Example waveforms for 1.0-Hz oscillations of the seat for i) lateral oscillation ii) roll oscillation, and iii) fully roll-compensated lateral oscillation.

1). Objective measurements.

The 'lateral transmissibility' (Ty) of the foam was calculated with three magnitudes of i) roll oscillation, ii) lateral oscillation, and iii) fully roll-compensated lateral oscillation in frequencies from 0.25 to 1.0 Hz. The transmissibility was calculated by dividing the lateral acceleration at the seat-body interface of the foam cushion by the acceleration on the rigid seat surface [7].

$$T_y = a_{y\text{-foam}} / a_{y\text{-rigid}}$$

If there was roll motion on either the rigid seat or on the foam cushion, the lateral acceleration included the influence of gravity. For roll oscillation and fully roll-compensated lateral oscillation, the roll transmissibility (Troll) of the foam cushion was calculated by dividing the rotational velocity at the seat-body interface with the foam cushion (Vroll-foam) by the rotational velocity on the rigid seat surface (Vroll-rigid):

$$T_{\text{roll}} = v_{\text{roll-foam}} / v_{\text{roll-rigid}}$$

2). Effect of seating on rate of growth of discomfort.

Median rates of growth of discomfort for the three directions of oscillation, i) lateral, ii) roll, and iii) fully roll-compensated lateral oscillation, on the two types of seat i) rigid and ii) foam are shown as a function of frequency in Fig. 5. The seat pan type did not have a significant effect on the rate of growth of discomfort for any direction or frequency of oscillation, except for 0.63-Hz lateral oscillation where the rate of growth of discomfort was greater on the rigid seat than the foam cushion [7].

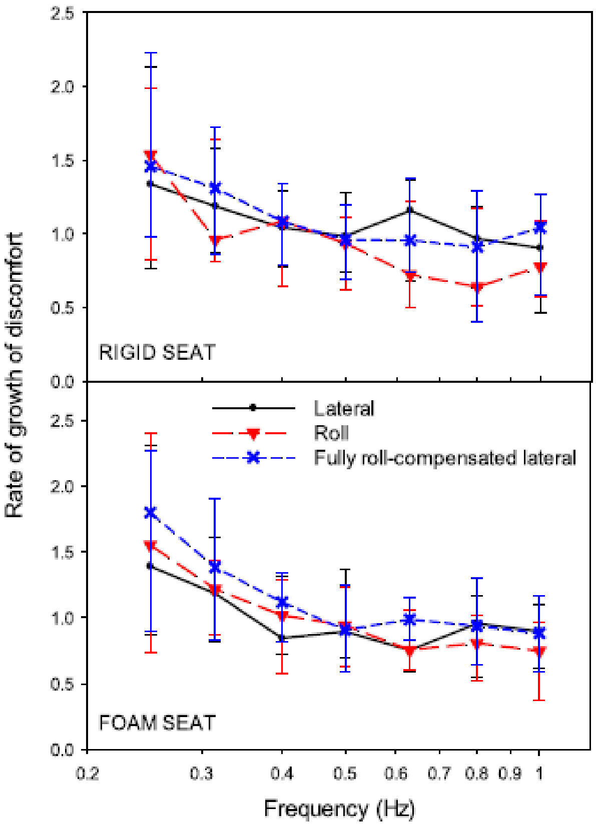

Fig. 5. Effect of seating on adjusted equivalent comfort contours for i) lateral oscillation, ii) roll oscillation, and iii) fully roll-compensated lateral oscillation.

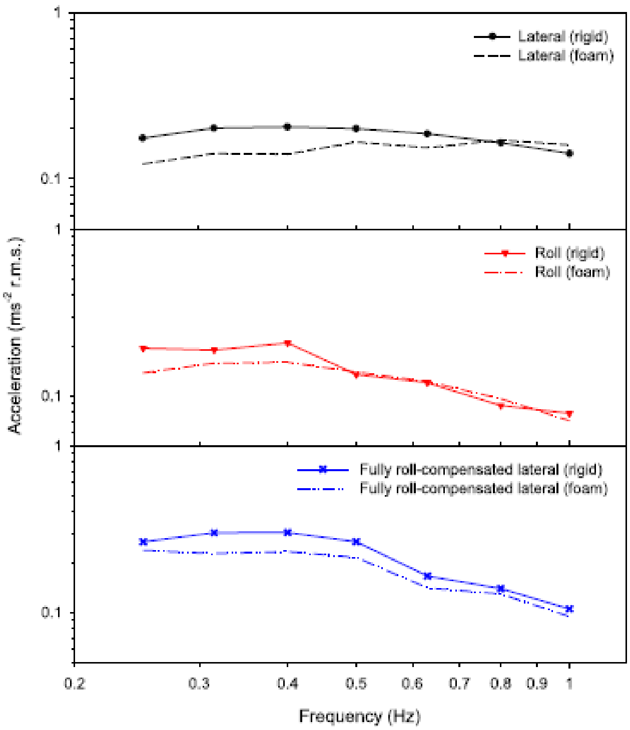

Fig. 6. The Rates of growth of discomfort for i) lateral oscillation, ii)roll oscillation, and iii) fully roll-compensated lateral oscillation on the rigid seat and the foam cushion

3) Effect of frequency and direction of oscillation on discomfort

The level of comfort corresponding to a subjective frequency of oscillation for all three directions of oscillation on the rigid seat , roll oscillation and fully roll compensated lateral oscillation on the foam cushion [7]. With the foam cushion, the frequency of oscillation did not have a significant effect on the equivalent comfort contour for lateral oscillation. With the rigid seat, the acceleration equivalent comfort contours were approximately constant between 0.25 and 0.4 Hz and then declined between 0.4 and 1.0 Hz, by approximately 3 dB and 6 dB per octave for lateral oscillation and roll oscillation, respectively. With fully roll compensated oscillation of the rigid seat, the acceleration contours were approximately constant between 0.25 and 0.5 Hz and declined by approximately 8 dB per octave between 0.5 and 1.0 Hz. With the foam cushion, the acceleration equivalent comfort contours were approximately constant between 0.25 and 0.5 Hz and declined between 0.5 and 1.0 Hz by approximately 6 dB and 7 dB per octave for roll oscillation and fully roll-compensated lateral oscillation, respectively. The effects of the direction of oscillation on median equivalent comfort contours representing discomfort equivalent to that produced by 0.5-Hz lateral oscillation at 0.2 m s_2 r.m.s. on a rigid seat without backrest are shown in Fig. 6. The level of the equivalent comfort contours was dependent on the direction of oscillation across all frequencies with both the rigid seat and the foam cushion. On the rigid seat, at 0.5 Hz and higher frequencies, the equivalent comfort contours were at greater magnitudes with lateral oscillation than with roll oscillation ,at 0.5 Hz and lower frequencies the equivalent comfort contours were at lower magnitudes with lateral oscillation than with fully roll-compensated lateral oscillation. However, at frequencies greater than 0.5 Hz, the equivalent comfort contours were at greater with lateral oscillation than with fully roll-compensated lateral oscillation, at all frequencies, the equivalent comfort contours were at lower magnitudes with roll oscillation than with fully roll-compensated lateral oscillation. On the foam cushion, at 0.8 and 1.0 Hz the equivalent comfort contours were at greater magnitudes with lateral oscillation than with roll oscillation, at 0.5 Hz and lower frequencies, the equivalent comfort contours were at lower magnitudes with lateral oscillation than with fully roll-compensated lateral oscillation. However, at frequencies greater than 0.63 Hz, the equivalent comfort contours were at greater magnitudes with lateral oscillation than with fully roll compensated lateral oscillation, at 0.63 Hz and lower frequencies, the equivalent comfort contours were at lower magnitudes with roll oscillation than with fully roll compensated lateral oscillation

VIII. CONCLUSION

The comfort and discomfort has mainly related with the human factor and ergonomics. In HFE, the preferences related to the height of the apex of the lumbar support, seatback width, cushion length, and cushion width. It has concluded that, comfort and discomfort is depends and correlate with each other, it has more difficult to balance, most of the time we should compromise with each other for better result, while it has important to understand the relation between ergonomics and human factors. The automobile seat comfort is a unique science. It should be involves different consideration of HFE. Only in this way can the development process ensure comfortable automobile seats [7].

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