ABSTRACT

Customer’s expectations for comfort in automobile seats rise continuously. As the design parameters for automobile seats are complex, the design and analysis have been always challenging for engineers. Three design objectives, comfort, safety and health need to be satisfied simultaneously. For comfort, Hip joint location (H-point) is a critical design parameter used by car seat manufacturers. Polyurethane foam is most commonly used material for automobile seat. Over the past few years the usage of polyurethane foam in automotive seating applications has increased considerably because of its excellent vibration isolation properties, comfort features and durability. Location of H-point is primarily dependent on quasi-static behavior of foam which is a highly nonlinear as it is viscoelastic material. The objective of this paper is to study the quasi-static behavior of foam. Such study can be very useful for investigating the effects of the seat design, occupant’s comfort and ergonomics.

Keywords— H-Point, Comfort, Quasi-Static Behavior, Polyurethane Foam, Nonlinear, Viscoelastic Material.

ARTICLE INFO

I. INTRODUCTION

Polyurethane foam pad is a key component in seat design. It gives the shape and contour to the seat. It’s properties affect comfort and H-Point which is the pivot centre of the human torso and thigh. Comfort experience is a combination of many different factors, vehicle package, social, individual, seat including aesthetics. During a journey, car occupants are subjected to both mental and physical stresses when exposed to road vibrations, dense traffic, noise and different weather conditions. Polyurethane foam helps to reduce those stresses. Static equilibrium position is related to the form and support provided by the seat itself, the posture and orientation of the occupant, and location of the occupant relative to certain critical points in vehicle interior. It was seen that the static equilibrium position varies considerably with the type of foam used in the seat design. The equilibrium position was also shown to be dependent on the initial posture of the occupant and the location of springs in the model.

Polyurethane foam is an important engineering material with applications in the fields of mechanical damping, acoustic absorption, impact retardation, automotive seating, etc. Over the past few years the usage of polyurethane foam in automotive seating applications has increased considerably. This is because of it’s excellent vibration isolation properties, durability and comfort features. Since most modern car seats are full-foam, the quasi-static and dynamic performance of foam significantly affect the static and dynamic comfort of an occupant in a seat. [2]

I. BACKGROUND

Chemical composition of the foam consists of the following components:

- Standard Polyol
- Polymer Polyol
- Water
II. EXPERIMENTS

A. Experimental set-up for quasi-static behavior of foam:

Seats are selected in vehicles produced by a different manufacturer from the compact car segment. The foams in seats are distinguished using the letters A through C. For compare the three foams were in similar set-up as follows:

The experimental setup is shown in Fig. 1. Experiments were conducted on a servohydraulic testing machine which can be used for accurate testing under axial loads up to 25kN with standard displacements of 100mm. The foam is placed on hardness tester table with wooden block shall be formed in same way as the back shape of the pad. No lift is allowed between the bearing surface and the back of the pad. Design the base so that the loading surface will be horizontal when the test specimen is placed on the wooden block. The upper plate is attached to the actuator which can be programmed to move along pre-specified paths. For the tests, the actuator displacement specified as a function of time. The load cell locator in the upper plate measures the force in the foam. The displacement is measured using an linear variable differential transformer. The result of the quasi-static test on Foam ‘C’ is shown in Fig. 3. The same tests were conducted on two types of foams ‘A’ and ‘B’. [2]

It can be seen clearly from Fig. 3 that the load–deformation relationship is highly nonlinear. Furthermore, there is substantial difference between the force in the foam during the compression and during relaxation phases. This is due to the viscoelastic nature of foam.

Fig. 1 Experimental setup for quasi-static behavior of foam

[Diagram of experimental setup]

It is clear from Fig. 4 that as the density increases it reduces the deflection.

Fig. 2 Schematic of the experimental setup [2]

[Diagram of load vs deformation graph]

Fig. 3 A graph of load vs deformation for quasi-static behavior of Foam ‘C’
TABLE I
Summary of rear seat foams

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Foam A</th>
<th>Foam B</th>
<th>Foam C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardness @ 25% (N)</td>
<td>197.2</td>
<td>128</td>
<td>243</td>
</tr>
<tr>
<td>2</td>
<td>Hardness @ 50% (N)</td>
<td>404.7</td>
<td>235</td>
<td>472</td>
</tr>
<tr>
<td>3</td>
<td>Density (Kg/m³)</td>
<td>40</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>Hysteresis (%)</td>
<td>33</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Load Vs Deflection (10Min)</td>
<td>8.9</td>
<td>4</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td>Load Vs Deflection (20Min)</td>
<td>9.9</td>
<td>4.9</td>
<td>3.4</td>
</tr>
<tr>
<td>7</td>
<td>Load Vs Deflection (30Min)</td>
<td>10.6</td>
<td>5</td>
<td>3.6</td>
</tr>
</tbody>
</table>

B. H – Point Measurement:  
The procedure was as follow:  
- The seatback angle was set to 25° from vertical.  
- The track position was set to full rear.  
- The H-Point manikin was placed in the seat without weights.  
- The seat was adjusted until the H-Point manikin was adequately positioned in front of the pedals and steering wheel.  
- The H-Point manikin was loaded with weights.  
- In this position, the H-Point to heel point relationships and the H-Point manikin’s critical angles (i.e. torso, hip, knee, and foot) were determined for each seat.  

After setting the seat to the estimated design position, a coordinate system was established in relation to the vehicle. The H-Point was digitized and removed after H-Point measurement. This coordinate system used for scanning seat using a portable coordinate measurement machine (CMM), known as a FaroArm shown in Fig. 5. Once enough, data points were collected, the dots are connect to create line. Center points of the probe were taken. For this reason, the scan lines, in a post processing operation, were offset by the radius of the probe. [4]

![Fig. 5 FaroArm coordinate measurement machine (CMM) [4]](image)

![Fig. 6 H – Point measurement set-up](image)

III. CONCLUSIONS
The tests were conducted on three foam pads to determine the quasi-static characteristic of foam. It is observed that as the density increases then it’s deflection decreases.

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REFERENCES