PASSENGER SEAT STRUCTURE OPTIMIZATION FOR AIS -023 BY USING COMPOSITE MATERIAL

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Abstract— Seat is important parts of vehicle. The intention of this paper was analyzing existing passenger seat and modified seat as per necessity. In these paper seat modifications means structure modification and material substitution. The FEA results of existence model indicate that cannot offer effective safety for the occupants and necessitate for structural enhancement. In structural modification, it would be better if we can offer weight reduction and cost effective by undertaking material substitution. Here we doing two modifications in existing seat like structure modified and material substitution for some extent. But modified seat have to be compulsory to meet the AIS requirements. Evaluate FEA results of modified design with respect to displacement range as per standard. So modified seat analyzed through Hyper Mesh and LS-DYNA software.

Keywords— Automotive passenger Seat, Composite Material, AIS 023 Standards, Optimization.

I. INTRODUCTION

In Automotive sector, design of seat is always challenges for designer to meet all requirements. And it’s one of the most costly structures. The collapse of seating system has direct impact on service and warranty claim cost.

Generally now a day accident happens in commercial vehicles are side (25%), rear (8%), frontal (57%) and rollover (8%). In front impact, without seat belt, the head and body have rest by striking comparatively firm and immovable objects, gives increasing the forces acting over very small duration, this may causes serious injury to the passenger. In most of the evident frontal crash are reasons for major head injury. During any of the collision greatest force should be absorbed by structure and sticking the passenger seats within the suitable limit such that structure should be firm in some portions to avoid imposition into at hazard region.

A numerous studies have been carrying out on the relation among vehicle weight cut off and fuel spending. The 10% cut off in vehicle weight can result in a 6%–8% fuel economy enhancement. Due to that importance to design and test a seat for

- Its strength from safety point of view,
- Weight cut off, fuel spending and Cost effective.

To ensure the strength of seat, several regulations have been executed and different experiments are performing according to those regulation. Automotive Research Association of India, (ARAI), being the Secretariat of the AIS Committee, has printed this standard.

The weight cut off can be achieved by a combination of

- Material substitution, in which conventional materials in automotive engineering such as steel, plastic and iron are replaced with lighter and special alternatives such as aluminium, magnesium, high strength steel and composite.
- Innovative design where parts are optimized to achieve performance as per standard.

Traditional material, such as carbon steel (CS) is the material is use for many applications because of excellent weldability, high strength. But this material having certain disadvantages like

- High strength to weight ration
- Expensive

Using composite instead of traditional material has many considerable advantages.

- Higher strength with lower weight
- Forming complex shape easier
- Durability for longer periods of time
- Lower facility process cost.

A successful material selection process is solution between cost decrease, weight cut off and improved comfort and safety.

II. SEAT MODEL ANALYSIS

A. Model Build-up

Existing seat (19.3 Kg) CAD model was introduced to Hyper Mesh software for meshing. Final mesh model is shown in Figure 1.

Element quality criteria followed

- Average element size – 6mm
- Minimum element size – 3mm
- Maximum element size – 8mm
- Warpage – 15 degrees
- Min. quad angle – 45 deg
- Max. quad angle – 135 deg
- Min. tria angle – 30 deg
- Max. quad angle – 120 deg
- Jacobian – 0.6
- Aspect ratio – 4
Passenger Seat Structure Optimization For AIS-023 by Using Composite Material

B. Test Procedure

<p>| Table 1: Displacement range as per standard |</p>
<table>
<thead>
<tr>
<th>Sr No</th>
<th>Height from reference floor (mm)</th>
<th>Load to be applied (KN)</th>
<th>Displacement range mention as per standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>H₁-750</td>
<td>4</td>
<td>100 to 400</td>
</tr>
<tr>
<td>02</td>
<td>H₂-500</td>
<td>12</td>
<td>More than 300</td>
</tr>
</tbody>
</table>

This model was analyzed using first test force to 4KN shall be applied using a plunger; to the rear part of the seat. H₁ is at 750mm above the reference plane. The direction of application of the force shall be horizontal and from the rear to front of the seat and at a height H₁.

Second test force equal to 12KN shall be applied simultaneously to the rear part of the seat in the same vertical plane and in the same direction at the height H₂ which shall be 500mm above the reference plane. Test set-up is shown in Figure 2.

In existing model, back structure collapses for the rated load. Deflections are exceeding the specified limits as per standard AIS-023. The displacement and Load vs Displacement of the seats in the front impact was analyzed, and was shown in Figure 3 and Figure 4.

III. SUGGESTIONS AND RESEARCH FOR IMPROVEMENT PROGRAMS

A. Problem Description

From the above analysis showed that in the process of front impact, back structure collapses for the rated load and deflections are exceeding the specified limits, so the seat structure should be improved.

In the front impact, the stress mainly concentrated in the side gusset, cushion support tubes, central back & cushion supports.

B. Suggestions on Improvement

Given the seat deformation, seats had failed in testing the seat improvement is done by following two methods.

I. Modified side gusset, side sheet, side tube, back panel and add back strip as shown in Figure 5. Here we achieve weight reduction by 0.5 kg per seat.

II. Further modified material of supports (circular) tube Carbon fiber reinforced composite instead of CS 1008 as shown in Figure 6. Here we achieve further weight reduction by approximate 2 kg per seat. Material Details as per Table 2.
### Table 2: Material Details

<table>
<thead>
<tr>
<th>Description</th>
<th>Type / values</th>
</tr>
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<tbody>
<tr>
<td>Material Used</td>
<td>Carbon fibres reinforced composite</td>
</tr>
<tr>
<td>Density</td>
<td>1.5e9 Ton/mm³</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>0.25</td>
</tr>
<tr>
<td>Young’s Modulus in X-direction</td>
<td>22000 N/mm²</td>
</tr>
<tr>
<td>Young’s Modulus in Y-direction</td>
<td>6800 N/mm²</td>
</tr>
<tr>
<td>Young’s Modulus in Z-direction</td>
<td>6800 N/m²</td>
</tr>
<tr>
<td>Bulk Modulus</td>
<td>4800 N/mm³</td>
</tr>
<tr>
<td>No of layup</td>
<td>12</td>
</tr>
<tr>
<td>Lay up Sequence and direction</td>
<td>0°-90°-90°-0°; 0°-90°-90°-0°; 0°-90°-90°-0°</td>
</tr>
</tbody>
</table>

### C. Modified Model Analysis

On the basis of the improvement structure, the optimized seat finite element model was established. Modified model analysis was done again in LS-DYNA, and comparing with the simulation results with Base model. The displacement, Load Vs Displacement plot for modified seat was shown in Figure 7, 8 and 9.

### CONCLUSION

A. Mass of existing seat was 19.3kg and after modification mass of seat is 16.8 kg. That means 2.5 kg per seat reduction is achieved. Seat meet up its structural performance requirements as per AIS 023 with a 12% weight saving.

B. The cost of manufacturing for steel is higher than CFRP so that use composite material for mass production is cost effective with almost the same performance.

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### REFERENCE


[10] AIS -023,052,016