Seat structure strength and Energy disspation performance analysis and optimization

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Abstract **- Seating system plays an important role in safety of the occupant in automobiles. To access the safety of seating system, seat manufacturers have to pass through rigorous tests drafted by government agencies of various countries. This paper focus on Indian Automotive industry safety regulation AIS023.A automotive seat is verified for Energy dissipation performance and H1H2 test .Design is optimized to improve performance for the the above tests using FEA software. The results were compared with physical test carried out by seat Manufacturer**

keywords **- CAE, Seating systems,AIS-023,AIS-016,Explicit analysis, Energy dissipation performance test, Head injury.**

I. INTRODUCTION

With increasing number of automotive accidents day by day the importance of creating a safety regulations is important for government institutions. A automotive safety regulation ensure the quality of automobiles and force the automobile manufacturers to produce high quality automobiles along with minimum safety standards compliance. Let us consider a example of front crash scenario. This impact can be divided in three stages. In the first stage the front structure impacts with obstacle or barrier .In second stage the occupant impacts within passenger compartment and in third stage internal organs of occupant impact inside the body. In the passenger compartment the seat and restraint systems are the responsible to keep occupant safe. Indian automotive industry has AIS 023 standard which is related to seating systems.

The AIS 023 states that the seat must pass the H1H2 test and Energy dissipation performance test to pass the regulation. H1H2 test evaluate the strength of seat back and (Energy dissipation performance) EDP test evaluate the impact energy absorption of head restraint area of seat to reduce head injury. The existing seat design was failing for H1H2 test. The simulation results of above test were validated with experimental test.

II. AIS 023 AND AIS 016 REGULATION LOAD CASE DETAILS

This standard's have two major tests automotive manufacturer's need to pass.

A. H1H2 test

A test force 1000/H1 N is applied to rear part of the seat using advice. The height h1 is between 0.7 to 0.8 m above the reference plane as specified by the manufacturer. A test force equal to 2,000/ H2 N shall be applied simultaneously to the rear part of the seat corresponding to each seating position of the seat in the same vertical plane and in the same direction at the height H2 which shall be between 0.45 m and 0.55 m above the reference plane. To pass the test the seat must have displacement at H1 in between range 100 to 400 mm The displacement at H2 must greater than 50mm.The seat is fixed to a rigid floor.[2]

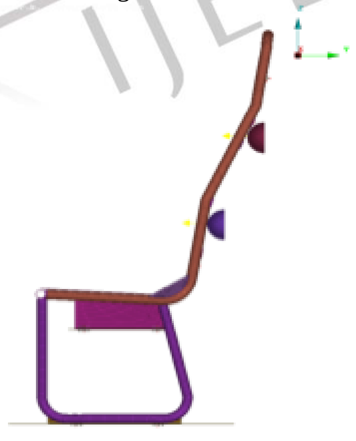

Fig 1.H1H2 Load case Setup

B. Energy dissipation performance test

A spherical ball weighing 6.8 Kg is strike at head restraint 100 mm below the top of seatback. The strike velocity of impactor ball is 24 km/hr. [1] In case of bench seat two impactor need to strike simultaneously. There is an accelerometer present in impactor which measures the deaccleartion. The seat is fixed to a rigid floor. The deaccleartion of head form should not exceed 80 G for 3 msec. If the deceleration crosses the above mentioned state there is risk of injury to brain.[10]

Image below shows a setup of EDP test simulation and result comparison with unreformed state.

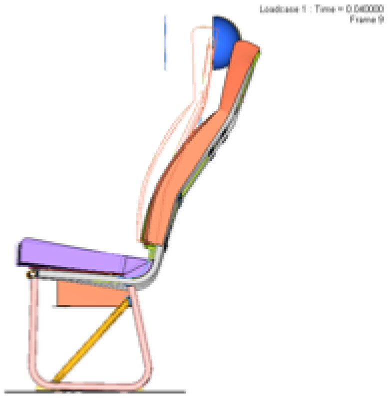

Fig 2.EDP Load case Setup

III. MODELLING

The sheet metal parts and tubes were discretized using 2D elements. Mid-surface of all parts was extracted. Meshing was done on all the mid surface using mixed mesh type and thickness was assigned to mid-surface. Weld were modelled by same procedure above. The thickness of weld was given as the average thickness of the two connecting parts. Bolt connection are modelled by using CNRB (constrained nodal rigid body) or multipoint constraint. Thin wires were modelled as 1d element. Circular cross-section was assigned for modelling 1D elements. Foam is modelled by using solid tetrahedral elements. Mesh model was checked for required mesh parameters viz: warpage, aspect ratio, minimum length tetra collapse.

Minimum length is an important mesh criteria for explicit analysis to have stable solution. Minimum length of model further affects time step size for solution which is responsible for solution time. Courant–Friedrichs–Lewy (CFL) condition is used to find the ΔT (minimum time step size) for stable explicit solution[3]

$\Delta T = L/C$

$C = E/\rho$

Where,
ΔT= Minimum Time step for stable explicit solution.
L= minimum length
C = sound speed across material.
E= Young's modulus of material
ρ = density of material.

IV. SIMULATION

Simulation is carried out using LS-dyna software. Material modelling is done using simple tension test results on material specimen. Test data was converted in true stress and strain. MAT type 24 material model is used to model the material for seat structure.

To assess the correctness of explicit simulation results energy balance is important.

Below are the results obtained from simulations iterations.

A. AIS 023: H1 H2 test base design

The base seat design was simulated for H1H2 test.

It was observed that the seat was failing for AIS 023 regulation mentioned above. The seat structure was unable to withstand the load. The H1 displacement was exceeding the max displacement criteria of 400 mm and seat structure collapsed completely before achieving full load.

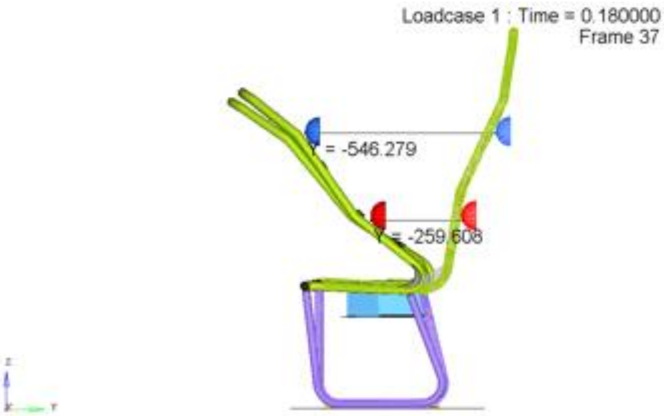

Fig 3:H1H2 load case deformation plot for base design.

B. AIS 023: H1 H2 test Optimized design based on design iterations

The base designed was optimized after many design iterations with varying cross sections and taking economical aspect in to point of view. The design iterations consisted varying parameters like thickness, cross section changes and deformation behaviour observed in simulation. As a final design iteration selection, Pipe in pipe structure design was used to add additional energy absorption members in seat structure pipe. Also a cross member was added to seat leg for additional strength. The load was ramped up to 200 msec and held constant for 50msec as per the regulation. The optimized design have successfully passes the deformation criteria in regulation. The displacement at H1 loading point is 119 which is in range 100 to 400 mm allowed in AIS 023 regulation The displacement at point H2 is 91 m which his above min 50mm range specified in the regulation.

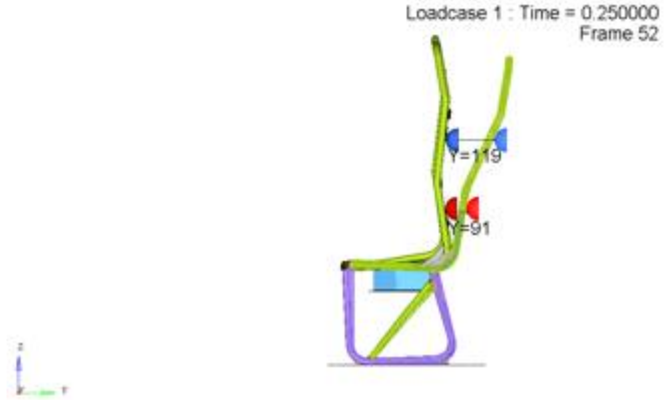

Fig 4:H1H2 load case deformation plot for optimise design

C. AIS 016:Energy dissipation performance test

The optimized design was further evaluated for EDP test. The importance of this test is asses the head restraint for head injury criteria. The seat used for study has a integrated head restraint. The test is performed as mentioned in above AIS 016 regulation details. In simulation the head form is given an initial velocity of 24 Km/hr. In the current seat the seat foam acts as the energy absorbing material. This is an explicit simulation which was carried out for 100 msec. The performance of seat is evaluated by assessing the deceleration of head form impactor. Below is deceleration plot of head form in simulation. It is observed that the max acceleration is 77 G for both head form.

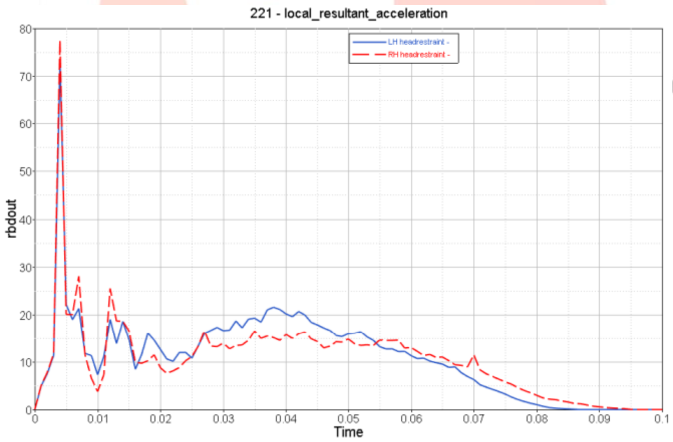

Figure 5:Deaccleration curve for Left and Right Impactors

The figure below shows energy plot during this simulation. It is observed that the energy plot is ideal energy plot in impact load case. Thus it further validates the simulation.

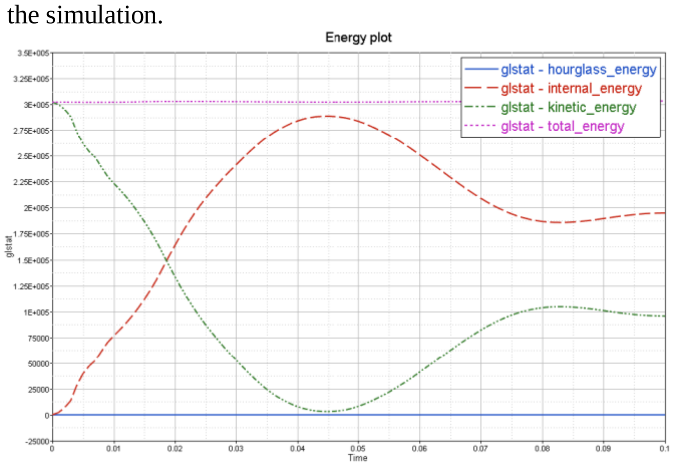

Figure 6:EDP Simulation Energy Plot

V. SUMMARY OF CORRELATION OF PHYSICAL TEST WITH SIMULATION RESULTS

The table below shows comparison of experimental test with simulation results for H1 H2 test which is carried out as per AIS 23 regulation.

Table 1:H1 H2 results comparison

H1H2 test	Experimental test results		Simulation results	
Height from reference floor	H1 800mm	H2 500mm	H1 800mm	H2 500mm
Actual displacement	108	97	119	91
Load achieved (KN)	2.5	7.27	2.5	7.27

The table below shows comparison of experimental test with simulation results for energy dissipation performance test which is carried out as per AIS 16 regulation.

Table 2:Energy dissipation performance test results comparison.

Energy dissipation test	Experimental test results		Simulation results	
Head restraint	LH	RH	LH	RH
Average "g" level	76.2	85.4	77	77
Time duration above 80 G in msec.	N.A	0.4	NA	NA

VI. CONCLUSION

The final results obtained from simulation were compared with experimental test carried out by seat manufacturer. The deformation and behaviour of seat structure in simulation was similar to as observed in physical test. Due to modelling approximations there was deviation in deformation of about 8%.

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