Study and analysis of automotive seating system riser design & development for M1 category vehicle

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Abstract— Seat is a sub system of automobile or vehicle. It is the main aggregate in a vehicle, which impacts the visibility, comfort, safety for the occupant. H-point plays vital role in seat system design & occupant safety. As a part of vehicle development, requirement raised is to have elevated H-point to have better visibility & control for occupant. Use of carryover seat with minimum part alterations is a challenge. After studying all relative factors, it has been decided to integrate carry over seat with BIW by addition of seat riser member. This paper speaks about design and development of seat riser member for automotive seat.

***Keywords**:* Automotive parts, Seating system, Riser Design, Validation

I. INTRODUCTION

The occupant position in a vehicle is constraint by complete seat. To locate all components in the vehicle, the three dimensional reference systems are used. It relates the seat system and other component designs to the total vehicle. The reference system allows the identification of points of interest, such as the driver's eye location, seating reference point, and the centre line of the vehicle. H-Point is defined with respect to three dimensional systems, to locate seat in a vehicle. It is also known as seating reference point (SGRP). All the seating components are designed with respect to H-point. The new version has elevated H-point by 40mm, results in changed relations with surrounding & BIW. To maintain relation with BIW and with minimum alterations, seat riser has been identified as a member with measure modifications.

This paper speaks about procedure followed for new riser design, theoretical calculations for load requirement, finite elements analysis for the concepts designed, its correlation with each other. The seat riser member is finalized on the basis of correlation done. It explains the development procedure for riser member with sheet metal processing.

After getting proto sample for riser member & get assembled with complete seat, it enlighten the validation procedure in compliance with regulatory requirement. After observing validation results, it concludes by fulfilling the requirement.

II. RISER – SEAT STRUCTURAL MEMBER

Riser plays significant role in deciding the mounting and total height of seat. Riser plays significant role in load path, load is transferred from complete seat to vehicle floor through riser. It is most important metal part in frame or structure. It is of two types by means of material, stamped or sheet metal riser and second is tubular riser.

Sheet metal/stamped riser is produced by thin steel sheet; the thickness varies from 0.8 mm to 2.0mm. It is produced by stamping, piercing, forming, clinching or processes like bending. Depending on strength requirement local embosses or deformations incorporated/designed.

In tubular type riser, it is produced by steel tubes. Numbers of steel tubes are welded to each other to form riser frame. Processes like tube cutting, bending, flattening etc. Tubular riser is bolted to vehicle. Sheet metal formed bracket can be welded to tubular frame or tube may be flattened locally for bolting.

In many cases Seat adjusting sliding mechanism, or slider, height adjuster mechanisms is fitted on the riser. Belt buckle can be mounted on the riser which is one of the safety features.

Riser is also accountable for H-point and occupant comfort. [2]

III. RISER DESIGN

Statement of requirement (SOR) provides requirement for the design and development of new seat, information about vehicle class, regulatory requirement needs to comply with, vehicle environment in terms of input parameters.

SAE J1100 endorsed exercise defines a uniform set of interior and exterior dimensions for all automotive vehicle class like LUV, MUV, HCV etc. it also tells about the references to be considered to define manikin position like eyellips, accelerated heel point, head roof clearance, torso angle, passenger heel point. By using this information, Vehicle reference point, H point can be derived which in turn assists to vehicle aggregate packaging. For seat system positioning SGRP (Seating reference point) is defined.

Benchmarking study delivered the current trend in seat system design & risers. The features that can be include into the riser, riser mountings, seat belt anchorages, manufacturing process used for riser. No of Mechanisms like recliner & slider (track) available in the market & can be used as per specifications required.

For trimmed out seat (The completely finished seat consists of seat frame, foam & trim), the riser member should facilitates the location & provision to assemble or attach the seat trim to the seat frame. J-Type, C Type & L-type retainers are some of the attachment with which we can assemble seat trim to the seat frame. The appropriate feature needs to be design at riser plate by considering the assembly sequence & sheet metal design and process constraints.
From the SOR, information received is as follows.

(1) Vehicle class, Region where Vehicle to be launched.
(2) Elevated H- Point.
(3) Seat mounting points.
(4) Track angle.

(5) Accelerated Heal point.
(6) Cushion angle.
(7) Weight targets.
(8) Regulatory requirements.

After evaluating the above information, it has been judged that, carry over seat with integration of riser will fulfil the requirement. Figure 1 shows desired output for seat.

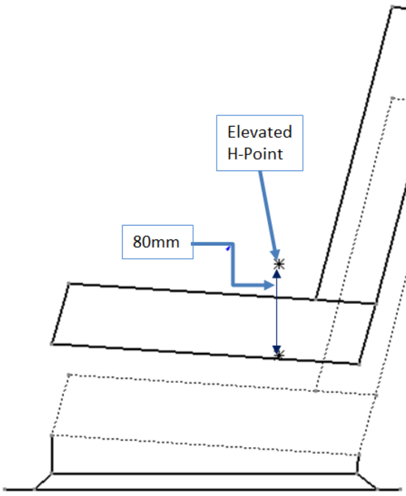


Fig. 1: Concept requirement.

Concept layout has been designed to fulfil the requirement as shown in figure 2.

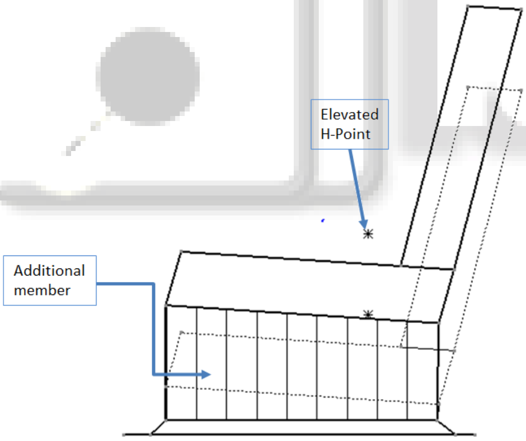


Fig. 2: Concept Layout.

As a product engineer, need to understand production process, assembly sequence for seat, predominantly for riser & its environment parts. Design considerations by taking production & manufacturing process into account, must be followed while designing the riser.

IV. Methodology

The work content for riser design can be divided in to, reviews the literature, data collection, design, analysis, development and validation. The tentative methodology is as follows

In the literature review, related information has been collected from reference books, training material and journal papers. In data collection, information is collected from literature review and from statement of requirements for vehicle from customer. Design phase has given various riser alternatives. Design process is done by software like Catia V5 R19. During analysis, FEA is done and compared the results to come to finalize the riser design. Analysis will use software like hyper mesh; LS dyna. In development phase, riser prototype has been produced. Then Validation of riser according to regulation has been done.

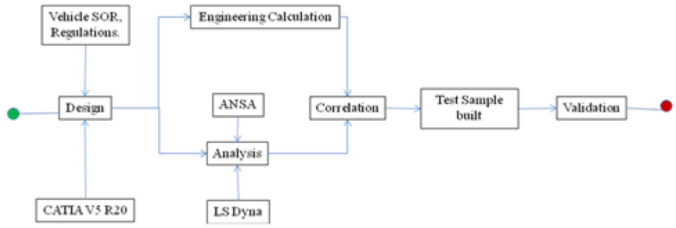


Fig. 3: Flow Diagram: Methodology

The above image shows the methodology followed to accomplish the objective of the project.

The work content for riser design can be broadly divided in to, the literature review, data collection, design, analysis, development and validation. The methodology followed is as follows. To achieve desired results, work has been distributed further in following steps. Each step is explained in detail in forthcoming sections.

Regulations need to be consider to design & develop seat riser are ECE R14, ECE R16, ECE R17.

ECE R14 speak about

(1) Least No of seat belt anchorages required for front & rear seat for M & N category vehicles.
(2) Permitted zones for the seat belt anchorages.
(3) Describes threaded anchorage holes for Seat belt anchorage mounting.
(4) Inspection & measurement methods & devices for seat belt anchorages.
(5) General test requirement & procedure.

Detail summary, ECE R 14 is as below.

This Regulation is relevant to safety-belts anchorages & anticipated for adult occupants for forward-facing or rearward-facing seats in vehicles. This regulation considers vehicles of Categories M and N.

A. The position of anchorages is discussed in following section.

Assume Points L1 and L2 are the lower efficient belt anchorages. Point C is a point situated 450 mm uprightly above the R Point. However, if the Distance S as defined is not less than 280 mm and if the alternative formula BR = 260 mm + 0.8 S specified is chosen by the manufacturer, the upright distance between C and R shall be 500 mm. The angles $\alpha 1$ and $\alpha 2$ are correspondingly the angles between a horizontal plane and planes perpendicular to the median longitudinal plane of the vehicle and passing through the Point H and the Points L1 and L2.

S is the space in millimetres of the efficient upper belt anchorages from a reference Plane P parallel to the longitudinal median plane of the vehicle defined as follows:

If the seating arrangement is well- described by the shape of the seat, the Plane P shall be the middle plane of this seat.

B. In the absence of a well-described position

The Plane P for the chauffer's seat is an upright plane corresponding to the median longitudinal plane of the vehicle which passes through the middle of the steering-wheel in the plane of the steering-wheel rim when the steering-wheel, if adjustable, is in its middle position.

The Plane P for the front outboard occupant shall be symmetrical with that of the driver. In addition to above, general provisions to position anchorages needs to be consider

C. Anchorages for safety-belts shall be so planned, made and positioned as to

Enable the installation of a appropriate safety-belt. The belt anchorages of the front outboard positions shall be suitable for safety-belts incorporating a retractor and pulley, taking into deliberation in particular the strength characteristics of the belt anchorages, unless the manufacturer provides the vehicle equipped with other types of safety-belts which incorporate retractors. If the anchorages are appropriate only for particular categories of safety-belts, reduce to a lowest amount the risk of the belt's skidding when worn perfectly.

Shrink to a minimum the risk of strap damage due to touch with sharp rigid parts of the vehicle or seat structures.

Facilitate the vehicle, in normal use, to comply with the provisions of this Regulation.

For anchorages which take up dissimilar positions to allow persons to enter the vehicle and to restrain the occupants, the specifications of this Regulation shall apply to the anchorages in the effective restraint position.

D. Minimum number of anchorages to be provided

Every vehicle in Categories M and N must be equipped with safety-belt anchorages which assure the needs of this Regulation.(Exception: M2 & M3 Category Vehicles).

The anchorages of a harness belt system accepted as a S-type belt (with or without retractor(s)) according to Regulation No. 16 shall obey with the needs of Regulation No. 14, but the supplementary anchorage or anchorages provided for the fitting of a crotch strap (assembly) are exempted from the strength and position needs of this Regulation.

The least number of safety-belt anchorages for each forward and rearward sided seating location shall be specified as in annexure-2.

No part of the vehicle is in the reference zone, or proficient of being in the reference zone when the vehicle is moving or parts of the vehicle surrounded by the said reference zone fulfils the energy absorption test mentioned in Regulation No. 80.

E. Position of the Belt Anchorages

The belt anchorages may be positioned entirely on vehicle structure or entirely on the seat structure or distributed between these regions.

F. Locality of the effective lower belt anchorage

Vehicle class M1: first row or Front seats.

In automotive vehicles of class M1 the angle L1- $\alpha1$ (excluding buckle side) shall be constrained in the range of 30 to 80°and the respective angle for L2- $\alpha2$ (buckle side) shall be constrained in the range of 45 to 80°. Both angle requirements shall be applicable for all usual travelling positions of the front seats. Where in any case one of the angles $\alpha1$ and $\alpha2$ is constant (e.g. anchorage mounted on the seat) in all usual positions of use, its angle shall be 60 ± 10°. In the case of adjustable seats with a mechanism provided for adjusting seat with a back frame angle of less than 20, the value of angle $\alpha1$ may be below the minimum (30°) predetermined above, provided it shall be equal to or greater than 20° in any ordinary position of use. Refer annexure-2**.**

G. Position of the efficient Upper Belt Anchorages

If a device analogous to strap guide or strap guide is used which influences the position of the efficient upper belt anchorage, this location shall be calculated in a conventional manor by bearing in mind the position of the anchorage when the longitudinal centre line of the strap goes through a Point J1defined sequentially from the R Point by the subsequent three segments:

RZ: a part of the torso line considered in an upward direction from R and 530 mm protracted;

ZX: a part normal to the median longitudinal plane of the vehicle, considered from Point Z in the track of the anchorage and 120 mm long;

XJ1: a part normal to the plane defined by lines RZ and ZX, considered in a forward direction from Point X and 60 mm long.

Point J2 is calculated by symmetry with Point J1 about the longitudinal vertical or Y0 plane passing through the torso line of the manikin situated in the considered seat.

The efficient upper anchorage shall lounge under the Plane FN, which runs normal to the longitudinal middle plane of the seat and makes an angle of 65° with the torso line. The angle may be minimizing to 60° in the case of rear seats. The Plane FN shall be so located as to meet the torso line at a Point D such that,

DR = 315 mm + 1.8 S. ----------------------------Eq-1.1

However, when S ≤ 200 mm, then DR = 675 mm.

The efficient upper belt anchorage shall lounge at the rear of Plane FK running normal to the longitudinal middle plane of the seat & crossing the torso line at 120°angle of at a Point B such that,

BR = 260 mm + S. --------------------------------------Eq-1.2

When S ≥ 280 mm, the maker may use at his judgment,

BR = 260 mm + 0.8 S. ---------------------------------Eq-1.3

The value of S shall be equal to or greater than 140 mm.

The efficient upper belt anchorage shall be positioned to the back of a vertical plane normal to the middle longitudinal plane of the vehicle and passing through the R Point.

The efficient upper belt anchorage shall be positioned over a horizontal plane passing through Point C as explained earlier. Refer annexure-1.

Any additional anchorage shall comply with above mentioned requirements. Size of threaded anchorage holes: threaded hole of 7/16 inch, an anchorage shall comprise of. It shall be possible to disengage the safety-belt with no damage to the anchorage.

H. Seat Belt Anchorage (SBA) test for belt anchorages

Subject to appliance of the requirements for securing the vehicle for SBA test., and at the demand of the manufacturer; the tests may be performed either on a vehicle structure or on a completely finished vehicle.

I. ECE R16 speaks about

The belt, which is the occupant's safety mechanism in an accident, there is a bigger test constraint.

(1) The durability of a belt, the tension for the speed, angle, and the acceleration, is tested by cycle tests.
(2) In addition to a dynamic and static tensile test, the habituation of all elements is tested for life, against temperature variations, water and resistance to dust.

J. ECE R17 speak about

(1) The strength of Seats & seat belt anchorages.
(2) Rear Parts of seat back & projection at the seat looking from rear side.
(3) Inspection & measurement methods & devices for seat belt anchorages.
(4) General test requirement & procedure.

K. Concept Design

The product design & development planning process mainly involves three sub practices: conceptual, logical & physical. Conceptual design is the method of gathering, investigating, and prioritizing requirement and perspectives of the problem and the solution, and then creating a representation of the solution. It is the construction and exploration of new ideas.
Concept design is a systematic process in which certain approach for the part design is defined by available information, requirement through detailed layout. It helps to analyze the interim part/ riser architecture.

Design a part which will fill the gap between cushion and track is main requirement captured from the requirement & packaging study. Also by benchmarking study the present trend is analyzed. The regulatory requirement study gives apparent suggestion about the important zones on the part & its strength required. With the above inputs, concept needs to be design.

The constraints considered for riser concept are design position of seat. It consist of track position, track angle, cushion angle, cushion position, type of recliner, recliner positions, recliner mountings (recliner packaging), and antisubmarine member position, cross tube position. Towel Bar assembly, its working envelope also needs to be involved in consideration.

Two Concepts designed one is tubular & other one is stamped member. By considering regulatory & packaging requirement stamped member has been finalized. By improving section modulus in the area where loading impacts, three concepts designed for stamp member with reference to above constraints. The concepts use same mounting points, almost same anchorage point & packaging points. The concept varies from one another by thickness, form, weight. Refer below images for concepts designed.

The concepts then tabularized to have comparative idea on the basis of different parameters. Figure 4 to 6 shows different concepts designed.

Proposal No	Material	Weight (Kg)
1	E34, 1.6mm Thk	0.632
2	E34, 1.6mm Thk	0.663
3	E34, 1.6mm Thk	0.745

Table 1: Concept comparison

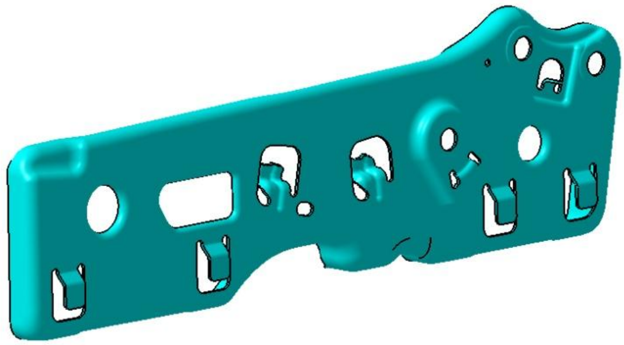


Fig. 4: Concept -1

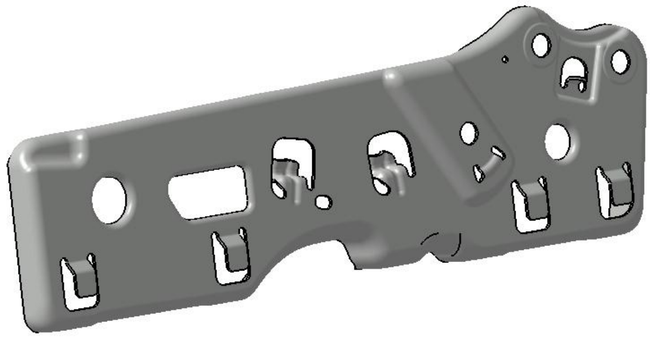


Fig. 5: Concept -2

Fig. 6: Concept -3

L. Engineering Calculation

Hand calculations are a vital part of an engineer's work when scoping out projects and checking FEA calculations. Before begin with a complex simulation model, a first pass calculation using fundamental equations can invariably shorten the overall product development and assessment cycle. Additionally, as basic user mistakes can easily occur, it is always vital to undertake a 'reality check' on the results from an FEA analysis.

In previous section, three concepts designed. Before going to FEA, a hand calculation gives fare idea & confidence for our design. FEA is nothing but simulation model by constraining the design & applying known load case.

After gathering the information for requirement, we have strength requirement, material requirement, and seat weight requirement. We can build a model or can define load cases at different conditions.

Considering the worst case for Riser, it plays vital role in frontal crash. This is by considering that one of the seat belt anchorage points is on the seat.Seat riser exposed to different loads in frontal crash. Loads are the result of seat weight, manikin weight, and inertia. Riser should sustain the above load & should transfer the weight to vehicle body through mounting points. In frontal crash, seat should perform by withstanding the manikin & sear weight with inertia. It should exhibit antisubmarine effect to manikin so that, manikin should not jumped out from the seat. Seat belt anchorages experience the load because of the manikin weight & seat back. This load condition can be simulated by Seat Belt Anchorage (SBA) test as specified in ECE R14. By having load values &application condition, we can formulate the load case & can have a formula to evaluate the riser behaviour under the load condition.

Following section provides the approach to get different load acting on the riser & the resultant stresses developed at different locations. From which we can determine the failure modes/ areas in the riser.

As per regulation, three loads acts on front or self-standing seat for seat belt anchorage test. The loads act as shown in figure 7

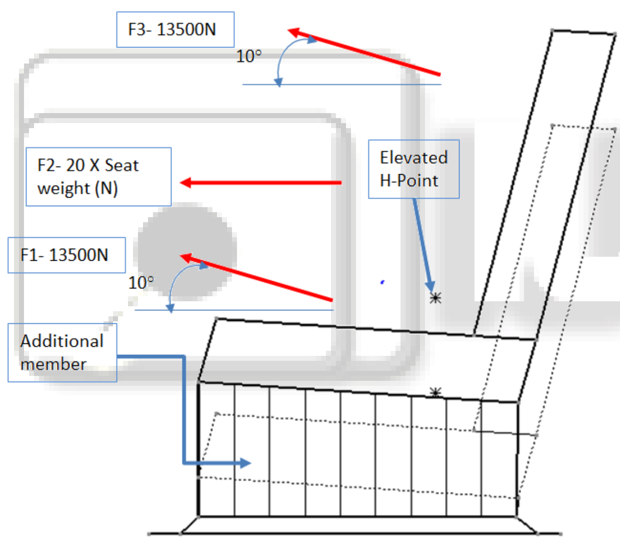


Fig. 7: Loads acting on seat on account of ECE R 14

In this case we need to calculate load on riser member which is a result of load dues to seat anchorages and the load because of seat mass.

Assume the track angle is 0º from horizontal, the belt loads are 10º from horizontal, the 20 times weight load is also 0º from horizontal, and the seat weight is 11.2 kg (112 N).

For seat with integrated seat belts, the peel off load on the riser member will be calculated as follows.

$F(p) = \{f(1) + f(2)\}sin10°.$ -----Eq-1.4

$= 2 \times 13500 \times 0.1736\ N = 4687.2\ N = 4.68kN$

Taking 20% safety factor over the requirement, the peel off load will be

$F(P) = 1.2 \times F(p)$------------------Eq-1.5

$= 1.2 \times 4.68\ kN = 5.624\ kN$

For seat with integrated seat belts, the longitudinal load on the riser member will be calculated as follows.

$F(t) = \{f(1) + f(2)\}cos10° + 20 \times seat\ mass$ -------Eq-1.6

$= (2 \times 13500 \times 0.9848 + 20 \times 112)$

$= 28.829\ kN$

Taking 20% safety factor over the requirement, the longitudinal load will be

$F(T) = 1.2 \times F(p)$----------- Eq-1.7

$= 1.2 \times 28.829\ kN = 34.595\ kN$

In this case, one side seat belt anchorage is on the vehicle body (BIW). So peel load becomes,

$F(p) = \frac{1}{2} \times \{f(1) + f(2)\}sin10°$-------Eq-1.8

$= 13500 \times 0.1736\ N = 2.34\ kN$

Taking 20% safety factor over the requirement, the peel off load will be

$F(P) = 1.2 \times F(p)$---------Eq-1.9

$= 1.2 \times 2.34\ kN = 2.808\ kN$

In this case, one side seat belt anchorage is on the vehicle body (BIW). So longitudinal load becomes,

$F(t) = \{f(1) + f(2)\}cos10 \times \frac{1}{2} + 20 \times seat\ mass$---------Eq-1.10

$= (13500 \times 0.9848 + 20 \times 112) = 15.534\ kN$

Taking 20% safety factor over the requirement, the longitudinal load will be

$F(T) = 1.2 \times F(p)$----------Eq-1.11

$= 1.2 \times 15.534\ kN = 18.614\ kN$

The above loads indicate force values will be acting on complete seat.

Seat is symmetrical about longitudinal seat centre plane & all seat components & mountings also symmetrical about longitudinal seat centre plane. We can take advantage with going forward, to save time & material cost, we can factories the load.

As seat is symmetrical about longitudinal seat centre plane, seat back has dual sided recliner which in turn transfers seat back load symmetrically to cushion frame.

So we can consider that the load due to seat mass will get distributed into two.

In this case, seat mass load can be resolved into two. So longitudinal load becomes,

$F(t) = \{f(1) + f(2)\}cos10 \times \frac{1}{2} + 20 \times seat\ mass \times \frac{1}{2}$ --------------Eq-1.12

$= (13500 \times 0.9848 + 10 \times 112) = 14.415\ kN$

Taking 20% safety factor over the requirement, the longitudinal load will be

$F(T) = 1.2 \times F(p)$-------Eq-1.13

$= 1.2 \times 14.415\ kN = 17.297\ kN$

For calculating strength of the seat riser member, the stresses induced in the body can be calculated as follows.

Because of axial force, normal stress will be,

$\sigma(n) = \frac{P}{A}$-----------------Eq-1.14

The three concepts analysed as per above load calculations.

M. Finite Element Analysis (FEA)

Finite element analysis (FEA) is a process of obtaining solution by using computers for engineering problems. Engineering structures that have intricate geometry and loads, are either very complicated to analyse or have no theoretical resolution. But, in FEA, a structure of intricate type can be easily analyzed. Commercial FEA programs, written so that a user can solve an intricate engineering problems without knowing the principal equations or the mathematics; the user is required only to identify the boundary conditions and geometry of the structure. FEA software offers a complete solution together with deflections, stresses, reactions, etc. Numerical solutions to even very complex stress problems can now be obtained normally using FEA.

FEA plays very significant role in automotive industry. Because of computerization of the analysis, it saves the lot of efforts in terms of time & material. It provides or helps to identify behaviour in actual scenario without constructing it. As one of the significant automotive aggregate, seats are analysed individually by FEA to know its response in crash & in unusual circumstances. It also helps to know whether it comply with regulatory requirement or not.

In general, FEA consists of three measure steps.

(1) Pre-processing or Structure Modeling.
(2) Solving or Analysis.
(3) Post-processing.

The European ECE R14 categorizes the vehicles on basis of their maximum allowed weights and obligates them to sustain different loads reliant on their weight. Refer table below.

ECE R 14 load value			
Load at	**Load in kN**	**Load application**	**Load hold time**
Shoulder Block	13.5±0.2	As fast as possible	0.2 Second
Lap Block	13.5±0.2	As fast as possible	0.2 Second
Complete seat CG	20 x Seat weight±0.02	As fast as possible	0.2 Second

Table 2: ECE R14 test loads

Evaluated against Abaqus the main complexity in LS-Dyna simulations is not the modelling of the loading system, though these have to done with care too, but to suppress un-wanted dynamic effects. Setting a global damping constant is an well-organized method for this purpose, but the damping value has to be preferred with respect to the relevant Eigen modes of the structure. If the load application time, the holding time and the damping constant are properly chosen a balanced state can be reached.

With LS-Dyna one can use the built-in capacities to model the entire load application system. Seatbelt and slipping elements are used to replicate the belts not in contact with other parts of the structure. The region where belts and loading devices are in contact, have to be handled with special care. As mentioned earlier, slip between the loading device and the seatbelt is allowed, so that the load has to be transferred over a contact condition between belt and body block. A numerically more robust method of modelling this contact than with seatbelt elements is the use of membrane elements for the belt in this region only.

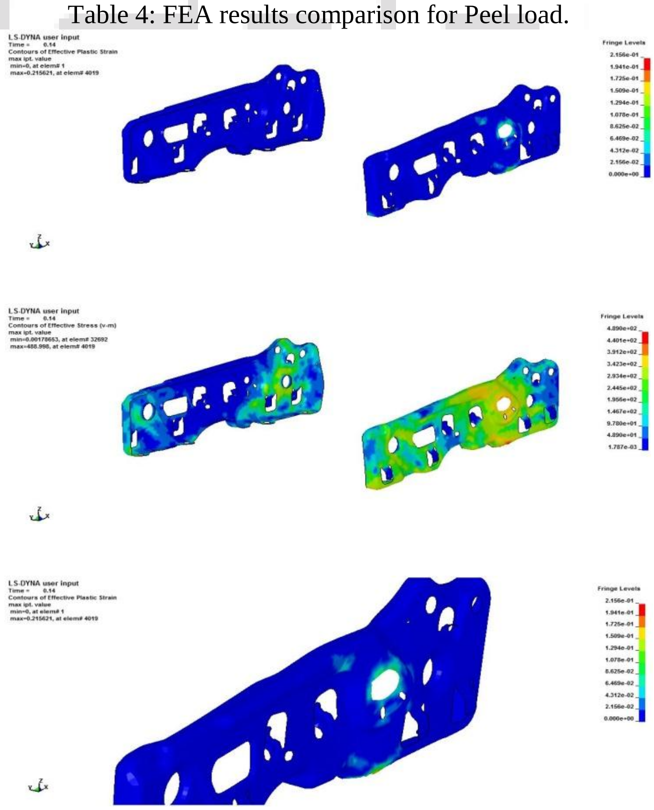
Proposal No	**Plastic strain %**	**Von misses stress (Mpa)**	**Max Displacement along – X, mm**	**% Improvement**
1	56.3	891.35	120	_____
2	25.89	532.34	99.25	40.27
3	21.5	489.01	32	8.13

Table 3: FEA results comparison for Longitudinal load.

Images on next page shows riser component behaviour under LS-Dyna simulation for proposal no 3

Proposal No	**Plastic strain %**	**Von misses stress, (Mpa)**	**Max Displacement along – X, mm**	**% Improvement**
1	94	76.4	1.84	______
2	58	71.5	1.78	6.41
3	21	44.15	1	38.25

Table 4: FEA results comparison for Peel load.



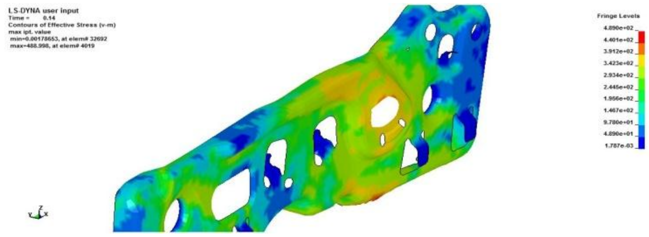


Fig. 8: LS Dyna Simulation results-proposal-3

Proposal No.	Max Stresses developed By Calculations (Mpa)	Max Stresses developed By FEA (Mpa)
1	757.61	891.35
2	471.12	532.34
3	442.55	489.01

Table 5: Engineering calculations & FEA results correlation

Table 5 shows that option no three is best suitable among the three proposals

N. Physical Validation

For the analysis done by FEA & by engineering hand calculations, we predicted the actual behaviour of component & its probable failures may occur. From past experience & with the help of physics we resolved the forces to solve the load case. But it is necessary to know the product behaviour at actual scenario & loading conditions. To solve this purpose, Physical validation is next step to be performed.

Physical Validation is a process which analyses the physical product in definite environment under the actual loading & surrounding conditions for the pretended designed product. It gives actual product behaviour or results under which under which we have imagined it should perform.

To make the test samples for physical validation, after manufacturing the riser part, it has been assembled to complete seat. The H-point inspection in accordance with ECE R 17 with all other basic quality checks has been done after assembling the complete seat. This seat is then ready to get mounted on Test rig specially designed to perform seat belt anchorage test.

The seat has been tested and validated at certified regulatory validation agency. The test result has to be prepared in form of graph.

Load as mentioned in the regulation is applied to the seat belts through traction devices. Seat is mounted on the test bed. The traction devices as shown in annexure-7 are fastened to the seat with the help of seat belts. The SBA test carried away as per procedure mentioned in ECE R 14.

V. RESULTS & DISCUSSION:

The seat with newly developed riser has been validated for seat belt anchorage test to comply with ECE R14.

The results received from Engineering Calculations, FEA & physical validation has been tabularized & correlated with each other. The results found shows good correlation between each other.

The complete seat features have been defined. The new riser component designed to integrate carry over seat with BIW, as per the requirement

The validation or the physically tested seat with deformation observed & results are discussed through table 6.

For the comparison between computations and test results an existing driver seat chosen. As per ECE 14 full loads of 13.5 kN have to be applied. ECE R14 also demands to consider seat weight, only this test was performed. Due to the high loads one can expect large deformations at anchorages of the body in white. Indeed, large deformations at the slipring occur, but no breakdown of the structure. The comparison between LS-Dyna simulations and the test results show a superior correlation of the overall deformations of the riser and also of the local deformation at the anchorage points of seatbelts and seats.

Pro. No	Engg. Calcu. (Mpa)	FEA			Physical Validation
		Pl. strain %	V-M stress (Mpa)	Max Displac mm	
1	757.61	56.3	891.3	131	-
2	471.12	25.89	532.34	102	-
3	442.55	21.5	489.01	36	Comply with regulation.

Table 6: Results comparison for conclusion.

From the above section, reached to the conclusion that New designed riser will accomplish the requirement for elevated H-point.

It has been concluded that the integrated seat with new riser component complies with regulatory requirement and can be productionized as per requirement.

VI. FUTURE SCOPE

As per regulatory standard, current riser design has been developed & validated. But as per OEM's specification, additional requirements are, seat should comply with are as follows.

(1) Slant Durability- for 1Lakh Cycles
(2) 45°side Durability
(3) Torsional rigidity.

To check whether riser is complying with above requirements, respective forces need to be resolve for hand calculations. Dynamic FEA needs to be done accordingly.

VII. ACKNOWLEDGMENT

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