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Design And Analysis Of Automotive Seat Recliner Mechanism

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ABSTRACT

The current trend in automotive industry is to produce vehicles with lighter materials & economic cost yet ensuring the safety for the occupant. Same principle applies to automotive seat design. In seating measure cost involves in seat mechanisms like slider, recliner, height adjuster etc. The Recliner is a mechanism which allows the seat back to rotate forward & rearward direction from a pivot point at the base of the seat back according to the passenger's seating comfort. The aim of this presentation work is to design and optimize the automotive seat recliner subjected to loading.The present work involves designing of new recliner mechanism by doing bench marking recliner mechanism available in market. Aim is to meet all safety & functional requirement of seat with giving advantage of cost.The project scope involves hand calculations, design study of benchmarking recliners, CAD modeling, Finite Element modeling of designed recliner mechanism using hypermesh. Pre-processing steps such as updating of element type, material properties, application of loads and Boundary conditions will perform using hypermesh.The results in the form of stress and deformation will be extracted using LS-Dyna.The factor of safety for assembly is calculated based on Von Misses theory of Failure. Optimization will done in terms of reduction in its weight and there by the cost of the seat recliner assembly. Thickness of various components of recliner assembly satisfies the strength criteria and the factor of safety which is within the allowable limits.

Keywords- **Automotive Seat, Recliner Mechanism, Low Cost, Safety, FEA Validation.**

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I. Introduction

Generally, seat recliner mechanism includes a base and an arm mounted on the seat cushion and seat back respectively, to house a locking and unlocking by external locking and internal unlocking means, which is effected by a rotatable cam operated by operating lever, which is mechanically linked to the cam for producing rotary motion of the cam. Safety is a basic consideration in all aspect of automotive engineering.

The current trend in automotive industry is to produce vehicles with lighter materials yet ensuring the safety for the occupant. In order to achieve this goal with minimum of expensive prototyping testing, new designs must be investigated numerically for strength and failure terms. The main objective of a good automotive seating system is not only to provide comfort but also to provide style and more importantly the safety feature. Pavan Gupta et al [1] studied that Anti-submarine Performance of an Automotive Seating System - A DOE study. But the system yet is sufficiently light weight to facilitate vehicle fuel economy and to minimize collision stresses. D. M. Severy et al were [2] developed Collision Performance LM Safety Car. Seating system design and materials must be affordable and durable to give acceptable service life. F W Babbs et al [3] studied that the packaging of car Occupants – A British Approach to seat designs. In addition to provisions for comfort and position adjustments, a seating system should have adequate structure for housing safety and convenience accessories. A. W. Siegel et al [4] were developed Bus Collision Causation and Injury Patterns. The design of seat recliner is very important because during an accident or a crash, occupants tend to be thrown back against their seat backrest due to inertial forces and if the recliner is not built to withstand such an impact, it results in failure. Toshiki Nonka et al [5] studied that the Development of Ultra-High Strength Cold-Rolled Steel Sheets for Automotive Use.

Sarah Smith et al [6] were developed that the Improved seat and head restraint evaluations. Recliner failures result in Seat backrest twisting and collapse and which can lead to severe neck, back and spinal injuries. G. Nadkarni et al [7] also studied that Advanced High Strength Steel Strategies in Future Vehicle Structures. The area of interest in a recliner is usually the locking mechanism, which holds the seat back at the angle desired by the occupant. The locking mechanism needs to be designed for sufficient strength, so that the seat back does not collapse during an impact. Guillén Abásolo et al [8] developed that Magnesium: the weight saving option. C. Blawert et al [9] studied that the Automotive applications of magnesium and its alloys. The renewable materials also used in automotives, Dr.Thomas et al [10] studied that Renewable Materials for Automotive Applications. For accurate positioning of recliner and to accept the recliner mechanism the lever release should be able to with stand the applied load in the locking position. When the load is applied then the whole assembly is subjected to combined stresses. Hence the lever release strength is the basic parameter for analysis. The desired position of back rest is achieved by operating the lever. When lever is operated force is transformed to cam. Which intern unlocks the upper tooth and lower tooth.

I. Design

A. *Requirement*

As per ECE17, automotive seat should pass Head rest performance, Seat back strength, Head rest energy absorption, Forward & rearward impact test, Luggage retention test etc. From this tests in Head rest performance testing maximum load is coming on recliner. As per Head rest performance test requirements, 373Nm moment applied on seat back &spherical head form 165 mm in diameter, an initial force producing a moment of 373 Nm about the H point is applied at right angles to the displaced reference line at a distance of 65 mm below the top of the head restraint & increased the load till 890 N or unless the breakage of the seat whichever occurs earlier.To meet this requirement, recliners designed more than 1000Nm torque value.

B.Recliner Strength Hand Calculation

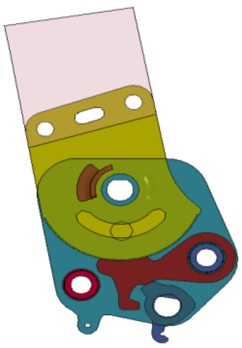


Fig. 1Recliner Internal Mechanism

Width of tooth at centre = 0.733mm

Sector thickness = 5mm

Cross sectional area of tooth = 3.665mm2

Number of teeth's engaged = 17 nos.

Distance of teeth's from pivot = 40mm

Tensile strength of sector/pawl material = 616MPa

Shear strength =616/1.5

=410.67Mpa

Shear failure load on each teeth = 410.67 x 3.665

=1505.1N

Recliner strength = Shear failure load x Number of teeth x Distance from pivot

=1505.1 x 17 x 0.040

=**1023.4Nm**

C. End Stopper Hand Calculation

Diameter of semi pierce feature = 7mm

Cross sectional area = 3.14/4 x 7 x 7 = 38.465mm2

Tensile strength of sector/pawl material = 616MPa

Shear strength = 616/1.5

= 410.67Mpa

Shear load = Shear strength x c/s area = 410.67 x 38.46

= 15796 N

= **15.7KN**

.D.CAD Modelling

The design is the construction of the geometric model by using UNIGRAPHICS software. The model may be recalled and refined by the designer at any point in the design process and it may be virtually used as an input for all other CAD/CAM functions.

Fig. 2 Recliner CAD geometry

II. FINITE ELEMENT ANALYSIS

A. Loading condition

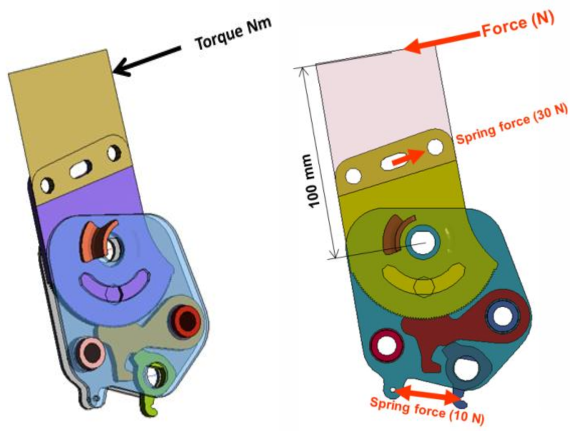


Fig. 3 Loading condition

The two mounting consider fixed at the center to represent the cushion side member mounting region.The arm representing back modeled and considered as rigid to apply the torque on the Sector plate. Force applied 100mm above from recliner pivot to find out torque. Handle spring force (10N) considered for cam locking and clock spring force (30N) considered for back returning.

B. Analysis Notes

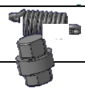
Recliner Torque Strength Simulation done as per provided requirements by using LS-Dyna is performed.The material properties assumed as engineering stress and strain values. They are converted to True stress and True strain values for calculation.Any part failure is assessed based on plastic strain output.For interfering surfaces, in order to clear the initial over closure, the surfaces are moved by very small increment.Bolts modelled as beam elements connected by rigid elements to the parts&linear material properties applied to all these beam elements.The beam torsion stiffness is given to represent actual torque transmission.All parts meshed with an average element size of 2-3 mm and the teeth locations are modelled with fine elements for better contact efficiency.

Consistent units in this analysis are:

Force = Newton
Length = mm
Time = Second
Mass = Ton

C. Material Specification

TABLE I

Sr no	Name	Snap	Mtl.	Thk (mm)	YS(MP a)	TS(M Pa)	% El
1	Upper sector		16Mn Cr5	5	425	616	19
2	Pawl		16Mn Cr5	5	425	616	19
3	Cam		16Mn Cr5	5	425	616	19
4	Mount ing rivet		EN8	ϕ18.2	465	899	14.8
5	Handl e Rivet		EN8	ϕ13.9	465	899	14.8
6	Side plate		E34	2.5	340	492	18.2
7	Cam spring		IS445 4 DM	ϕ1.8	-	1710	20
8	Pivot rivet		EN8	ϕ12.9	465	899	14.8
9	Clock spring bracke t		E34	2.5	340	492	18.2
10	Clock spring		IS445 4DM	ϕ6	-	1470	20

III. FEA ANALYSIS

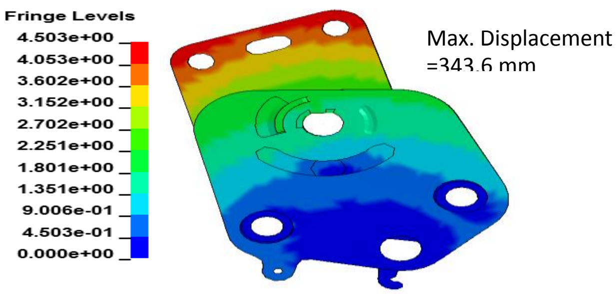


Fig. 4 VonMises Stress contour in upper sector

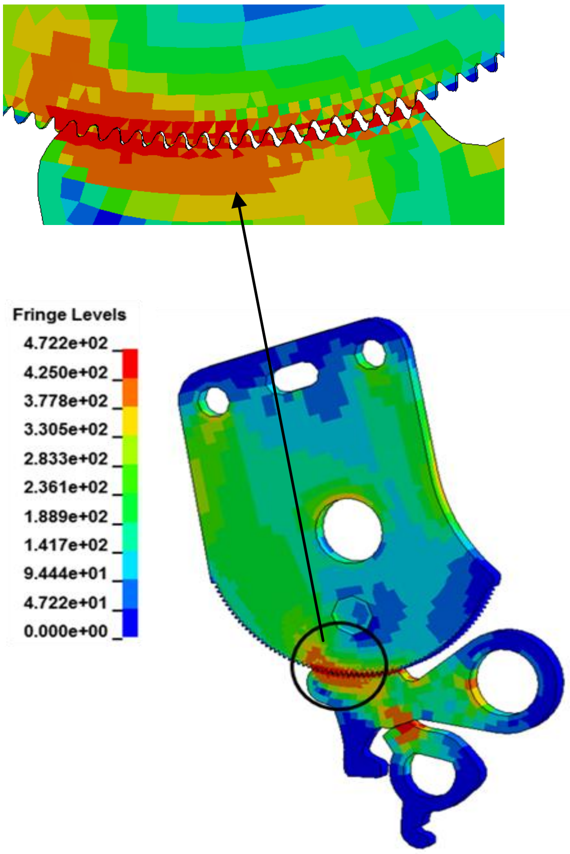


Fig. 5 VonMises Stress ccontourat upper sector & pawl contact area

Stresses which are more than 425MPa are shown in **RED** colour.The recliner is able to withstand a maximum load around **1080 Nm**. The maximum average stress in the Sector plate and Pawl are crossing the respective material ultimate true stress value of 616 MPa. Crushing of Sector plate teeth and Pawl teeth is observed.

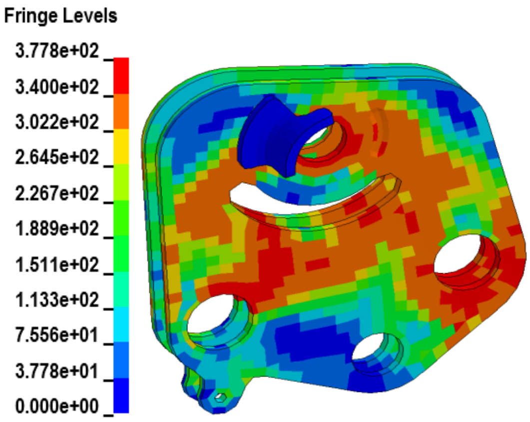


Fig. 6 VonMises Stress ccontourin side plates

Stresses which are more than 340MPa are shown in **RED** colour. The maximum average stress in the Side plates is around 342 MPa which is little more than the material yield value of 340MPa but less than the material ultimate true stress value of 492MPa. No material failure is observed.

IV. Factor of Safety Calculation

As per regulatory requirement Recliner Design target set for **1000Nm**.

Hand calculation result shows recliner can withstand torque **1023.4Nm.**

FEA result shows recliner can withstand torque value **1080Nm.**

Factor of safety with Hand calculation= 1023/1000=**1.023**

Factor of safety with FEA results= 1080/1000=**1.08**

V. Future Scope of Work

From hand calculation & FEA its observed material thickness & material properties plays an important role in designing recliner. In this project, material selected is 16MnCr5 as easily available& core part thickness 5mm. By selecting higher strength material we can optimise thickness, indirectly we can reduce weight but may be cost will increased. With different combination of material & part thickness we can optimise designed recliner mechanism.

VI. Result Summary

TABLE II
OUTCOME PARAMETERS

Sr. No.	Method	Material	Recliner strength
1	Hand Calculation	16MnCr5	1023.4 Nm
2	FEA	16MnCr5	1080 Nm

VII. Conclusions

The Recliner assembly is expected to withstand the maximum torque around more than 1000Nm to meet head rest performance test. As per hand calculation recliner assembly can withstand the maximum torque around 1023Nm and as per finite element analysis recliner assembly can withstand 1080Nm torque. Hand calculation results & finite element analysis results observed within 10% of variation. The Sector plate and pawl are experiencing the maximum average stress - strain properties.

VIII. Acknowledgment

Thanks to Prof. Prashant M. Patil for his valuable guidance. Also thanks to Mr. Premji Natarajan& Magna seating India fortheir valuable support.

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