International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 3, No. 3, July 2014

Research Paper

OPTIMIZATION SEAT OF BACK REST OF A CAR

Praful R Randive[1]*, Mohan D Karambe[2] and S M Kamble[1]

*Corresponding Author: Praful R Randive, ✉ raj.dhabekar@yahoo.com

With the goal of reduced weight, free-size finite element based optimization with constraints on stresses and deflection of a car seat backrest manufactured from low strength steel plate is performed using ANSYS software. In the free-size optimization, sheet metal thickness in a finite element plate of the backrest is design variables with stress and deflection limits as the constraints, with an objective to minimize mass. Using the results from the free-size optimization and a minimum draw-able sheet metal thickness, a final design is derived which obtains a total mass reduction. To verify the functional performance of the final design, the final optimized seat backrest is performed using the ANSYS software package. Results from the analysis provide an accurate prediction of the material yielding and load distribution on the backrest plate provide factor of safety estimates on yield and ultimate strength.

Keywords: Finite element, Optimization, Stresses, ANSYS

INTRODUCTION

Car seat research is related to comfort quality and mainly to human safety. Passengers are in the permanent contact with seat. Material characteristics of applied material are important for level of comfort and safety. Pressure distribution in contact between human body and seat determine the seating quality. Safety of sitting human in car during crash (front side and rear impact) is very important in car. Automotive seats are generally constructed from metallic frames covered by foam. Cushions, backrests, headrests, armrests, and other parts that make up a vehicle seat are designed according to three principal criteria integration within the vehicle like safety, aesthetics, and comfort. The design of seat backrest, however, is primarily based on safety requirements which give support to spinal cord of body.

Optimization is an important and necessary design tool that generally is used to design of component in the conceptual design stage. The importance of optimization in the automotive industry is to reduce the mass and improve safety.

[1] Department of Mechanical Engg, DMIETR, Wardha.

[2] Department of Mechanical Engg, S.S.P.P, Bhandhara.

In the present work, optimization will be done to show the potential mass reduction in available sheet metal of seat backrest of car. As part of this work, a reference seat backrest will be considered for optimization under the side and rear load on the basis of result by ANSYS software. The feasibility of the optimization and the subsequent weight reduction can be attributed to the large safety margin, obtained from the results of finite element analysis of the reference seat backrest.

Finite element analysis is accepted across a wide range of industries as a important tool for product design and optimization. When designing car seats, most of the variables to be considered relate to either geometry or materials. A valuable tool for facilitating and shortening this complex design process is numerical simulation using Finite Element Analysis (FEA). FEA can predict the response of a particular design under specific circumstances and supply data that can be used to optimize geometry and materials.

OBJECTIVE

The objectives of the present work are:

- To optimize automotive seat backrest frame manufactured from low carbon ductile steel sheets for light weight design, while conforming to the load and strength requirements of ECE R-17 backrest moment under specified constraints on stresses and displacements.
- A new range of sheet metal thickness is obtained from the results of free-size optimization using CAD software.
- Using the results from the free-size optimization and also by conforming to a minimum draw-able sheet metal thickness, a final design is derived which obtain total mass reduction.
- To verify the functional performance of the final design and to determine Factor of Safety for strength, a non-linear finite element analysis including an rear and side impact of the reference seat and the final optimized seat backrest frame is performed using the ANSYS package.

DESCRIPTION OF THE REFERENCE SEAT BACKREST FRAME

A typical automotive seat is comprised of a backrest frame, a base frame, connector components connecting the two, headrests, armrests and foam components like cushion and seat back. The frame forms the skeleton of the seat which is completely wrapped by the foam and thereafter, fabric or leather materials. The frame provides shape, strength, and rigidity to the seat under varied loading conditions. The frame and foam also hold certain control components of seat adjustments and comfort components within them. Seat adjustments are part of the skeletal frame with controls conveniently placed for easy passenger access. The design of an automotive seat is carried out according to four important criteria: passenger safety, comfort, integration within the vehicle and aesthetics. The present work is concentrated toward the optimization and analysis of the backrest frame along with the connectors. Functional performance of the base frame and seat adjustment mechanisms are not considered in the present work. In National Highway Traffic Safety Administration, it is shown that similar overall deflection, stress levels and distribution are obtained in the backrest frame and backrest when the connector is included in the model. The backrest frame is constructed from stamped low-carbon steel sheets and consists of two vertical members and two horizontal cross members welded to the top and bottom of the vertical members.

TEST REQUIREMENTS OF UNECE REGULATION NO. 17

A automotive seat for commercial usage must conform to strength, deflection and energy test requirements. These tests are carried out physically for vehicle front end, rear end and side impact loads. Two of the important test requirements are prescribed by the United Nations Economic Commission for Europe, Vehicle Regulations No. 17 or UNECE R-17. The regulations require the prevention of injury and death due to structural and functional defects of the vehicle seat. There are two tests under this regulation and they are the backrest moment test, seat anchorage test. Backrest moment test is a test of strength for the seat backrest frame and its adjustments, Seat anchorage test is a test of strength for the seat anchorage and the adjustments, locking and displacement mechanisms.

Loading and Boundary Conditions

Backrest Loads

As per the ECE R-17 backrest moment test, a moment of 530 N-m is to be applied rearwards on the backrest about the H-point. With the absence of backrest support plate, the required moment is applied as a distributed pressure along the front surface of the top cross member. This is a conservative assumption of the overall effect of the force. The approximation is justified as the major portion of the human load is applied through the upper half of the human torso in contact with the seat backrest or at the furthest position from the H-point.

The magnitude of the pressure is determined by the following equation, , where, is the pressure in , is the equivalent force producing a moment at a perpendicular distance from the H-point, and is the surface area (in) of the surface on headrest support (or top) cross member on which the pressure is applied. The distance is the perpendicular distance measured between the center of pressure on the applied surface and the reference seat H-point.

Boundary Conditions

For the model with the backrest frame with the connector, the boundary conditions are defined on the connectors, as they are the components in contact with the base frame, through the backrest adjustment mechanisms. Coupling constraints are defined on a slot on the connector that accommodates the cross tube, that further connects it to the base frame. The center node of the coupling constraint is allowed to rotate about the axis of the center point, whereas other degrees of freedom are restrained. A fixed boundary condition is defined on the leading half of the bottom edge of the connector, the region of the connector that meshes with the gear of the backrest adjustment mechanism. All degrees of freedom are restrained in that region; this boundary condition is the replication of the necessary restraint generated by locking the seat backrest at any particular position using the backrest adjustment mechanisms.

Factor of Safety for the Reference Seat Backrest Frame

The factor of safety for the reference seat backrest frame is computed. Three types of failure criteria are taken into consideration; Von Mises stress Max in-plane ultimate plastic strain and deflection of the top most point on the backrest frame. If any of the three parameters in the backrest frame components exceeds the corresponding limiting value, it is considered to be failure. Failure is considered at the point in time where one of the three criterions is first exceeded.

SCOPE

- Free-size optimization is performed on the reference backrest frame sheet by conforming to the load and strength requirements of ECE R-17 backrest moment. The backrest moment test is quasi-static strength tests that are predicted during vehicle rear-end crash.
- This gives rise to a scope for better optimization of the reference backrest frame under various other load cases (offset, side and buckling loads) that are predicted during vehicle front end and side impact during crash.
- Optimization encompassing multiple load cases will be optimal to all the load cases and will be conforming to the test requirements as well.
- The considered backrest frame is constructed from low carbon ductile steel sheet metal components made of multiple sheets of steel with a number of stress relief features. In the present work, free-size optimization of the backrest frame is considered and a mass reduction is obtained in the backrest frame by only changing the thickness of sheet metal components.
- By using the suitable types of welding, the strength of seat can be improved.
- In An evaluation properties of seat, specially stress distribution in the contact zone, during side and rear impact very can play very important role for the comport.
- By using FE model, it is possible to predict dynamic behavior of the automotive seat before the prototype is made and optimizing mechanical characteristics of used material and optimizing comfort layer with different layer of seat cushion to reduce the effect of impact.
- After all this result, we can find the stress analysis on backrest portion of seat in any accidental condition.

REFERENCES

1. Andrzejak D V, Hering W E and Viano D C (1995), “Seatback Load Applying Device”, US Patent No. 5,379,646, January 10.
2. Bertholon N, Robin S, Le-Coz J-Y, Potier P, Lassau J-P and Skalli W (2000), “Human Head and Cervical Spine Behavior During Low-Speed Rear-End Impacts: PMHS Sled Tests with a Rigid Seat”, Proceedings IRCOBI Conference.
3. Federal Motor Vehicle Safety Standards: 571.207, Department of Transportation, National Highway Traffic Safety Administration.
4. Federal Motor Vehicle Safety Standards: 571.301, Fuel System

Integrity, Department of Transportation, National Highway Traffic Safety Administration.

5. Laboratory Test Procedure for FMVSS 301R, Fuel System Integrity – Rear Impact (2007), Department of Transportation, National Highway Traffic Safety Administration.

6. Herbst B R, Clarke C C, Meyer S E, Oliver A A, Hock D A, Hayden J D and Forrest S M (2008), "Quasi-Static and Dynamic Testing as a Basis for Determining Seat Back Strength", *ASME*.

7. MLIT/JAMA/JARI (2004), "Proposals for Activities on International Harmonization Advanced Frontal Impact Dummies", July 16, IHRA BIO-WG in Washington DC, USA.

8. States J D, Balcerak J C Williams J S, Morris A T, Babock W, Polvino R, Riger P and Dawley R E (1972), "Injury Frequency and Head Restraint Effectiveness in Rear End Impact Accidents", Proc. of 16th Stapp Car Crash Conference, pp. 228-245, LC 67-22372, Detroit, MI.

9. Van Der Horst M J (2002), "Human Head Neck Response in Frontal, Lateral and Rear End Impact Loading Modeling and Validation", Ph.D Dissertation, Tech. Univ. of Eindhoven, Eindhoven, North Brabant.

10. Viano D C (2002), "Role of the Seat in Rear Crash Safety", *SAE International*, ISBN 0-7680-0847-6.