

Design Optimization and Validation of the Chassis of SUV car

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ABSTRACT

Automotive Chassis design is challenging task particularly in term of the weight reduction and simultaneously consider all the vehicle loads and loads coming from the ground to make the chassis safe for real time environment. In this paper, the chassis design from the dummy block using the topology, topography, size optimization techniques is applied and that chassis model is tested virtually in Hypermesh (Opti strut) for Durability Stiffness and Modal point of view. The desire dimensions of the chassis and loads applied particularly for SUV cars. The objective of this study chassis weight reduction, fulfillment of the structural performance for SUV cars.

Keywords: Automotive chassis design, Topology optimization, Topography optimization, Structural Analysis, Modal Analysis.

I. INTRODUCTION AND LITURATUTRE SURVEY

Many Researchers published papers on the topology optimization related works. For the new product development, there are series of challenges involved like designed product should sustain loads, occupy the certain space only, material should be light weight, it's cost should not be more than estimated cost. In such a case, it's difficult to predict which is the best and optimized design. Designer may know how the final product look like but to get it design space needs the FE Topology optimization methods.

Now a days Researchers in the automotive industries are more focused on reducing the weight of the vehicle because that directly improves the performance of the vehicle. Fuel consumptions, braking, Pollutant emissions, Ride handling and performance is directly depending on the vehicle weight also. Topology optimization is "Non-traditional" approach of achieving the targeted mass with best suitable mass distribution. Many paper related to this work published. To cite few [1] address the optimization of the high-performance chassis design with topology and topography approach. [2] discuss about the optimization through the series of constraints like crash, modal, torsion and bending. Series of the manufacturing constraints and design constraints are defined to achieve the final objective. [3] "address the optimization of the suspensions system" again with series of bending and torsion and sway modes frequencies. [4] address the optimization of the air conditioning system bracket used in the automotive. Its objective was minimum compliance in the static and natural frequency

constraints. [5] address the optimization under the minimum compliance under volume constraints for different static loading. [6] gives the detail information on the topology optimization in hypermesh with Opti struct as a user profile. Deck preparation was done in the hypermesh and Post processing in Opti struct and HyperView. [7] address the extracting the chassis the light weight chassis through the topology optimization methods with the stiffness, durability loads.

In this paper, the chassis model was extracted from the dummy block of the actual designed space for SUV cars chassis. Extracted the chassis model through minimum compliance design under the durability loading and Natural frequency loading constraints like Vertical bending, lateral bending and torsional Mode etc. Finally, the optimized model was interpreted to construct the real time SUV chassis geometry in the Solid Thinking Inspire 2017.3.1 software. The Real-time geometry of the SUV cars which was constructed in Inspire ST was tested in the same software for the Stiffness loads like Bending and torsion.

II.METHODOLOGY

2.1 Extracted the Solid Block out of the actual chassis Model or Actual design Space is consider for the topology optimization.



Fig. 1: Dummy chassis block Geometry

Fig. 2: Dummy chassis block meshed

The dummy chassis block is model with Hexahedral elements as shown in Fig. 2 out of the geometry of the of the solid block shown in Fig. 1. In the volume of the dummy block 311850 Hexahedral elements were created.

2.2 Rigids created at the locations were the loads applied and Durability loads were applied on the independent node of those rigids.

Load Cases:

- A] 321G_Front_Right_Side B] 321G_Rear_Left_Side C] 321G_Rear_Right_Side
- D] 321G_Front_Left_Side E] 2G_Twist_Side F] 3G_Front_Side G] 3G_Rear_Side

Each load case includes around 30 loads. In that loads half were Forces and half Moments that to be applied on the nodes in the model. Real times loads which the different chassis manufacturing industry uses for the testing of their chassis were considered for the above deck preparation.

2.3 Initial material considered for the dummy block was STEEL AISI 304. Normal Deck without optimization was prepared and solved for the confirmation of the connections.

2.4 Deck prepared for the topology optimization. [iteration-1]

Steps in Topology optimization deck:

- 2.4.1 Desvar: Parameter- mindim: 60 maxdim:120 mingap:120 Draw-none
 Extrusion-3pnts
- 2.4.2 Design Response: Volfrac- card: volumefrac Region: Total
 Wcomp- Load cases: All durability load cases
 Stress- card- static stress
- 2.4.3 Dconstraints: Volfrac- upperbound: 0.3 Response: Volfrac
- 2.4.4 Objective: Wcomp: minimize

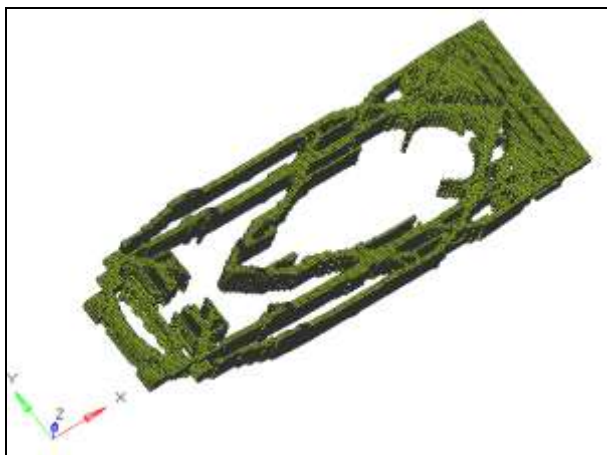


Table 1: Dummy chassis block meshed	
Volfrac	0.3
mindim	60
maxdim	60
mingap	120

Fig. 3: Optimization results of durability Aspects

In this iteration only the 30% of the actual volume is considered for the optimization. Fig.3 shows the topology optimization results obtained in the above iteration.

Iteation-2:

In the Next iteration along with the durability loads the natural frequency aspect was also considered as the constraints. Same as the previous iteration the in this also min 30% volume was taken for the optimization. Normal chassis modes in frequency analysis:- Lateral Bending, Vertical Bending, Torsional Mode this modes and their related frequencies were considered for the dconstraints and those frequencies were taken from the baseline reference of the chassis.

- 2.4.5 Desvar: Extrusion-3pnts
- 2.4.6 Design Response: Volfrac- card: volumefrac Region: Total
 Wcomp- Load cases: All durability load cases
 Stress- card- static stress;
 Lateral Bending : Vertical Bending : Torsional Mode
- 2.4.7 Dconstraints: Volfrac- upperbound: 0.3 Response: Volfrac
 Lateral Bending : Vertical Bending : Torsional Mode
- 2.4.8 Objective: Wcomp: minimize

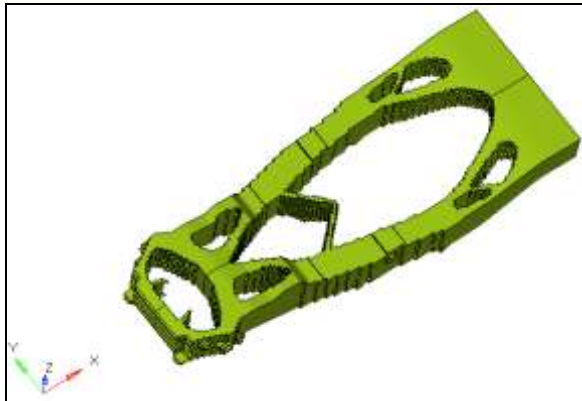


Fig. 4: Optimization results for Durability and Modal aspects

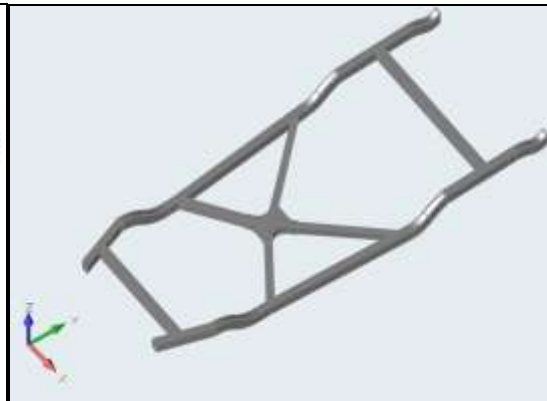


Fig. 5: Geometry constructed in the Solid thinking

The results obtained in the topology optimization in Opti struct was used to construct the geometry in Solid thinking inspire 2.17.3.1. The outer structure and all beams are modelled according to the Fig.4 i.e optimized results in the topology optimization. standard sections are considered in the geometry modelling in inspire.

2.5 ANALYSIS:

The Constructed Geometry in the solid thinking inspire was further tested for the Stiffness aspects.

Stiffness Aspects Considers Bending and Torsion.

2.5.1 Bending Analysis:

In the middle of the chassis the concentrated loads of the magnitude 750N was applied and the SPC given at four different corners of the chassis.

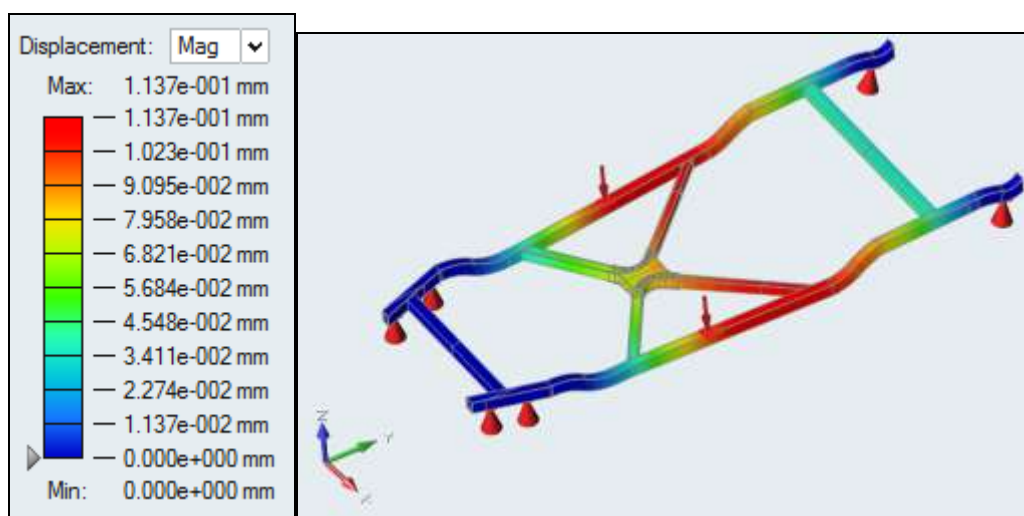


Fig. 6: Displacement results in Bending Analysis

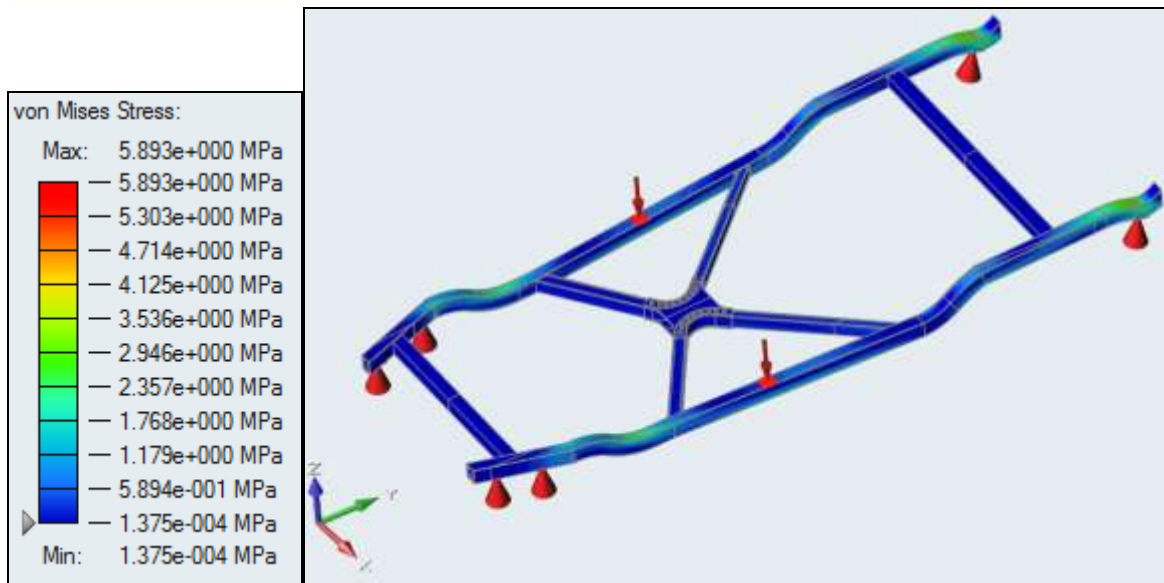


Fig. 7: Stress results in Bending Analysis

The displacements and stress results in the Fig. 6 & Fig.7 is well within the limit max. displacement is only 0.01137mm and max. stress is only 5.893Mpa respectively. Stresses in the model are well within the yield strength of the Material.

2.5.2 Torsion Analysis:

The loads appear in the deck are of magnitude 3296N each. The SPC are three at different locations as shown in Fig. 8.

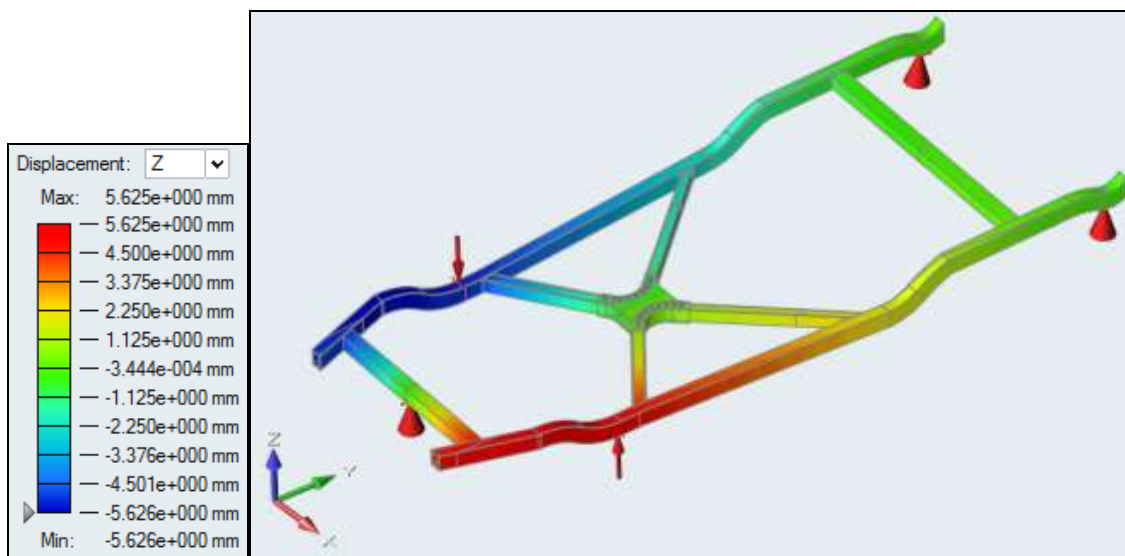


Fig. 8: Displacement results in Torsion Analysis

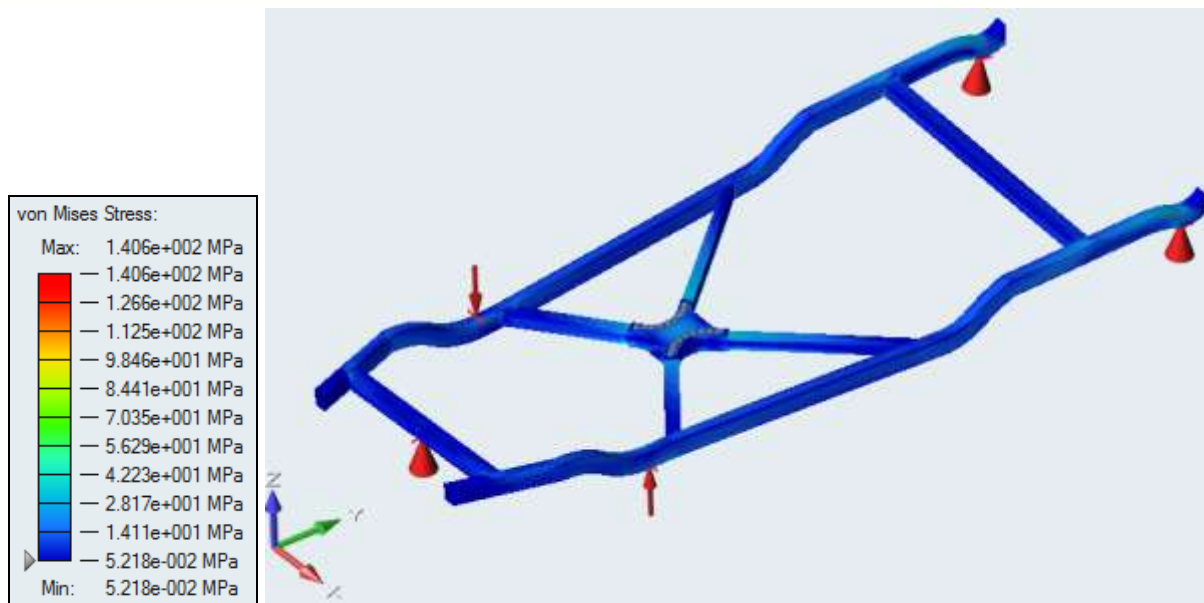


Fig. 9: Stress results in Torsion Analysis

Results in the above Fig. 8 and Fig. 9 shows the displacements and stress in the torsion analysis respectively. Max. displacement in the torsion analysis is 5.624mm only and von mises stress max is 140.6Mpa which is within the yield limit of the steel (YS=210Gpa)

V. CONCLUSIONS

Topology optimization may be of single step optimization or multi step optimization. In this paper, the chassis model is extracted from the single step optimization. It can be possible to go more in topology optimization for refining optimized results. But in this paper, in first step only the results are interpreted for constructing the geometry in the solid thinking and modelled geometry is further tested according to the different aspects or different loading conditions.

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