Analysis of Front Suspension Bracket under Pretension and Service Load

Nagesh S.[1] Sudindra S.[2]
[1]PG Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]AMC Engineering College, Bangalore

Abstract— Automotive chassis is the back bone of an automobile, which acts as the frame to support the body and other different parts viz., bumper, front suspension bracket, engine mount bracket, fuel system, etc., of the vehicle. Chassis frame and bracket are the most critical element that gives strength and stability to the vehicle under different conditions. So the frame as well as brackets should be strong so that it can withstand shocks, twists, stresses and vibrations to which it is subjected while vehicle is moving on road. Thus strength and stiffness are the two important design considerations. Frame and brackets are connected by using welding as well as bolts and nuts. The main function of the front suspension bracket is to properly balance and transmission on the vehicle chassis, suspension bracket is an important part of the vehicle to reduce the vibration and noise, by which smooth ride of the vehicle can be achieved. Vibration and strength of suspension bracket has been continuously a concern which may lead to structural failure if the resulting vibration and stresses are severe and excessive. Present work mainly focused to select the best material for the front suspension bracket of the automobile. Non-linear static analysis is carried out on the bracket to determine the behaviour i.e., Stress and Displacement for different material. ex-mild steel, aluminium and cast iron. Bolt slippage calculation is considered here to know the friction co-efficient between bolts and nuts. Since it is easy to analyze structural systems by finite element method, the front suspension bracket is FE modelled using HYPERMESH and the FE analysis is done using the ABAQUS.

Key words: Service Load on Bracket, Suspension bracket

I. INTRODUCTION

In this automotive era the need for light weight structural materials is increasing as there is a more focus on fuel consumption reduction and improvement in decreasing the emission. The magnitude of production volumes has traditionally placed severe requirements on the robustness of process used in the manufacturing. The manufacturers have strong importance on the cost has the demand for the component to improve the material performance and to deliver these materials at low cost is the requirement. There are number of vibrations and noise equipment's which affect the vehicle body. Due to uneven roads and by bad suspension, vibration and noise are generated in a vehicle body, which will result in the high frequency. The noise and vibration generated by the equipment's is transferred to the vehicle body points. Body attachment stiffness plays a vital role for performance improvement. Due to disturbance from the road and engine at idle, usually below 30 Hz frequency is developed. To reduce and control the vibrations suspension bracket should be stiff.

Suspension bracket is one of the most important components of a road vehicle such as car. High performance sports car has their suspension supported by bracket. It plays an important role in improving the comfort & work environment of a car. The improvement of suspension bracket system has been the subject of intense interest for many years. It is necessary to design proper suspension bracket for a car. As such, bracket has been designed as a framework to support suspension. Vibrations and fatigue of bracket has been continuously a concern which may lead to structural failure if the resulting vibrations and stresses are severe and excessive. Prolonged exposure to whole-body vibration in the working environment may lead to fatigue and in some cases it damages the car.

The suspension system supports the weight of the vehicle and provides for a smoother ride for the driver and passengers. But suspension systems also protect your vehicle from damage and play a critical role in maintaining safe driving conditions. A well-functioning suspension system shields a vehicle from excessive wear and potential structural damage associated with prolonged exposure to bumps and pot holes but also keeps the wheels pressed firmly to the ground for traction. Spring mass (weight) refers to vehicle parts supported on the suspension system, such as the body, frame, and engine. The spring weight typically includes the body, frame, the internal components, passengers, and cargo. By contrast, unspring weight refers to the components that follow the road contours, such as wheels, tires, brake assemblies, and any part of the steering and suspension not supported by the springs. The suspension system isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load. It also must keep the tires in contact with the road. When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the unspring mass at each wheel assembly. The primary function of the suspension system is to isolate the vehicle structure from shocks and vibration due to irregularities of the road surface.

Preload is the tension created in a fastener when it is tightened. The clamp force in an unloaded bolted joint is assumed to be equal and opposite of the preload. If proper preload, and thus clamp force, is not developed or maintained, the likelihood of a variety of problems such as fatigue failure, joint separation, and self-loosening from vibration can plague the bolted joint leading to joint failure.

II. OBJECTIVES

The main objective of this project work is

1) To study the design of existing front suspension bracket.
2) Nonlinear Static analysis is carried out to calculate the maximum principal stress and maximum displacement.
3) Solutions are carried out for different materials for optimize the bracket.
4) Theoretical calculation is done to calculate and compare the first natural frequency of the model.

5) Selection of the suitable variant considering the results and cost.

III. METHODOLOGY

Following methodology adopted to accomplish the objectives written above,

1) Literature survey on the materials for chassis and brackets, design etc.
2) Literature survey on the loads static and dynamic loads on the chassis and the brackets.
3) Literature survey on the FE modelling and Numerical analysis methods.
4) Collection of all the data and regarding material, loading, design etc.
5) Development of 3D models.
6) Exporting 3D model to the preprocessing tool (Hyper mesh).
7) Development of FE models discretizing the surface, applying loading and boundary condition for ABACUS.
8) Enrooting FE model to solver (ABACUS).
9) Solving and plotting the Results.

A. Geometric Modeling

A standard Front suspension bracket is imported from SAE (Society of Automotive Engineers), different views are shown in figure.

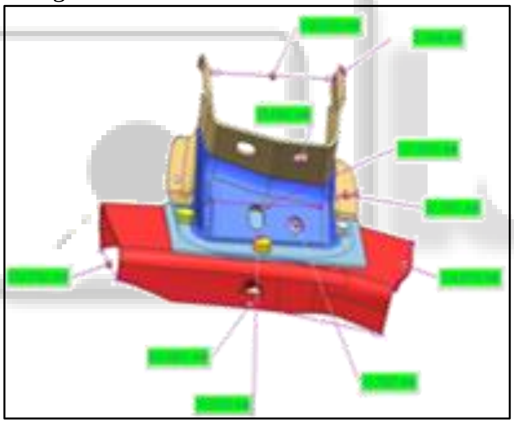

Fig. 1: Isometric view of suspension bracket

B. Materials Properties

Materials used for the analysis of the suspension bracket are and their properties are tabulated in bellow table.

Mechanical Property	Mild Steel	Cast Iron	Aluminium
Young's modulus (Mpa)	2.1e5	1.2e5	0.7e5
Poisson's ratio	0.30	0.28	0.30
Density(kg/mm^3)	7.89e-9	7.20e-9	7.75e-9
Yield strength (ey) (N/mm^2)	370	130	210
Ultimate strength (eu) (N/mm^2)	440	220	320

Table 1: Materials and their properties

C. FE Modeling of Suspension Bracket

Elements of Front suspension assembly bracket are modeled with solid and 1D element meshed according to the geometry. Front suspension assembly bracket is meshed using HEXA8, PENTA5 and RBE2. Rigid elements are used at the boundary conditions and for some connections at the fasteners. FE model of the chassis frame of Front suspension assembly bracket is shown. It consists of 21596 nodes, All components are modeled with hexa and penta elements, so we used the solid section property.

Category	Spring elements	Line elements	Surface elements	Solid elements	Rigid elements
Physical behavior	Simple spring	Rod, Bar, Beam	Membrane, Thin plate	Thick plate, Brick	Rigid bar
Symbol					

Table 2: Types of Elements

A three dimensional suspension bracket model has been modelled using non-linear finite element analysis

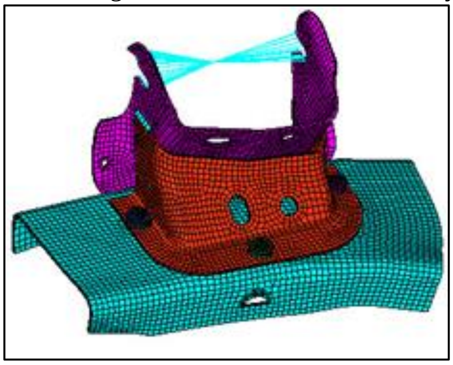

Fig. 2: Meshing of Suspension bracket

D. Loading and Boundary Conditions

1) Boundary Conditions

The proper specification of boundary conditions is just as important for analysis. The improper specification of the boundary conditions leads to incorrect answers. One must constrain the structure on the basis of real model. When static analysis is carried out for a bracket to determine the stress and displacement then chassis frame is constrained.

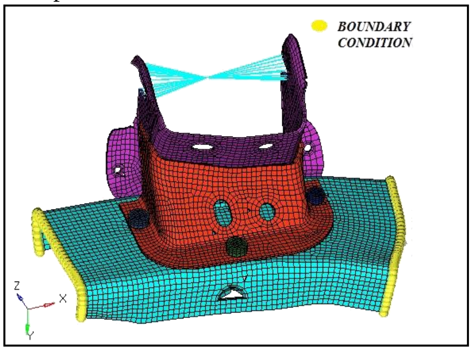

Fig. 3: Boundary Condition of suspension bracket

2) Loading condition for pretension Load on bolt

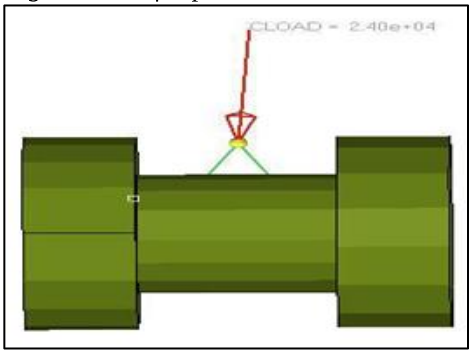

Fig. 4: Pretension Load Applied to M12 bolt

3) Loading condition for service load

a) Load condition in (X- direction)

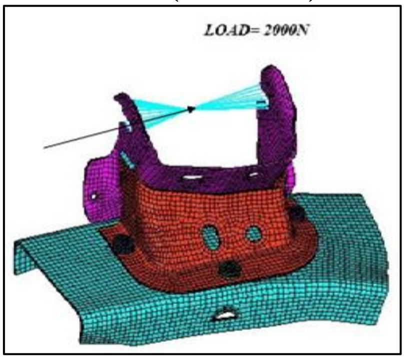

Fig. 5: Service load on bracket in X-direction

b) Load condition in (Y- direction)

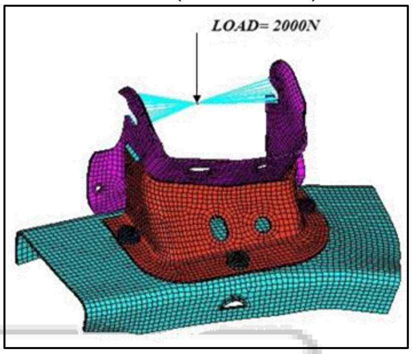

Fig. 6: Service load on bracket in Y-direction

c) Load condition in (Z- direction)

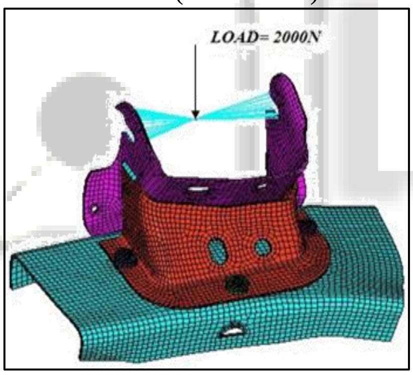

Fig. 7: Service load on bracket in Z-direction

IV. Results and Discussion

A. Maximum Displacement for Different Material by Applying Pretension and Service Load

1) Material-1(Steel)

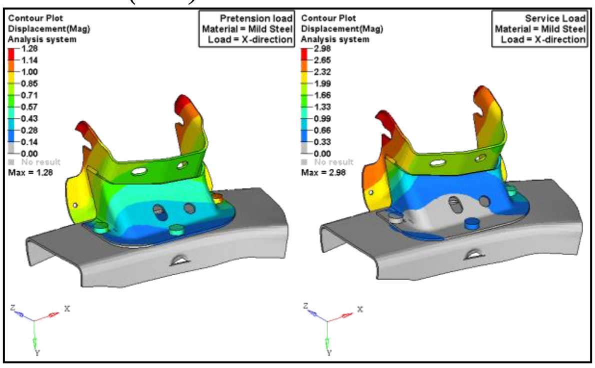

Fig. 8: Displacement of suspension bracket for Steel material by the application of pretension and service load along X-direction.

The above result shows that the maximum displacement for Steel material by the application of pretension loads and service load along X-direction. It is seen that displacement obtained is 1.28mm for pretension load and 2.98mm for service load.

B. Comparison of Displacement for Different Material and Different Direction of Service Load

Material	Load	Displacement	
		Pretension	Service
		mm	mm
Mild Steel	Load_x	1.28	2.98
	Load_y	1.28	3.39
	Load_z	1.28	12.91
Aluminium	Load_x	1.63	5.76
	Load_y	1.63	5.28
	Load_z	1.63	49.07
Cast Iron	Load_x	1.44	4.7
	Load_y	1.44	4.35
	Load_z	1.44	25.18

Table 3: The analysis results by applying the service load for different material

C. Maximum Stress for Different Material by Applying Pretension and Service Load

1) Material-1(steel)

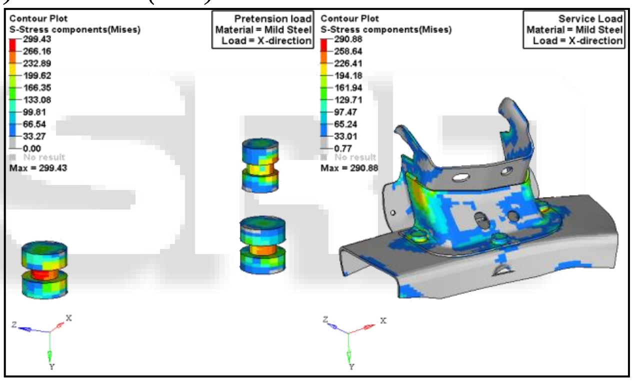

Fig. 9: Stress of suspension bracket for Steel material by the application of pretension and service load along X-direction

The above result shows that the maximum Stress for Steel material by the application of pretension load and service load along X-direction. It is seen that Stress obtained is 299.43N/mm2 for pretension load and 290.88 N/mm2 for service load.

D. Comparison of Stress for Different Material and Different Direction of Service Load

Material	Load	Stress	
		Pretension	Service
		N/mm^2	N/mm^2
Mild Steel	Load_x	299.43	290.88
	Load_y	299.43	290.14
	Load_z	299.43	335.92
Aluminium	Load_x	301.7	300.17
	Load_y	301.7	300.35
	Load_z	301.7	462.21
Cast Iron	Load_x	301.36	298.8
	Load_y	301.36	297.23
	Load_z	301.36	395.06

Table 4: The analysis results by applying the service load for different material

V. Graphical Representations of the Results

A. Comparison of Displacement

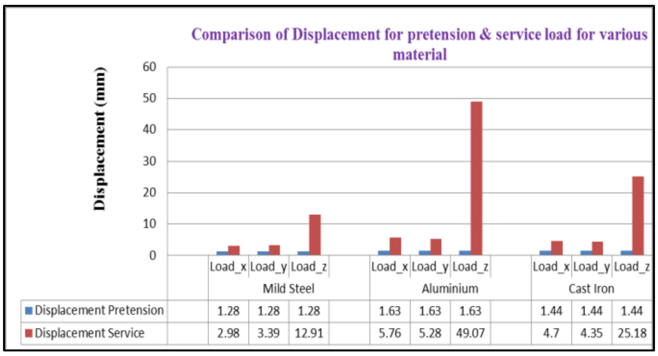

Fig. 10: Comparison of Displacement for Pretension and service load with different materials

B. Comparison of Stress

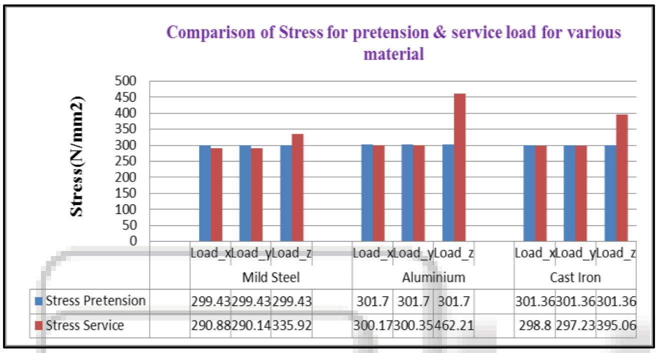

Fig. 11: Comparison of Stress for Pretension and service load with different materials

VI. Slippage Analysis

Due to some loading conditions, slippage occurs in between bolt, front suspension bracket and Frame(chassis). Obtaining CFSM and CFNM values calculate the Frictional strength .If CFSM is greater than Frictional strength means slippage occurring, to overcome from this problem, change the material and do the iterations to avoid the slippage between bolt, front suspension bracket and Frame(chassis) In this project slippage analysis carried out for six cases, namely for

1) Bolt-1 top face and top of front suspension bracket = Contact pair(Cp)-1
2) Bolt-1 bottom face and bottom of frame(chassis)= Contact pair(Cp)-3
3) Bolt-2 top face and top of front suspension bracket = Contact pair(Cp)-4
4) Bolt-2 bottom face and bottom of frame(chassis)= Contact pair(Cp)-5
5) Bolt-3 top face and top of front suspension bracket = Contact pair(Cp)-6
6) Bolt-3 bottom face and bottom of frame(chassis)= Contact pair(Cp)-7

And finally check out whether slippage occurring in any of cases.

VII. Conclusion and Future Scope

A. Conclusions

- The displacement of Mild steel (1.28mm) is less when compared to aluminium and cast iron, for all the load direction considered.
- The slipping of the bolt can be analysed in the simplest way by changing the friction coefficient, by which it is possible to find the critical condition of slipping. For the loads considered, there is no slippage occurs here.
- Present work mainly focused on the validation of the material for the front suspension bracket of the vehicle.
- Non-linear Static analysis is carried out to determine the displacement and the maximum von-misses stress for the front suspension bracket by changing the three different materials i.e., mild steel, alluminium and cast iron. Among all the materials considered, maximum stress obtained for mild steel is lesser than yield point, hence mild steel is considered as better material to design front suspension bracket.

B. Future Scope

1) Fatigue life estimation of front suspension bracket by numerically using different simulation software's.
2) By reducing the thickness of front suspension bracket analysis can be carried out to gain better efficiency of the vehicle.
3) Scope to carry out the dynamic analysis such as modal frequency response, transient response analysis etc, for better correlation with real world.

References

[1] Umesh S. Ghorpade, d. s. chavan, vinaay patil & mahendra gaikwad, "Finite element analysis and natural frequency optimization of suspension bracket" (IJMIE) ISSN No. 2231 –6477, Vol-2, Iss-3, 2012.
[2] Mr.Pramod Walunje Prof. V.K. Kurkute, "Engineering Optimization of suspension Bracket Using FEA" Indian Journal of Research ISSN - 2250-1991 Volume : 2 | Issue : 12 | Dec 2013.
[3] Pavan B. Chaudhari, Dr.D. R. Panchagade "Comparison of Magnesium, Aluminum and Cast Iron to obtain Optimum Frequency for suspension Bracket using Finite Element Analysis" (IJERA) ISSN: 2248-9622 Vol. 2, Issue 5, September- October 2012.
[4] A.S.Adkine, V.S.Kathavate, G.P.Overikar, S.N.Doijode, "Static Behaviour of suspension bracket" International Advanced Research Journal in Science, Engineering and Technology ISSN (Online) 2393-8021Vol. 2, Issue 4, April 2015.
[5] Monali Deshmukh, Prof. K.R.Sontakke "Bracket Analysis and Optimization of suspensiom" (IJSER) ISSN (Online): 2347-3878 Volume 3 Issue 5, May 2015.
[6] Dr.Yadavalli Basavaraj, Manjunatha.T.H, "Design Optimization of Automotive suspension System" International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734. Volume 2 Issue 3 March 2013.