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DESIGN, DEVELOPMENT AND ANALYSIS OF ELLIPTICAL SPRING CAB MOUNT

#1Mr. Patil Kiran P, #2Prof. B.D.Patil

#1PG Students Department of Mechanical Engineering, Savitribai Phule University
1kpp03008@gmail.com
#2Professor Department of Mechanical Engineering, Savitribai Phule University
2bdppvpit@gmail.com
TSSM's
PADMABHOOSHAN VASANTDADA PATIL INSTITUTE OF TECHNOLOGY, BAVDHAN
PUNE, MAHARASHTRA, INDIA.

ABSTRACT

A Cab mount is an application segment that attach the cabin to the chassis or frame of a vehicle. The Cab is connected to the Chassis or frame by several mounts, which are important for smooth operation of the Vehicle. The Cab mount must hold the cabin in place and to restrain cabin on vehicle chassis or frame. Project work is focused on design and weight optimization of cab mount. Since the composite material has high strength to weight ratio, good corrosion resistance. Part Design & Static analysis of cross type elliptical leaf spring mount using Ansys & CATIA V5 software. The dimensions of an existing conventional steel leaf spring of a Light design calculations. Here in this work an analysis is done on cross type elliptical cab mount and it observed as opportunity for the optimization, hence optimization are performed and the results are satisfactory and within the load bearing capacity of respective materials.

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I. INTRODUCTION

Automotive Passenger & Commercial vehicle with single cabin & double cabin used for industrial, agriculture & goods transport purpose, extended driving hours & severe working condition due to increased number of vehicles & Complex ride behavior rough road condition demands for good ride and comfort. The ride vibration has significant influence on Occupants in cabin. The Cab mount must hold the cabin in place and to restrain cabin on vehicle chassis or frame. In order to overcome the defects in the cab mount it need to be optimized and the same has been shown in this work. The cab mount or motor mount assembly is complex joint, rubber bushing on top & bottom side of the chassis bracket connect with bolt & nut. Commonly used mounts for Vibration isolation are Elastomeric mount, hydro mount, Metal mount Cab/Cone mount, along with buffer stop and bushes. These mounts are conventionally used in engine, motor & Cab mount. Frequency of the vibration depends on the road load conditions & engine noise, Higher frequency range is commonly observed when bad road conditions & relative motion between cabin & chassis. These high frequency vibrations are major source of discomfort when vehicle sudden braking, bumping & turning, due to wearing of rubber bushes & compact structure of mount which covered by rubbers. Noteworthy work has being done in region of cab mount vehicle motor yet very little research is found in the Cross type elliptical mount.

Here these type of mount not found in Automotive cab mounts Hence in our endeavor we will build up a composite half elliptical spring mount and to a relative report to regular spring mounts accessible in market for same application. Diverse sorts of Cab mounts are utilized in vehicles. Elastic mounts (or elastomeric mount) are minimal effort and the most straightforward sort of mounts.

A. Problem Statement

- To analyse the performance of elliptical Spring Cab Mount.
- Optimize the current design of elliptical spring cab mount.
- Test the static performance for elliptical spring cab mount.
- Study the design analytically, numerically

B. Objective of work

- Design and development & Optimization of elliptical spring for Cab mount.
- Fabrication of elliptical spring mounts from spring steel EN 9 and SS-304 material

- Comparative analysis of the performance of the cabin with application for each spring.

II. METHODOLOGY

In our attempt to design a special purpose device we have adopted a very careful approach, the total design work has been divided into two parts mainly;

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the chassis frame of the vehicle no of controls position of these controls ease of maintenance scope of further improvement

In Mechanical design the components are.

- Design parts
- Standard Fasteners

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work.

In Automotive this type of Elliptical leaf spring mount used in shipping, Protects naval equipment (propulsion, combat systems, auxiliary systems) from underwater shock and whipping events application.

Figure 1

(Type PSM) from Advanced Anti-vibration Components.

a. DFME

The design failure mode and effect analysis (DFME) technique was carried out for current study to identify, prioritize and eliminate potential failure from the system, design or process before they reach the customer as it provides a disciple for documenting the analysis for future use and continues process improvement. Generalised failure modes can occur while testing the component by the organisation and the other testing agencies. Further, design validation plan is a tool that document the plan that will be used to confirm that a product, system or component meets its design specification and performance requirement. These both techniques are used for the development of any component from the concept to the final product.

Fig. 2 DFME

b. Design Optimization & Packaging in vehicle.

Packaging study of cross type elliptical leaf spring concept in place of conventional rubber mount with Minimum modification in the mating parts from Underbody floor & validate the same in between Chassis Frame & Cabin in vertical direction. Refer below figure Packaging View of conventional rubber mount

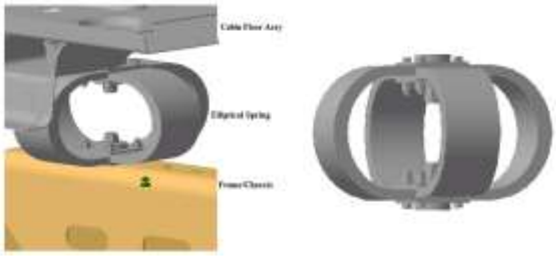

Fig. 3 Elliptical Assembly Packaging

III. DESIGN OF COMPONENTS OF ELLIPTICAL SPRING ASSEMBLY

Material chose for the frame spring is SS304 (2mm) thick and Polyurethane material as filler in the sandwich spring. The two materials are impenetrable to erosion and will work productively under extensive variety of temperature. Fundamental structure utilizes two high pliable hardened steel SS 304 shaped leaves on each favor the polymer sheet of 6 to 8 mm thickness sandwiched between them.

Table 1 Material Properties

Designation	**Component**	**Tensile Strength**	**Yield Strength**
		N/mm^2	**N/mm^2**
NYLON 66	Bush	55	40
EN 9	Plate	600	480
SS304	Leaf	505	215

a. Design of top mounting plate

Vehicle cabin Weight is 160Kg & Number of mounts used is 2 on LH & 2 on RH side.

As Per ASME Code;

Top plate is subjected to direct compressive load under the action of weight of the cabin and accessories which is not to exceed 40 kg

Hence the load on bush = Total load/ No of plates

No of bushes = 4 (top and bottom plates included)

Hence load on top plate = 10kg

Direct Tensile or Compressive stress due to an axial load

F act = W

Actual Area of mounting plate where the force acts,

A act = L x W - [π/4 x (D^2) + 4{π/4 x (d^2)}]

σact = 0.688 N/mm2

As f act < f all, Hence Design is safe.

b. Design of top mounting plate (Optimized)

As Per Assembly requirement & Weight reduction top mounting Plate Design Optimization done for leaf assembly Fitment.

As Per ASME Code;

Direct Tensile or Compressive stress due to an axial load

F act = W,

Actual Area of mounting plate where the force acts,

A act = L x W - [π/4 x (d^2) + 4{π/4 x (d^2)}]

σact = 0.867 N/mm2

As f act < f all, Hence Design is safe

c. Design of top Bush

Material selection:-

Ref:-PSG Design Data. Pg.no.1.10, 1.12 & 1.17

σs allowable = 55/2 = 27.5 N/mm2

Bush is subjected to direct compressive load under the action of weight of the cabin and accessories which is not to exceed 40 kg

Hence the load on bush = Total load/ No of bushes

No of bushes = 4 (top and bottom bush included)

Hence load on top bush = 10kg

Direct Tensile or Compressive stress due to an axial load:-

F act = W

Actual Area of Bush where the force acts,

A act = $(\pi/4) \times (D^{2}-d^{2})$

σact = 0.926 N/mm2

As f act < f all, Hence Design is safe.

d. Design of Leaf

As Per ASME Code;

Top Leaf is subjected to direct compressive load under the action of weight of the cabin and accessories which is not to exceed 40 kg

Hence the load on Leaf = Total load/ No of Leaf

No of Leaf = 4 (LH and RH included)

Hence load on top plate = 10kg

Direct Tensile or Compressive stress due to an axial load

F act = W

Actual Area of Leaf where the force acts,

A act = $[2 \times \{L \times W\} - 4\{\pi/4 \times (D^{2}+d^{2})\}]$

σact = 2.32 N/mm2

As f act < f all, Hence Design is safe.

IV. FEA

All the components are modelled and assembled in CATIA V5 software. Component like bush, leaf and mounting plate are imported in ANSYS workbench software for static analysis & Assembly level static analysis done in Structural module of CATIAV5.

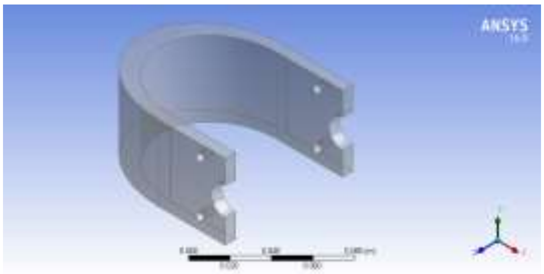

Fig. 4 Model Elliptical leaf

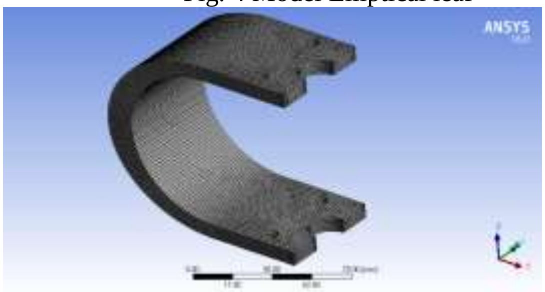

Fig.5 Meshing of Elliptical Leaf

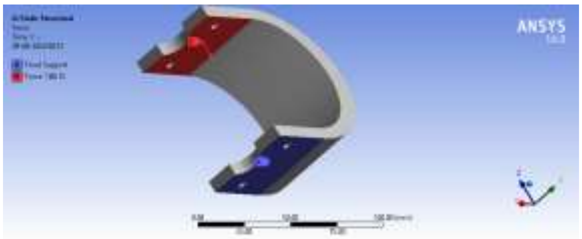

Fig. 6 Boundary Condition (Fixed Bottom Face/Edge)

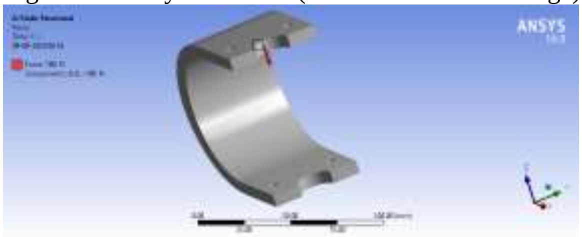

Fig. 7 Boundary Condition (load on Upper Face of Leaf)

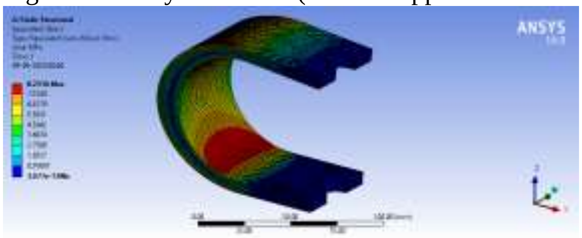

Fig. 8 Equivalent Stresses on Leaf

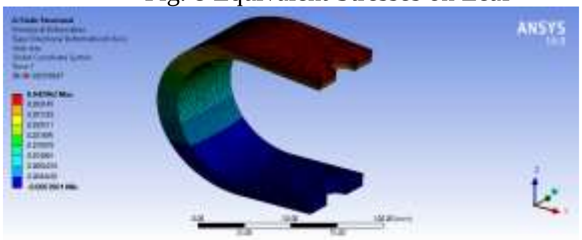

Fig. 9 Displacement of Leaf

The fine meshing was done and boundary conditions are applied.100N load was applied on top face of the elliptical leaf while bottom face made as fixed. After solving the problem equivalent stress (Von mises stress) are calculated which are shown in Fig 8. The Stress value is 8.25 N/mm2.

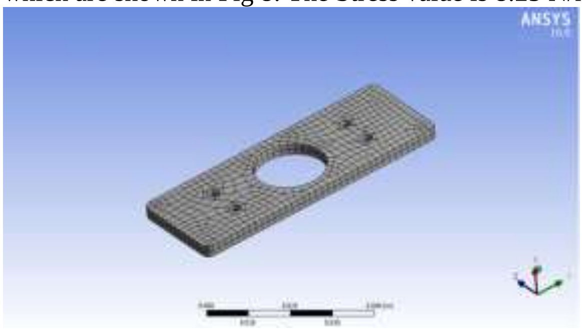

Fig.10 Meshing of Plate

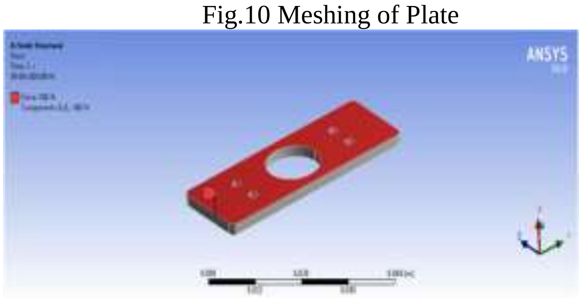

Fig.11 Boundary Condition (load on plate)

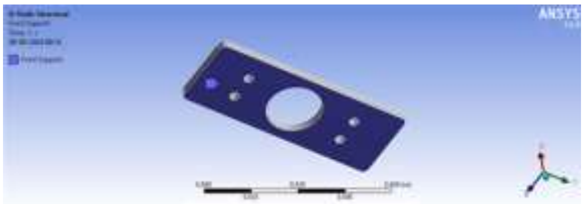

Fig. 12 Boundary Condition (Fixed Bottom surface)

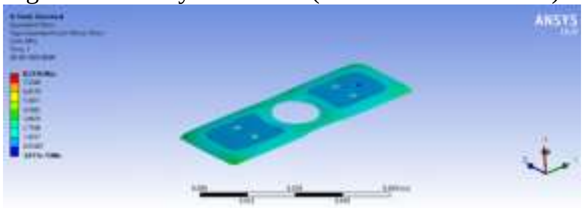

Fig. 13 Equivalent Stresses on Plate

The fine meshing was done and boundary conditions are applied. 100N load was applied on top face of the plate while bottom face made as fixed. After solving the problem equivalent stress (Von mises stress) are calculated which are shown in Figure 13. The Stress value is 1.12 N/mm2

As Per Assembly requirement & Weight reduction top mounting Plate Design Optimization done for leaf assembly.

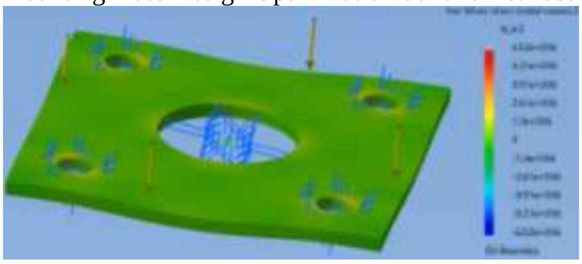

Fig.14 Equivalent Stress on Plate (Optimized)

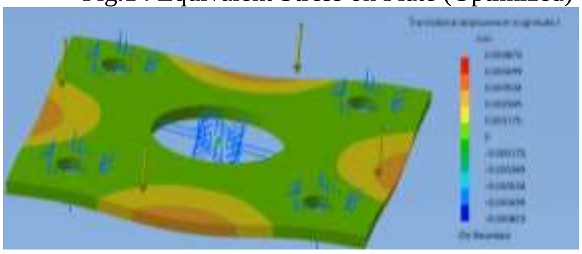

Fig.15 Deformation of Plate (Optimized)

The model of plate was created in CATIA software and imported in CATIA Structural workbench software. The fine meshing was done and boundary conditions are applied. 100N load applied on top face of the plate while bottom face made as fixed. After solving the problem equivalent stress (Von mises stress) are calculated which are shown in Fig. 14. The Stress value is 1.10 N/mm2

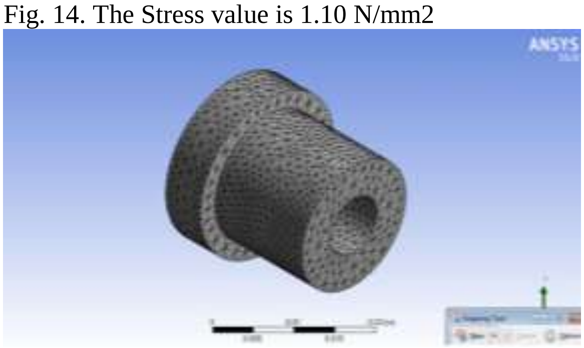

Fig. 16 Meshing of Bush

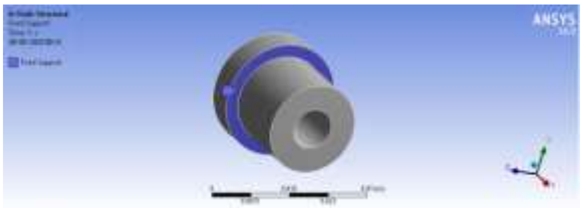

Fig.17 Boundary Condition
(Fixed Bottom Face/Edge of Bush)

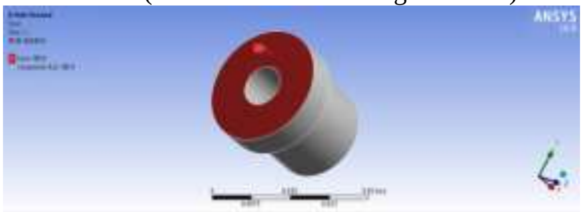

Fig. 18 Boundary Condition
(Load on Upper Face of Leaf)

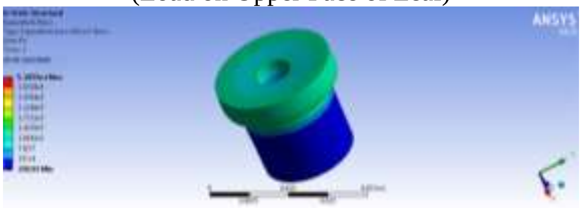

Fig.19 Equivalent Stresses on Leaf

The fine meshing was done and boundary conditions are applied. 100N was applied on top face of the bush while bottom face made as fixed. After solving the problem equivalent stress (Von mises stress) are calculated which are shown in Figure 19. The Stress value is 1.10 N/mm2.

Analysis of Elliptical Spring Assembly

Assembly level analysis carried out in CATIA structural Analysis Workbench 40 Kg load was applied on the Assembly SS304 Material is used for Elliptical Spring, Plate & Bush material is as per Table 1.

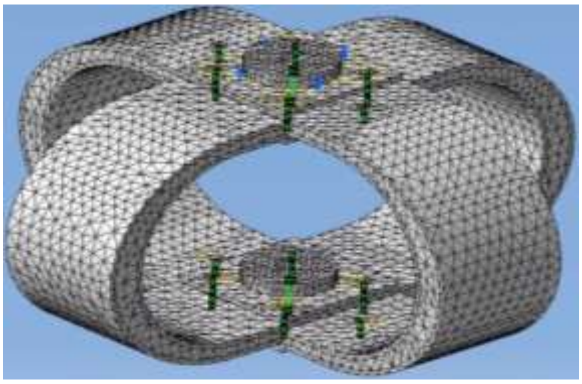

Fig.10 Meshing of Elliptical Leaf

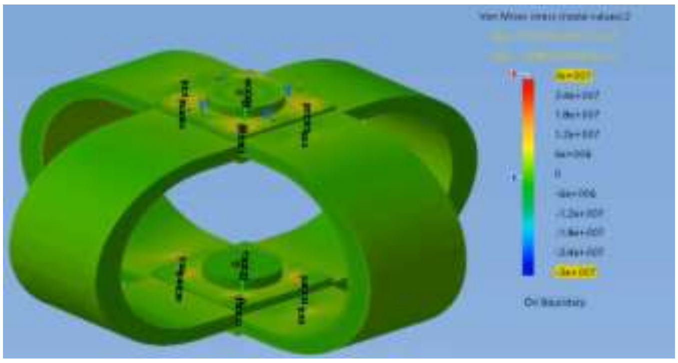

Fig.10 Equivalent Stresses on Leaf

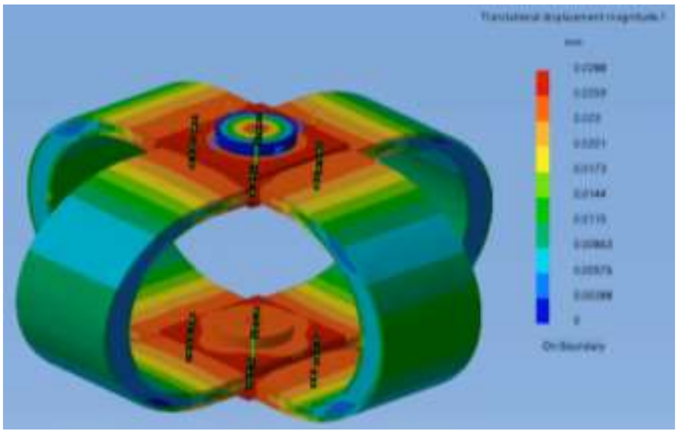

Fig.11 Displacement of Assembly Elliptical Leaf

Assembly level Static analysis carried out in CATIA structural Analysis Workbench Software. The fine meshing was done and boundary conditions are applied. 400 N load was applied on top face of the Assembly while bottom face made as fixed. After solving the problem equivalent stress (Von mises stress) are calculated which are shown in Figure 30. The Stress value is 30 N/mm2.

V. RESULT & DISCUSSION

TABLE 2

Sr No	Part Name	Theoretical Maximum stress N/mm2	Equivalent Von-mises stress N/mm2	Maximum deformation mm
1	Top Plate	0.688	1.12	0.009
2	Top Plate (Optimized)	0.867	1.1	0.008
3	Top Bush	0.926	1.1	0.007
4	Elliptical Leaf	2.32	8.25	0.042
5	Elliptical Leaf Assembly (for 4 leaf and 40kg load)	NA	30	0.0288

Elliptical leaf spring was designed and optimized in this work. The stiffness of the leaf spring must be so controlled that spring deflects to specified values during the bumpy surface so that shock will not be transmitted to the vehicle body. The leaf spring should have required fatigue strength to withstand the repeated loads arising due to bumpy surface. In this work, a procedure for designing an Elliptical leaf spring is formulated considering the constant force. Finite Element Analysis has been done in the created model, for the maximum load of 40 Kg for whole assembly. The maximum stresses are found, and it is compared in Table-2 which is within the allowable limit.

VI. CONCLUSION

A procedure to design, development of cross elliptical spring for cab mount has been established. Leaf spring made up of SS304 & mounting bracket bush and leaves has been assembled with minimum modification in the mating parts from Underbody floor & validate the same in between Chassis Frame & Cabin in vertical direction in CATIA. The Finite Element Modeling presented in the analysis is able to predict the stress distribution. When maximum load is applied on the elliptical leaf spring, the maximum stress is within the allowable limit.

a) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the Top bush is safe

b) Top bush shows negligible deformation under the action of system of forces.

c) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the top plate is safe

d) Top plate ring shows negligible deformation under the action of system of forces

e) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the elliptical leaf is safe

f) Elliptical leaf shows negligible deformation under the action of system of forces.

g) Assembly Elliptical leaf spring shows negligible deformation under the action of system of forces

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