"Buckling Analysis of Tie Rod of a Tractor and Its Optimization"

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ABSTRACT

A tie rod is a slender structural rod in the automobile steering system and it is capable of carrying tensile and compressive loads. Tie rod may fail due to compressive loads through buckling. Instability of vehicle may be caused due to failure of tie rod. So it's important to check the strength of tie rod. The load on tie rod is mostly compressive. In this paper we are going to do the finite element analysis of the existing tie rod of the tractor and will compare those with the FEA results of optimized tie rod. All the measures will be taken to improve the strength of the tie rod. 3D modeling of a tie rod is done in CATIA V5R19. Further, meshing and analysis is done on HYPERMESH (preprocessor) and ANSYS (postprocessor). Optimization of the tie rod will be carried out in iteration with topological changes. Optimized tie rod will be analyzed through FEM. After getting satisfied results a prototype will be fabricated and tested. The two results i.e. FEA and experimental results will be validated.

Keyword : - *Tie rod,buckling,hypermesh*

1.INTRODUCTION

The steering system is the group of parts which transmit the movement of the steering wheel to the front wheels. The primary purpose of the steering system is to allow the driver to guide the vehicle. The steering system of a vehicle is made of three major parts: the steering box, the suspension parts and the steering linkage. The steering box connects to the steering wheel, the suspension parts pivot the wheel assembly, and the steering linkage connects the steering wheel to the front wheels. The main function of the steering linkage is to transmit the movement to the front wheels.

In this paper we have undertaken, we are going to do the finite element analysis of the existing tie rod within the boundary conditions under compressive load. The finite element analysis will give us the stress concentration regions which will help us in optimizing the design of the tie rod. Based on these FEA results, tie rod will be modified for different cross sections and topology. Then this modified design of tie rod will be analyzed through FEM for different topological changes in iteration. This iterative approach will give us the optimum design. Optimized design of a tie rod will be fabricated and will be tested experimentally on UTM to validate the FEA results.

2.LITERATURE REVIEW

1. Raghavendra K [1] carried study on Buckling analysis of tractor tied rod subjected to compressive load to analyze tie rod for active to improve the mass and buckling load of tie rod and conducted theoretical, experimental and modal analysis of tractor tie rod to find different modes shapes by FEA.He concluded that mild steel SAE 1020 ITR 2 gives better result.
2. Manik A Patil [2] studied on FEA of tie rod of steering system of car with FEA analysis of rod of a car and found natural frequency. He concluded that tie rod undergoes continuous vibrations when vehicle is running. Hence natural frequency was calculated and suitable material was suggested.

3. Pradeep Mahadevappa Chavan [3] conducted research on Performance evaluation of passenger car tie rod with different materials and concluded that carbon steel rod is more suitable than cast iron.
4. Msc. Ismar Alagic [4] studied FEM simulation of tie rod tensile test and sufficiently accurate stress distribution and displacement distribution of tie rod assembly have been obtained through tensile test.
5. Ganesh b Baraskar [8] studied Performance evaluation of tie rod in suspension system of a car using FEA and assess buckling performance of tie rod for different dimensions and different materials.

3.PROBLEM SPECIFICATION

Conventional design of tie rod is more prone to stress region which results in crack and breakage after some time of operation due to non-optimized design and selection of wrong material, A tie rod can be design in different section profiles and has a lot of scope for topology structural and material optimization, Thus finding location of stress concentration region which results in breaking of tie rod and Design optimization for tie rod to find the optimum design solution can be done by calculating the forces acting on the component and finding out the optimum solution for better designed tie rod.

4.EXPERIMENTAL SETUP

The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. When the machine is on it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen.

5.FINITE ELEMNT MODELLING OF TIE ROD

5.1Linear Static Analysis of Tie Rod: (Existing Tie Rod)

*   Material   – Steel SM45C
*   Cross-section   – Circular

5.2 Calculation of Forces:

The earth's gravitational pull (F_{CG}) acts through the center of gravity and the reaction (remember: to every action there is an equal and opposite reaction) acts through the contact patches between the tyres and the road.

Max compressive force acting on tie rod

= Force required to steer wheel

= Reaction at one front wheel x Static frictional coefficient

= 3283.285 x 0.9

= 2954.96 N ~ 2955 N

5.3 Boundary Conditions:

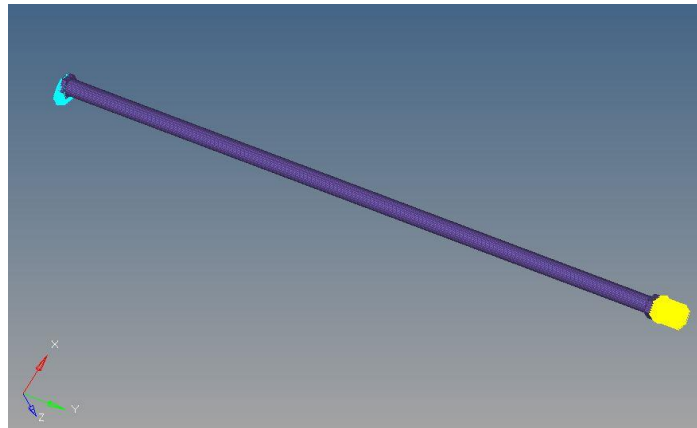The boundary conditions applied are as shown below.

Fig.1. Boundary condition

5.4 FEA Results:

The linear static analysis is carried out in Hypermesh (pre-processor) and Ansys (post-processor) to check the stress and deformation in the tie rod under load. The results are plotted as shown below.
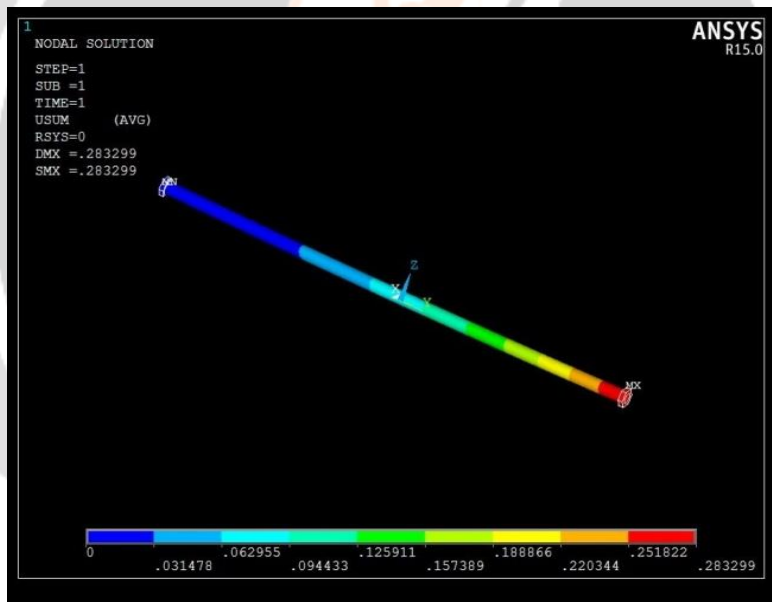

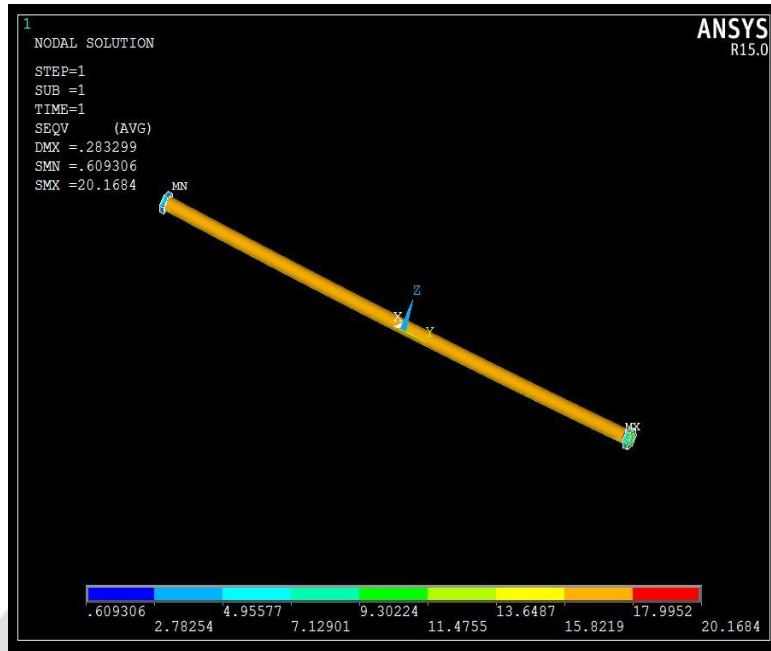**Fig.2.** Deformation Plot
The maximum deformation is 0.283299 mm

Fig.3. Von-mises stresses
Maximum stress 20.1684 MPa

Above are the FEA results for existing tie rod under compression loading. The induced von misses stress in the tie rod is 20.1684 MPa and the deformation is 0.283299 mm. These values have shown that the stress is within permissible limit and the deformation is also less. In the next part of the project, we will work on different cross sections with Aluminium and Steel as material.

Table.1. Comparison of FEA Results

Sr. No.	Cross-section	Material	FEA Results	
			Stress (MPa)	Deformation (mm)
1	Circular	Steel SM45C	20.168	0.2833
2		Aluminium	19.859	0.8608
3	Square	Steel SM45C	18.445	0.2175
4		Aluminium	18.384	0.6230
5	**Hexagonal**	**Steel SM45C**	**17.213**	**0.0893**
6		**Aluminium**	**17.097**	**0.2714**

- Above is the summary of all the FEA work performed.
- From the table above it can be concluded that the hexagonal cross section has better results among all three cross sections analyzed.
- Aluminum hexagonal tie rod has stress (17.097 MPa) lower than the stress (17.213) in steel hexagonal tie rod.
- The deformation in Aluminum hexagonal tie rod (0.2714 mm) is slightly higher than the deformation in steel hexagonal tie rod (0.0893 mm).

6.WEIGHT OF TIE RODS: (From CATIA)

Table.2 The weight comparison of tie rods

Sr. No.	Cross-section	Material	Weight (kg)
1	Circular	Steel SM45C	1.332
2		Aluminium	0.459
3	Square	Steel SM45C	2.058
4		Aluminium	0.710
5	**Hexagonal**	**Steel SM45C**	**1.593**
6		**Aluminium**	**0.549**

7.Comparison of FEA and Experimental Results

Table.3. FEA and Experimental result

Sr.No.	Deformation		Error (%)
	FEA Result	Experimental Result	
1	0.27	0.3	10

8. CONCLUSION

We have observed that the stress in aluminium tie rod is less than the stress in tie rod Steel SM45C, but the deformation in aluminium tie rod is slightly higher than Steel SM45C tie rod .

Though the deformation in aluminium tie rod is higher, the weight of aluminium tie rod (0.549 kg) is way too low as compared to the weight of Steel SM45C tie rod (1.593 kg).

Hence our final conclusion is that the tie rod , which has hexagonal cross section and Aluminum material is optimum design extracted through FEA.

Thus from experimental result the deformation will be 0.30 mm with 10 percent error.

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