Analysis of Axle Tie Rod using Finite Element Analysis

Mr Akhilesh Kumar Gupta[1],
Ashutoshkumar Dubey[1], Akash Mishra[2],Manish Pareek[3],Paras Panchal[4]
Assistant prof.,Mechanical Department,ARMIET,Shahapur
BE Student,ARMIET,Shahapur

***Abstract*—** the primary function of Tie rod is to keep the wheel in aligned position and to transmit the motion. Structural performance of any mechanical component is measured basically in terms of its deformation stress stiffness, natural frequency, fatigue life etc. In this paper FEA analysis is used to check stress and deformation of Tie rod .When steering turn the vehicle, tie rod mostly comes under compressive load and when vehicle running on rough road there is fluctuating forces which act on the Tie rod. in this paper static analysis is done.

Key words: Static Analysis of Tie Rod using Ansys.

I. INTRODUCTION

Tie rod is a part of steering mechanism that serves as linkage between steering gear and wheels. So it is important that tie rod operates reliably severe working conditions ,and this depends on proper design under such conditions. As shown in Fig. 1. Tie rod is spherical rod with threaded parts having outer and inner ends.

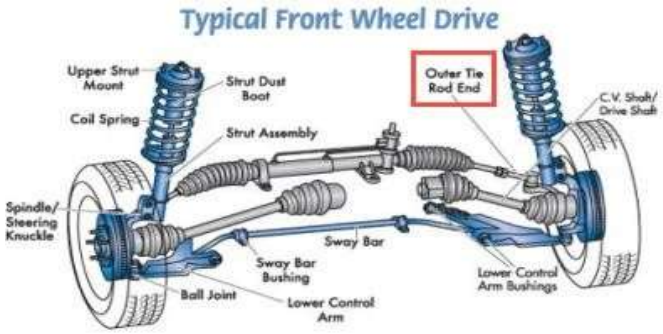


Fig.1. suspension system with inner and outer tie rod.

Tie rods are connected to both ends of steering gear and wheel which helps to pull and push the front tires as the steering wheel is turns. Force from steering gear to the steering wheel is transmitted by tie rod to turn the wheels. Tie rod directs the steering of a vehicle to turn the tire. Tie rod exist in pair in front axle. Tie rod allows cornering and angling of tire without causing much torque on wheel. The failure of tie rod may cause instability of vehicle and cause an accident.so it is important to check the strength of tie rod. The load coming on tie rod is mostly compressive. The effort required when car is moving on the road is comparatively less with stationary car.

Therefore checking the strength of tie rod is very important. If a tie rod end fails a driver will lose the ability to steer and control the vehicle. Tie rods are made thicker at the ends so they will become stronger after threads are cut into it. The point of loading may be altered if the ends are threaded left hand and right hand. Inner end connects to an sleeve which keeps length of tie rod adjustable. This helps to do set angle of vehicle's alignment. Worn tie rod can affect the performance so the suspension system and steering of car should be checked periodically. As the wheel of car is connected to the steering gear, which helps the wheel to turn .

II. LITERATURE REVIEW

Mr. ShripadMungi[1] studied various type of section for the Tie-rod design. His main objective was to optimize the weight. He performed various types of forces acting on tie rod by using finite element analysis tool. This results increase in the critical buckling load carrying capacity. He validated his experimental result by using FEA tool.

Prof. M M Patnaik[2] He compared performance of Buckling of a Tie Rod for different material. He also calculated mode shape, natural frequency, stiffness value and capacity for buckling load for different materials. The author conclude that carbon steel material is suitable for manufacturing of tie rod by comparing it with the cast iron and aluminum alloy material.

Bharat S. Gowda[3] He studied various types of section proposed for design of Tie rod. In this paper author has focused on forces that act on steering system during static condition. different material that are used for analysis are structural steel, grey cast iron etc.

.Purushottam Dumbre[4] Weight reduction of steering knuckle is the objective of this exercise for optimization using FEM software. Steering Knuckle is a non- standard part and subjected to various loads at different conditions. The targeted weight or mass reduction for this exercise is about 5% without compromising on the structural strength.

Manik A. Patil[5] concluded that, through distribution of stress and deformation do not exceed the yield strength value and that there was neither damages nor failure of Tie rod, still correctness and accuracy of computing results was depends on the selection of various modeling parameters. Some of the most important aspect such as boundary conditions or correct mesh and type of elements were performing a decisive role in achieving of correct results. According to deformation, stress and natural frequency result tie rod taking for analysis is safe

III. PROBLEM DEFINITION

IV.

The failure of tie rod may cause instability of vehicle and cause an accident.so it is important to check the strengths of tie rod. The load coming on tie rod is mostly compressive. The effort required when car is moving is comparatively less with stationary car.

The main task in the study is to find the deformation and stresses induced in the tie rod for various material combination. The 3D model is prepared for tie rod. Different types of materials are assigned and FEA analysis is carried out. Also hollow section with specific inner diameter is made for optimization of design.

A. Objectives of the research work

The main Objectives of this paper is

1. To calculate the critical load for tie rod for finding the stresses and deformation.
2. Study and selection of materials for tie rod and suggest the best material.
3. Design the tie rod for weight optimization considering different inner diameters Tie rod.

B. Methodology

In this work, finite element analyses were carried out to

determine the characteristics of the Tie rod. All methodology principles and theories discussed were utilized to achieve the objectives. The combination of all the analysis results were used to develop virtual model created using FEM tools and the model was updated based on the correlation process. The research methodology flowchart for this project was shown in the below fig 2.

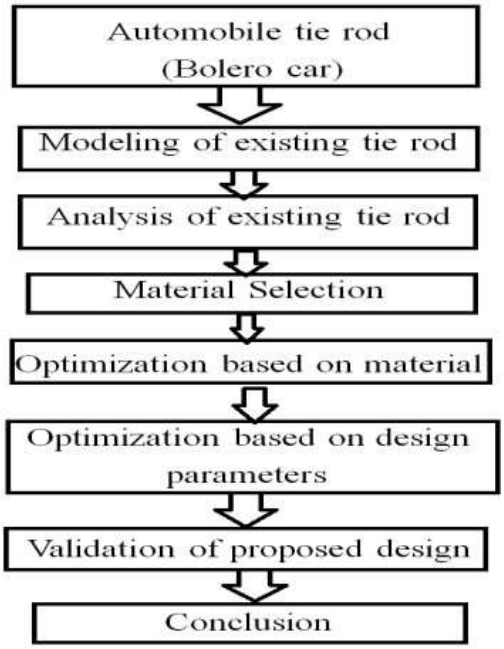


Fig 2. Flow Chart of Methodology Adopted in Research Work

IV GEOMETRICALCONFIGURATION

A. CAD Model

Bolero vehicles tie rod having length 405 mm and diameter is

19 mm. Also it is initially solid. The 2-D CAD model of bolero car's tie rod is considered for analysis. Tie rod drawing with dimension is as shown in Fig.3

2-D Drafted CAD Model

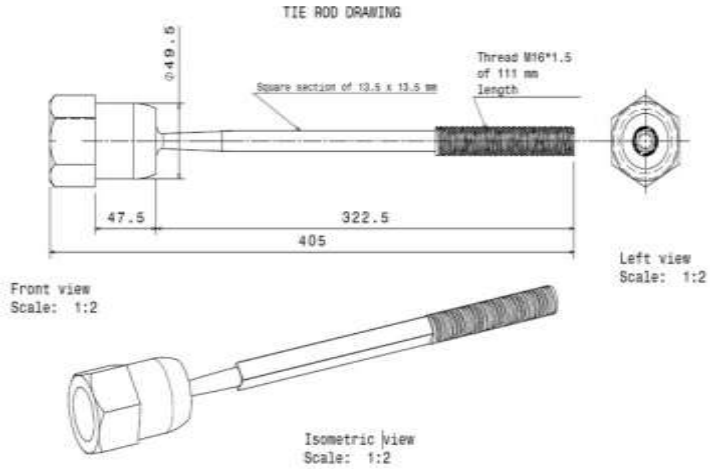


Figure.3. Tie rod drawing

B. Steering movement ratio and Force calculation on Tie rod

The rack and pinion mechanism is designed to transfer the circular input motion of the pinion into linear output movement of the rack.

1. For a full travel of the rack of 130 mm the pinion has to be rotated 3.0 turns.

$$X_0 = \frac{Full\ travel\ of\ the\ rack}{No.\ of\ rotations\ of\ pinion} = 43.33\ mm \quad (1)$$

2. If considered the pinion to make one revolution, the input steering movement is

$$X_i = 2\pi R = 973.89 \quad (2)$$

Where, R = 155 mm is the radius of the steering wheel.

3. And the output rack movement is

$$X_0 = 2\pi r \quad 43.33 = 2\pi r \quad (3)$$

4. Then, the movement ratio (MR) can be calculated as input movement over output:

$$MR = X_i / X_o = 22.48 \quad (4)$$

Therefore the movement ratio is 22.48: 1

In order to know the output load transmitted to tie rod for given input load we needed to know movement ratio.

5. For an effort of 40 N applied by both hands on the steering wheel and considering no friction, the output load will be:

$$F_o = F_i \times MR = 899.2N \quad (5)$$

6. Therefore the load transmitted to the tie rods is 899.2 N.

$$F_{crictical} = 2F_o = 1798.4N = 1800N \quad (6)$$

v.optimization analysis of tie rod for different materials

For this analysis the tie rod with diameter 19 mm and length 405 mm of bolero car is considered. The tie rod is made up of steel material. For material analysis we are considering different materials for FEA.

A. ***Sample Analysis of Steel Tie Rod***

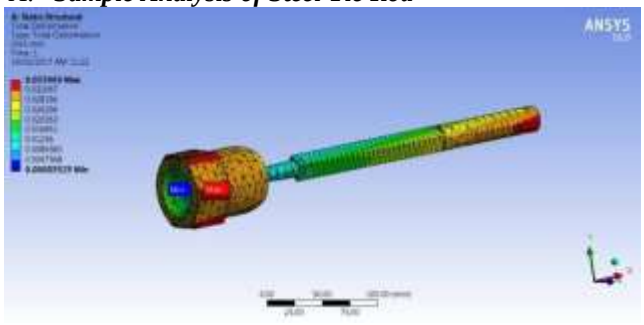


Figure. 4. Result for Deformation

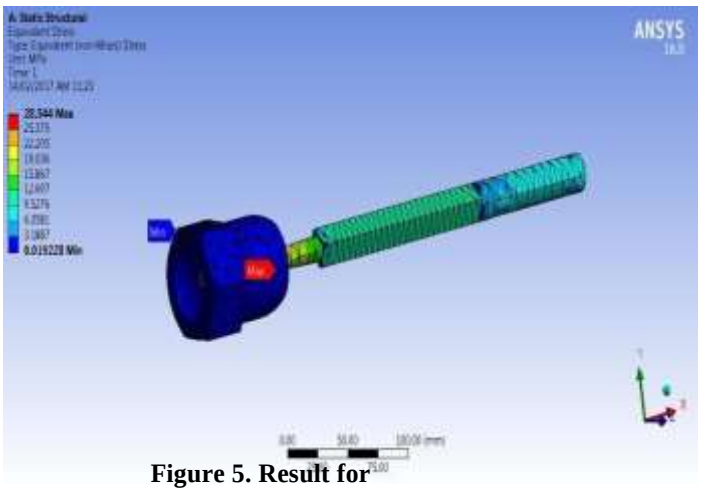


Figure 5. Result for stresses

Similarly analysis is done for various materials and results are Given in below figures.

VI.RESULTS AND DISCUSSION

A. Static Analysis

1. FE Material analysis results From FE analysis of all material their weight, deformation and stresses results are tabulated in following figure 6. And figure 7.

MATERIAL ANALYSIS RESULT

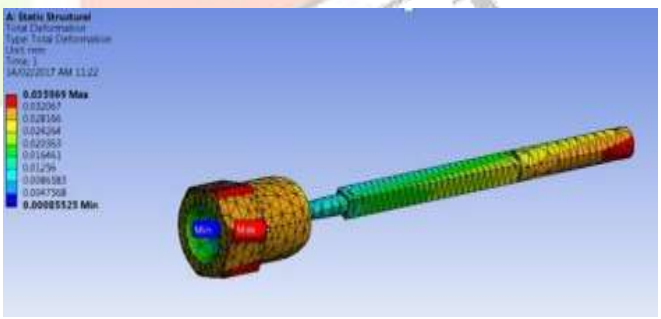


Figure 6.Achieved result deformation

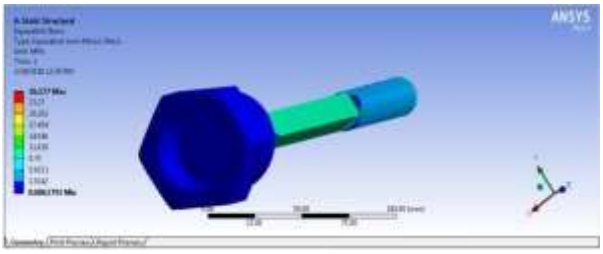
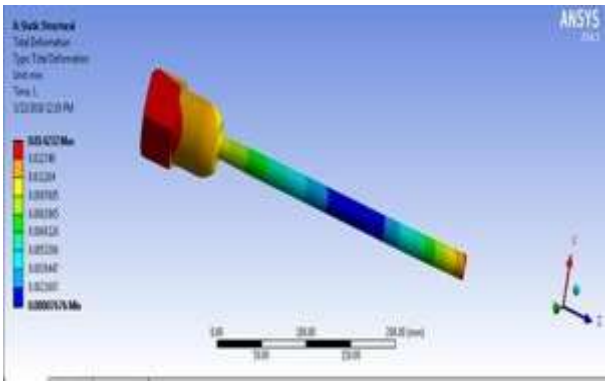


Figure 7.Achieved result stress



8.Mild steel deformation

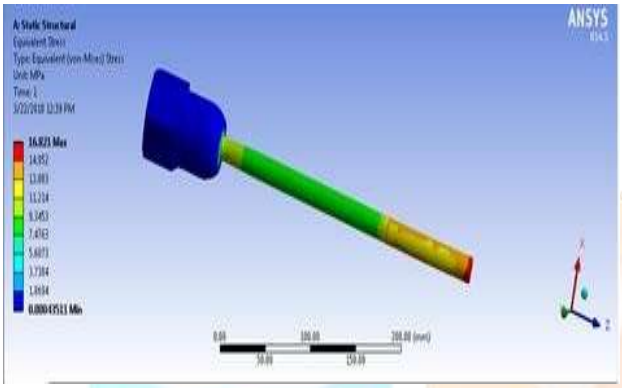


Figure 9.Mild steel stress

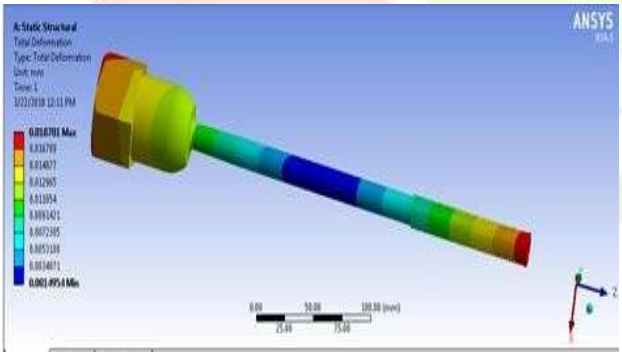


Figure 10.Mild steel deformation with thread

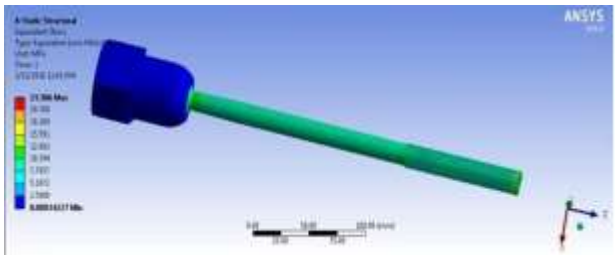


Figure 11.Mild steel stress with thread

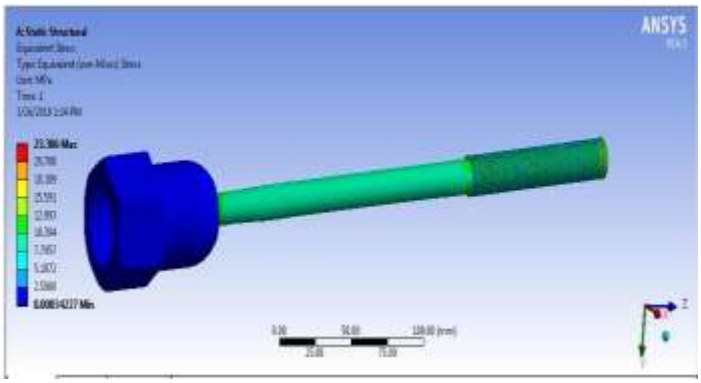


Figure 12.White cast iron stress

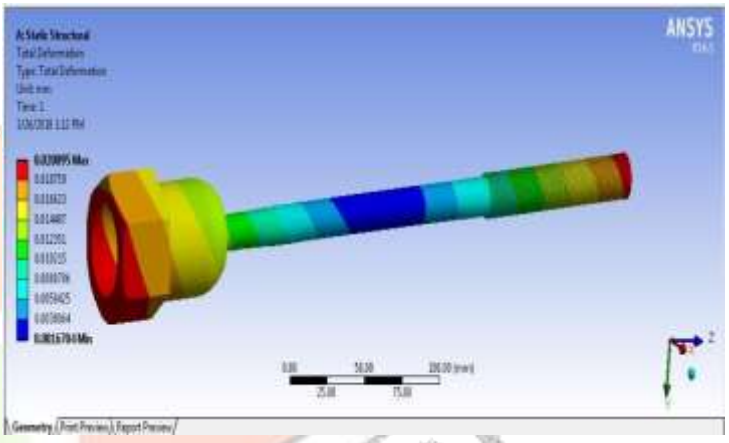


Figure 13.White cast iron deformation

Results

Material	Deformation (mm)	Stress (MPa)
Steel	0.038429	26.177
Al alloy	0.10825	25.551
Copper alloy	0.06987	25.34
Grey cast iron	0.0698	26.595
Titanium alloy	0.080052	24.911
Whitecast iron	0.020895	23.386
Mild steel	0.024556	26.203

Conclusion

- By analysing all the above result we have concluded that that the material Mild steel (low carbon steel) gives the result with the deformation-0.024mm and stress-26.203MPa (Square and Existing model) comparing the result from the given journal(fig-4) we are getting 0.0359mm and stress 28.55MPa so we are getting lesser deformation. .
- We have optimize the dimension by changing the circular shape and hollow in the threaded part. By using mild steel(low carbon steel) as a material the result obtain are stress- 23.386MPa and deformation-0.01807mm and white cast iron give the result with deformation-0.020895 and stress-23.386.

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