ANALYSIS AND OPTIMIZATION OF TIE ROD FOR STEERING MECHANISM OF A CAR

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Abstract—The FEA analysis of Tie rod is carried out to check its natural frequency, maximum stress analysis and deformation. The most percentage weight of vehicle is taken by suspension system; however tie rod may get fail due to fluctuating forces during steering and bumping of vehicle. The forces from the steering is also considered during the static condition of car. Vibration and fatigue of Tie rod has been continuously a concern which may lead to structural failure if the resulting vibration and stresses are severe and excessive. It is a significant study which requires in-depth investigation to understand the structural characteristics and its dynamic behavior. This paper presents and focuses on some Finite Element (FE) analysis of a typical tie rod of a car will be carried out and natural frequency will be determined.

I. INTRODUCTION

Tie rod of Steering system connects center link to the steering knuckle in conventional suspension system and rack to the steering knuckle in McPherson suspension system. Tie rod generally gets force from rack and transfer it to the steering knuckle to turn the wheels. Tie rod is a circular rod with threaded part, Outer end and inner end. Tie rod is mostly made up of alloy steel.

Fig.No.1 Suspension system

II. PROBLEM DEFINITION

Failure of tie rod may cause instability of vehicle and can cause an accident. So it’s important to check the strength of tie rod. The load coming on tie rod is mostly compressive. The efforts required where car is moving are comparatively less with stationary car. The working strength of the tie rod is that of the product of the allowable working stress and the minimum cross-sectional area.

Failure of tie rod may occur due to improper material selection, poor design, fatigue load and wear of tie rod. Also the indications given by the tie rod before failure is very less so it can be risky.

The main task in this study is to find the deformation and stresses induced in the Tie-rod and optimizing it for various material combinations. The
3-Dimensional model is prepared for Tie-rod. Different types of materials are assigned and analysis is carried out using finite element analysis software named Ansys.

III. METHODOLOGY

The project will begin with creation of 3D-CAD solid with different cross section approximate model in the form of a multi-bodysystem, after that solid mesh generation, and in final stage of testing finite element analysis for various cross section and different materials using FEA.

ANALYSIS OF TIE ROD

Analysis is done based on 2 concepts

- Structural design optimization.
- Material analysis and optimization.

Structural design optimization

Analysis is done according to structural design optimization, modeling of tie rod by varying the cross section of the middle part of assembly ie. Main rod. Since this part is subjected to more compressive loads of -4017.195N and 990.65N.

Different cross sections

- Circular cross section.
- Pentagon cross section.
- Hexagon cross section.

The results obtained by varying different cross section can be improved by proper selection of structural material so it is preferred to go for material analysis and optimization.

Material analysis and optimization

Analysis is done by varying different materials by keeping same structural design. we can have less deformation and high damping ratio by proper selection of structural material. Different materials that are used for analysis are,

- Structural steel
- Grey cast iron
- SAE 1045 steel
- Steel sus 304
From the above results it can be seen that pentagonal and hexagonal structure gives better results than circular structure among them pentagon gives better results. It gives less deformation and has high damping capacity compared to other two structures.

From the above static, transient and modal analysis results we can see for Grey cast iron less deformation is obtained and have low natural frequency in turn it is having high damping capacity. So that Grey cast iron is best among all the material analysis.

Tie rods are merely subjected with more compressive forces. From the above analysis shows that Grey cast Iron has more damping capacity and can withstand more compressive forces. This is due to because of carbon flake distribution in the material. Carbon flake distribution is better in Grey cast iron.

**IV. CONCLUSION**

In the structural design optimization it is seen that pentagonal and hexagonal structure gives
better results than the circular cross section. Among them the pentagonal structure has better results so that pentagonal structure is proposed for the Tie rods. From the material analysis and optimization the Grey cast iron gives lesser deformation and high damping capacity than the other material composition.

From the analysis, results shows that pentagon cross section gives less deformation combined with analysis on Grey Iron material gives high damping capacity and less deformation. From the presented results we can conclude that deformation and stress do not exceed the yield strength value that there are neither damages nor failure to tie rod.

From the results it can be seen that Grey cast iron gives best results compared to other material composition this is mainly because of its carbon flake distribution in it. It has better carbon flake distribution than the others. Because of this carbon flake distribution the wear and the friction can be reduced.

V. SCOPE FOR FUTURE WORK

➢ In future the above analysis can be done for laminated composite Tie rod with different fibers like carbon fibers and glass fibers and also by varying the angle of orientation of fibers.
➢ Analysis can be done by reducing weight of Tie rod.
➢ Life estimation of Tie rod can be done.
➢ Non linear analysis of Tie rod can be performed.

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