iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.41911

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

A Literature Review and Study on Design, Fabrication and Analysis of Tie Rods for Steering Mechanism

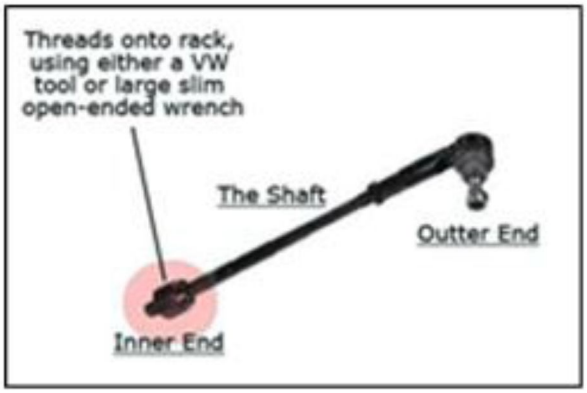
Mohammed Aamir Shareef[1], Dr. Ravindra N. Dehankar[2]
[1]*Student In M-Tech 2nd Year [Med].*
[2]*Asst.Prof.In Mech, Engg Department Guide*

Abstract: ***Tie rods or Track rods are an integral part of vehicle's steering system. Just as its name suggests a Tie rod ties vehicle's steering rack to the steering arm. It is used to give direction to tires according to steering wheel movement. A tie rod assembly is attached to each end of the relay rod. The tie rod assembly consists of inner and outer tie rods that are usually connected through an adjusting sleeve. Tie rod may get fail due to varying forces and bumping of vehicle during steering. The forces from the steering are also considered during the static condition of car. Fatigue and buckling of Tie rod has been continuously a concern which may lead to structural failure if the resulting vibration and stresses are undesirable and excessive. Even if the stresses are less than yield they may fail under repeated loading. Considering this problem research work is aimed to assess buckling strength and compare buckling performance of Tie rod for different materials. In this first according to the condition basic cad geometry is designed using cad software and finite element model generated using Hyper Mesh. And then modal, static and transient dynamic analyses to obtain natural frequencies, displacement, stresses distributions in tie rod. For safe design of tie rod corrective actions and considerable modifications carried out and to validate the modified design of tie rod finite element analysis carried out.***

I. INTRODUCTION

The tie rod is an important member in vehicle suspension system. It performs an important task of transferring the motion from the steering system to the suspension system. In a cars steering wheel is connected to the steering gear steering wheel turns the wheels. The steering gear is connected to the wheels via the tie rod ends. The job of the tie rods end is to ensure the wheels are aligned. It provides adjustment for wheel alignment that keeps the tires from wearing out on the inner and the outer edges. If they wear out the wheels will lose alignment and you may find that the tires and steering wheel are shaking when you are driving the car. To evaluate the structural performance of tie rod, we need to consider the load coming on tie rod. From the various studies and practical observations, it is found that tie rod is primarily under compressive loads and hence fails in buckling. Moreover due to suspension components fluctuating loads are also coming on the tie rod due to the random loads coming on suspension of vehicle.

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.



Location of tie rod in suspension system

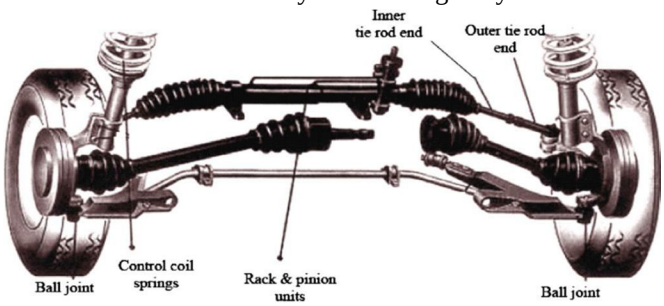
Rods are often made thicker at the ends and to keep its strength high at tie rod ends. It is advisable that steering and suspension systems are checked regularly, at least once a year along with a complete wheel alignment. A worn tie rod can cause loss of grip of vehicle, drifting, erratic steering and also major tire wear. If a tie rod is replaced, then a wheel alignment will also be required. Because tie rod replacement will disturb the alignment setting. As the ratio of its length to the radius of gyration of its cross section is normally quite large, it would likely buckle under the action of compressive forces.

Failure of tie rod may cause instability of vehicle and can cause an accident. 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. It is imperative to perform detailed fatigue analysis on the tie rod to evaluate its life.

Tie Rod

The aim of the project is to accurately find out the buckling loads and the fatigue life of Tie rods, especially ones that are critical in compression used in automobile industries. To perform the fatigue analysis of the existing tie rod. To modify the design of the tie rod for infinite life.

Failure of tie rod may cause instability of vehicle and can cause an accident. 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. It is imperative to perform detailed fatigue analysis on the tie rod to evaluate its life. Form the several years a great deal of research work has been invested to find out the critical fatigue life of the tie rod. Theoretical and experimental research has predicted that geometrical imperfections and modified boundary conditions greatly influence it.



A Tie rod contains such geometrical imperfections and modified boundary conditions from a perfect cylindrical rod, since a Tie rod consists of outer and inner ends threaded into a middle rod body, with changing end conditions. So it is important to accurately find out the buckling loads and the fatigue life of Tie rods, especially ones that are critical in compression used in automobile industries.

II. LITERATURE REVIEW

A. *"FEA OF TIE ROD OF STEERING SYSTEM OF CAR"*, Manik A. Patil, Prof. D.S.Chavan, Prof.M.V.Kavade, Umesh S. Ghorpade

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 it 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.

The conducted research has begun with creation of 3D-CAD solid approximate model in the form of a multi-body system, after that solid mesh was generated where all meshed elements assumed to be perfectly rigid, and in final stage of testing finite element analysis was performed using Ansys software package. From the presented results we can conclude that the distribution of deformation and stress do not exceed the yield strength value and that there are neither damages nor failure of Tie rod. The correctness and accuracy of computed results is still dependent on the selection related to various modeling parameters. Some of the most important aspect such as boundary conditions or correct mesh and type of elements are performing a decisive role in achieving of correct results. Tie rod analysis by using ANSYS software shows that the deformation is 0.13302 mm and the equivalent stress is 94.66 Mpa which is less than tensile and compressive yield strength i.e 250 mpa. The Tie rod undergoes continuous vibrations when vehicle is running. Hence Natural Frequency is calculated in Ansys software and its value is 201.30Hz. From the above results the tie rod taken for analysis is safe.

B. "RIGID BODY DYNAMIC SIMULATION OF STEERING MECHANISM", V.D.Thorat, S.P.Deshmukh

Project work present rigid multi body dynamic analysis approach in design. The application of this methodology simplify design process and give correct result. For the case study here work of design done on Ackerman steering mechanism for tipper. In this first according to Ackerman conditions basic geometry is design and then optimize it for static loading, modal analysis and then for dynamic forces generated on steering linkages while turning using Rigid Dynamics tool in Ansys. The results obtained from rigid body dynamic analysis are used for testing individual components and if necessary, corrective actions are taken in design in order to sustain that load. Results shows rigid dynamics approach for design reduces time for optimization, simulation and provide the chance to take most corrective action. Rigid dynamics approach is used in modern design techniques for various domains.

To understand the rigid body dynamic simulation, Ackerman steering mechanism is taken as a case study. For this TATA Tipper (Model-SA1212) is considered. Firstly, steering mechanism is designed considering only wheel track and wheel base by fulfilling Ackerman steering condition. It is then tested for static loading condition. Modal analysis is also done to ensure it does not create resonance while moving on roads. The force acting on the ball joint of tie rod and tie rod arm is calculated from analytical formulae with the help of the specifications of the vehicle. Rigid body dynamic simulation of steering mechanism is done in Rigid Dynamics tool in Ansys. The results obtained through FEA are validated using above analytical equations.

Generally mechanisms are tested under static conditions and more focus is not given for dynamic forces. For any mechanism, testing under dynamic forces has to be done in order to approach towards more safe design. 'Rigid Dynamic' tool in Ansys workbench helps us to find dynamic forces at all joints in all the three directions. Unlike static analysis, in rigid body dynamic simulation, variation of forces with respect to time are obtained which will be very useful for further analysis. By considering these forces, separate analysis should be done to check weather components survive under these dynamic forces or not.

C. "PERFORMANCE EVALUATION OF PASSENGER CAR TIE ROD USING NUMERICAL AND THEORETICAL APPROACH WITH DIFFERENT MATERIALS", Pradeep Mahadevappa Chavan, M M M Patnaik

Tie rods or Track rods are an integral part of vehicle's steering system. Just as its name suggests a Tie rod ties vehicle's steering rack to the steering arm. Tie rod may get fail due to varying forces and bumping of vehicle during steering. The forces from the steering are also considered during the static condition of car. Vibration and buckling of Tie rod has been continuously a concern which may lead to structural failure if the resulting vibration and stresses are undesirable and excessive. So research work is aimed to assess buckling strength and compare buckling performance of Tie rod for different materials. Finite element models of the Tie rod also analyzed to obtain stiffness and stress distributions in each component. Based on the experimental test results, theoretical calculation results and finite element analysis with NASTRAN results, stiffness values are validated. The mode shape and natural frequency results for different materials obtained in the normal modal analysis are compared. In buckling analysis, the load factor obtained for different materials were compared and critical buckling load is calculated and is validated by theoretical calculations.

Experimental analysis of the car Tie rod will be done. To generate 3D model of Tie rod initially accurate measurement of the Tie rod component will be done. Using that measured dimension, 3D modeling of the car Tie rod will be done using modeling software. To carry out all necessary checks on the model. Suitable boundary conditions are applied. Determination of displacement and stresses generated will be carried out through Static Analysis. Analytical approach for finding the stiffness and critical buckling load. Validation of results these are main objectives of this project.

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.

D. "PERFORMANCE OPTIMIZATION OF TIE ROD USING FEA", Shripad Mungi, Prof. Ravindra Navthar

Structural performance of any mechanical component is measured basically in terms of its natural frequency, deformation, stiffness, maximum stress level, fatigue life etc. In case of vehicle suspension system; however tie rod is mainly under compressive and fluctuating forces encounter from steering and bumping of vehicle. When steering acts to turn the vehicle, tie rod comes under compressive load. And when vehicle running on rough road condition, fluctuating forces. When we design the tie rod we need to know the design space available. The prime objective is minimize weight and cost. In order to achieve these targets we have optimize the parameters that affects the structural performance of Tie rod. This paper emphasizes on optimistic way of designing the tie rod that ultimately yields the effective and efficient performance of Tie rod.

A research starts with study of various types of sections proposed for design of tie rod. An objective of this research is a weight optimization. Here we are proposing the optimized design of Tie rod that has a minimum weight and maximum critical buckling load carrying capacity. From results of normal mode analysis, it is seen that the natural frequency of existing design is 626 Hz and proposed design is 736 Hz. So there is ~ 18% rise in natural frequency of proposed design. Further the second and onwards the frequencies of proposed design are increased compared to existing design. So overall the dynamic performance of tie rod is being improved. The weight of existing tie rod is ~ 0.498 Kg and proposed design is ~ 0.421 Kg. So there is approximately around 14% weight reduction is achieved. Apart from weight savings, it is interesting to note that the critical buckling load of existing design is 16.08 kN against critical buckling load of 17.7 kN of proposed design. Hence there is 10% rise in load carrying capacity of tie rod, which is quiet significant.

E. "FINITE ELEMENT ANALYSIS OF TIE-ROD FOR SPACECRAFTS", Kiran S Sankanagoudar, Dr.H.K.Amarnath, Prashant D. Bagalkot, Mukund Thakur

This paper describes the design and mechanism for the deployment of Equipment panel of a spacecraft. For this a tie rod is designed and analysis is done in UG NX 7.5, the design analysis section provides data on linear Buckling analysis. Both the ends of the Tie rod are hinged so that the Equipment panels assembled to Tie –rod can be tilted from Horizontal condition to vertical condition. And safety of factor taken is 3.0.

F. "COMPUTER AIDED STRUCTRAL ANALYSIS OF A TIE ROD END", M. Ozsoya; and M.K. Pehlivanb*

The tie rod end is one of the most elementary parts of a steering mechanism, which has direct and crucial importance in terms of driving safety. The main function of this part is to transfer the routing, coming from the steering linkage, to steering knuckle via tie rot arm. In this study the structural analysis of a tie rod end part for a van-type vehicle is carried out by finite element (FE) modeling of the body, the joint and the bearing. Hence, unlike the previous studies in literature, each component of the tie rod end is included in FE model and a complete assembly is analyzed by means of contact interactions between parts. The analyses for the joint assembly are carried out for different possible tie-end orientations, and by this modeling approach, the stress variations and deformation characteristics of each component are investigated for different operational loading conditions.

Based on the structural static analysis results, the maximum stresses for the joint, the body, and the bearings are 211 MPa, 160.8 MPa and 9.1 MPa respectively. Although the largest stress value occurs on the joint, because of the high yield stress of AISI 5140 and the high stress/life values, the smallest safety factor has not the joint, but the body. Hence according to the results, deformation and breaking will occur on the body first. These results are similar with the malfunction data obtained from Teknorot A.S. When the joint moves from perpendicular position to 25 degrees inclination, maximum stress decreases by 10 MPa. At the 28 degrees inclination, the value at which the joint touches the body, the maximum stress for the joint decreases by 13% and reaches the smallest value. On the other hand, with the increase in the inclination the stress value in the body increases and reaches the largest value (160.8 MPa) at inclination of 28 degrees. The maximum stress values for the bearings occur at 28 degrees inclination as well, when the stress value at the upper bearing becomes 9.1 MPa.

G. "BUCKLING ANALYSIS OF TRACTOR TIE ROD SUBJECTED TO COMPRESSIVE LOAD", Raghavendra K, Ravi K

A tie rod is a slender structural rod that is used as a tie and capable of carrying tensile and compressive loads. As the ratio of its length to the radius of gyration of its cross section is normally quite large, it would likely buckle under the action of compressive forces. When it becomes worn out, steering will become more difficult there by producing clunking noise. The vehicle will also typically be pulling or (dragging) to either side (left or right). Thus the aim of the project is to analyze tie rod for active to improve the mass and buckling load of tie rod. The objectives of this study are to carry out the theoretical, experimental and modal analysis of tractor Tie rod to find different modes shapes by analysis FE software.

H. "PERFORMANCE EVOLUTION OF TIE ROD IN SUSPENSION SYSTEM OF CAR USING FINITE ELEMENT APPROACH", Ganesh B. Baraskar, Dr.V.S. Joshi

Tie rods or Track rods are an integral part of vehicle's steering system. Tie rod ties vehicle's steering rack to the steering arm. Tie rod may get fail due to varying forces and bumping of vehicle during steering. The forces from the steering are also considered during the static condition of car. Vibration and buckling of Tie rod has been continuously a concern which may lead to structural failure if the resulting vibration and stresses are undesirable and excessive. Present paper is aimed to assess buckling strength and compare buckling performance of Tie rod for different proposed dimension of Tie rod with constant length and same material. Finite element models of the Tie rod also analyzed to obtain stiffness and stress distributions in it. The mode shape and natural frequency results for different proposed dimensions of tie rod obtained in the normal modal analysis and in buckling analysis, the buckling load factor obtained for that tie rod are compared and critical buckling load is calculated. Results getting from the Finite element analysis are validated by using the theoretical results.

I. "A REVIEW PAPER ON EVALUATION OF THE PERFORMANCE OF TIE ROD AND OPTIMIZATION USING FEA", Ganesh V. Gadge#1, Yugesh A. Kharche

A car's steering wheel is connected to the steering gear and steering gear is connected to the wheels via the tie rod ends. The job of the tie rod end is to ensure the wheels are aligned. It provides the adjustment for wheel alignment that keeps the tires from wearing out on the inner and outer edges. Hence the functioning of tie rod is crucial for steering as well as suspension performance of vehicle. Tie rod is utilized to help secure and support equipment on an automobile, so a robust knowledge of the design loads is required to ensure the part will satisfy its function on the automobile. Today's world is competitive. Market demands for the advanced technology at lower price. This reflects in making the technology cheaper.

Hence every organization striving for cost effective product at a lower price and within minimum period for 'time to market. This puts lot of pressure on engineers to consistently strive to design the more effective products at the lower price. The proposed work is focus on functioning of the tie rod, the methods of its performance evaluation and its optimization.

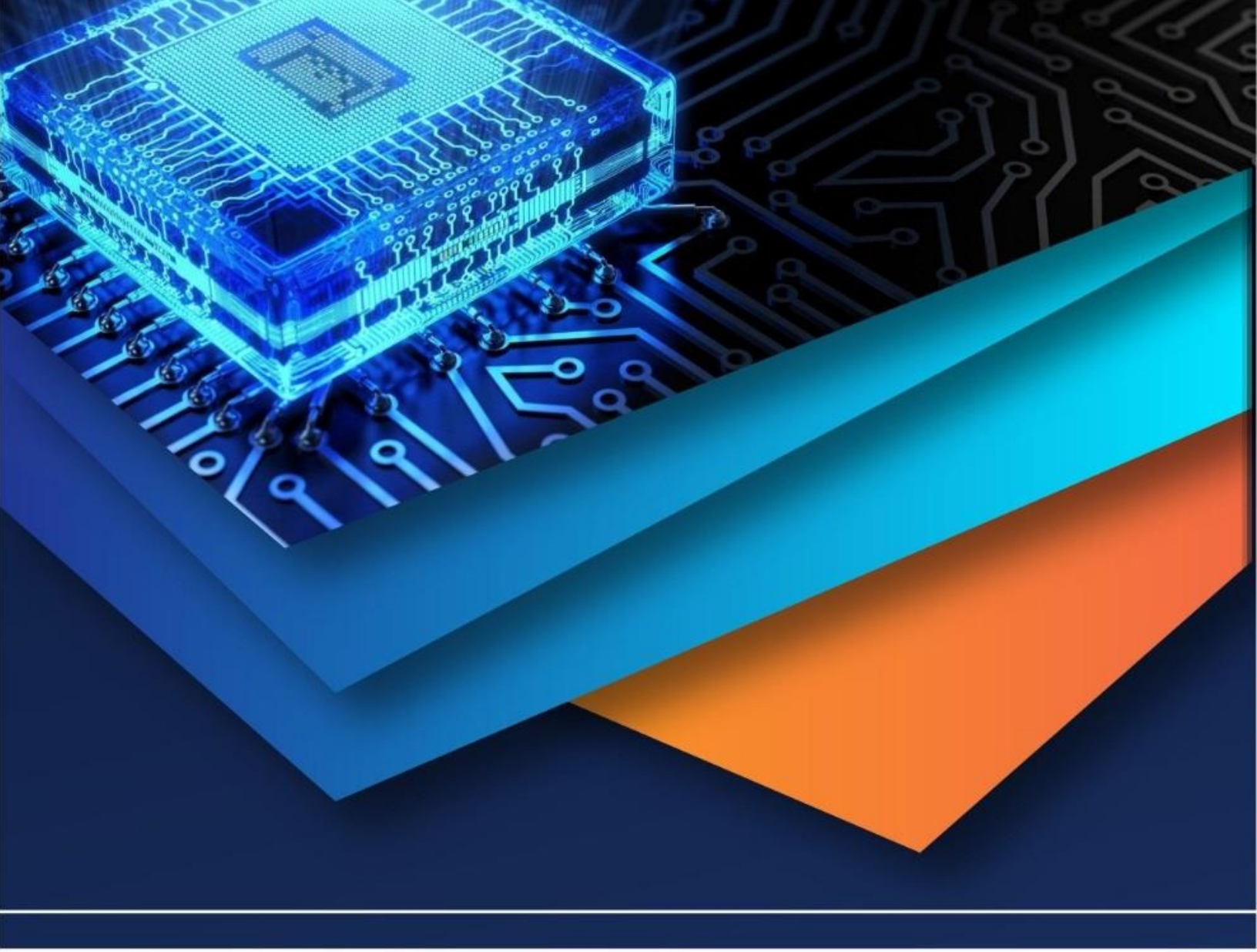
Still we are working over the project, As per the problem identified during the test in company, case study of problem, and also with help of research papers, international journals; we conclude that optimization using FEA is effective than other method so we go for Optimization of Tie Rod Design Based On Dimensional Parameter, Hollow Tie Rod Design (i.e Weight Reduction) and Improved Tie Rod Design Based On Materials also Overall Reduction In Stresses.

III. CONCLUSION

By collecting the details we have researched and study number of literature available from the internet sources. About 4 wheel steering mechanism the above discussed literature reviews are helpful. the project is to perform fatigue analysis of Tie-Rod and to modify the existing design in such a way that its life becomes infinite.

REFERENCES

[1] FEA of Tie Rod of Steering System of Car by Manik A. Patil, Prof. D.S.Chavan, Prof.M.V.Kavade Umesh S. Ghorpade.
[2] Failure investigation of a tie rod end of an automobile steering system by A.H. Falah, M.A. Alfares, A.H. Elkholy,
[3] Performance Evaluation of Passenger Car Tie Rod using numerical and theoretical approach with different materials by pradeep mahadevappa chavan , m m m patnaik
[4] Buckling and geometric nonlinear analysis of a tie rod in NASTRAN VERSION68", Light Truck Divison, Ford Motor Company by George Campbell and Wen Ting



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY