# **Design and Development of Steering Knuckle with Spindle and its Optimization- A Review**

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Abstract:-Steering Knuckle plays major role in many direction control of the vehicle it is also linked with other linkages and supports the vertical weight of the car. Therefore, it requires high precision, quality, and durability. The main objective of this work is to explore performance of the steering knuckle. This can be achieved by performing a detailed load analysis. Therefore, this study has been deal with two steps. First part of the study involves the determination of loads acting on the steering knuckle through hand calculations. Then the stress analysis will be performed using analysis software ANSYS and based on it optimization of steering knuckle will be suggested. This may also improve the depth knowledge of its function and performance in terms of durability and quality.

## Keywords: Spindle, Optimization, Stress Analysis, EN8, Redesign Knuckle.

# 1. INTRODUCTION

Steering knuckle is main part in any vehicle because it requires lots of attention in selection because replacement has to be done if it damaged. Steering knuckle is a prominent component in car which takes the loads from the wheels and transfers these forces to the suspension system. Structural Components such as a steering knuckle is generally strong component which is capable to withstand if load is but it can fail under fatigue and dynamic load. Depending on the vehicle and suspension design, the steering hub or spindle will also vary slightly. In the design variables of vehicles like all wheel drive and front wheel drive; knuckle joint will be point at which steering is connected.

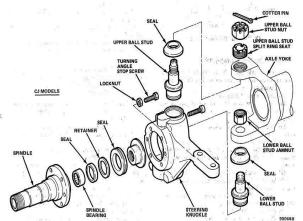


Fig No1.1Exploded view of Knuckle joint with spindle

The vehicle wheel will attached to the exterior part nearest steering knuckle with the help of spindle or hub (as shown in Fig1.1) The suspension inboard connection and the tie rod will be connected with each other by special mounts which allows pivot movement to the knuckle to the turning motion of steering wheel. The steering knuckles keep the wheels at point on the vehicle and allow you to select the direction according to your will. It shows that knuckle joint plays an important role in automobile steering system.

# 2. LITERATURE REVIEW

Mehrdad Zoroufi and Ali Fatemi<sup>1</sup>:- studied steering knuckle which undergoes different time-varying loads during its working life. As it under goes Fatigue stress, the behaviour of fatigue stress will have major impact on the characteristics of knuckle joint hence it should given prime importance while designing knuckle joint. This research paper aim assess fatigue life and compare fatigue performance of steering knuckles made from three different materials using different manufacturing techniques.

Chang Yong Songa, JongsooLee:-This paper discusses reliability-based design optimization (RBDO) of knuckle joint install in an automobile and its behaviour under bump and brake loading conditions. The probabilistic design problem is to reduce the weight of a knuckle component undergoing stresses, deformations, and frequency constraints in order to meet the given target reliability.

Wan Mansor Wan Muhamad:-The static analysis of steering knuckle is done by applying dynamic loading conditions and carried out using Hyper mesh. Optimization of the same is performed using shape optimization method. The main objective was mass reduction and finally the result is 8.4% reduction in mass of steering knuckle. It has also been observed that the maximum stress has not changed significantly.

Viraj Rajendra Kulkarni:-This paper focuses on optimization of steering knuckle targeting reducing weight as objective function, while not compromising with required strength, frequency and stiffness. Taking into consideration static anddynamic load conditions, structural analysis and modal analysis were performed. Mahesh P. Sharma:-Studied the static analysis of steering knuckle. Design of knuckle which accommodates dual calliper mountings for increasing braking efficiency & reducing a stopping distance of a vehicle. Static analysis was done in ANSYS WORKBENCH by constraining the knuckle, applying loads of braking torque on calliper mounting, longitudinal reaction due to traction, vertical reaction due to vehicle weight and steering reaction.

B.Babu et al. <sup>[6]</sup>:-The main objective of the this paper is to explore performance opportunities, in the design and production of a steering knuckle. Modelling is done in CATIA and analysis is carried out in CATIA applying boundary conditions. Studying the nodal displacements and stress distribution and to design the steering knuckle in order to avoid frequent failures to improve its reliability.

## 3. PROBLEM DEFINITION

Steering knuckle requires lots of attention in selection because once it is damaged then it have to replace with the new one. This problem can be solved by redesigning the steering knuckle. So, the steering knuckle can be made compact by integrating with spindle which helps in good steering capabilities and in turn saves cost. The study is performed to find out best possible solution & improve strength. The Redesign of steering knuckle is to verify by using customize package of ANSYS, HYPERMESH to perform finite element analysis. The static stress analysis is Perform and the results are compared with theoretical calculations. The experimental analysis is to perform on redesign of steering knuckle and the results are obtained to find its performance.

# 4 .RESULT AND DISCUSSION:-

4.1 Objectives

- Steering Knuckle is made compact by integrating with Spindle to improve steering capability and reduce cost and weight.
- Knuckle is redesigned in modelling Software CATIA V5.
- Optimization is done to reduce the weight of knuckle.

# 4.2. Methodology

- Develop CAD model and determine loads on different manoeuvres.(fig.no.3.1& fig.no.3.2)
- Manual calculation and mathematical modelling.
- Analytical study by using Ansys.
- Theoretical and mathematical study to validate results
- Redesign to optimize result
- Validation of all results

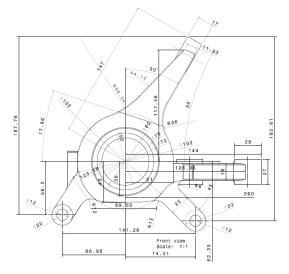


Fig. no.3.1 2D drawing of steering knuckle (front view)

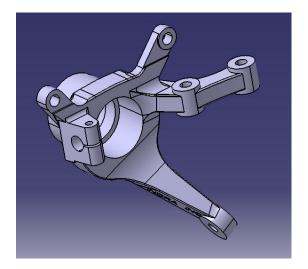


Fig. no.3.2 3D Drawing of steering Knuckle

# 4.3. Experimentation

The experimental analysis is to perform on redesign of steering knuckle and the results are obtained to find its performance. The static stress is perform and the results are compared with theoretical analysis. Optimization is done where the stresses acting are less without compromising its strength. The experimental analysis is done on UTM to analyse the axial and bend stress results. The result from experimental testing are to compare on software with the theoretical study and find out prediction of best optimal solution can be conclude.

# 4.4 Solving and Analysis

In this study, finite element analysis is done by using ANSYS simulation software. To model the steering knuckle with spindle EN8 element is used and it is modal analysis. The redesigned knuckle is analysed under boundary conditions.

## 4.5 Result Validation and Discussion

This work gives a experimental, analytical and theoretical study of stress analysis on different parts of steering knuckle.

The results obtained should be validated using above manual calculations and FEA report. The results of old and new design is compared and validated.

Redesigned steering knuckle is expected to perform better and it also leads to reduction in weight. The weight reduction will hence lead to better fuel efficiency

## IV. CONCLUDING REMARK

By using above case studies, we can determine the working and design (always very tricky) front suspension system which also takes care of steering system attached to the same front wheel. The vehicle suspension system is responsible for the vehicle control, driving comfort and safety as the suspension carries the vehicle body and transmits all the forces between the road and the body.

Based upon studies, we can apply boundary conditions to the model and carry out analysis.

Analysis can be done on FEA software to determine the nature of failure caused due to stresses developed.

Based on analysis optimization of steering knuckle be stated.

## 5. CONCLUSION

From the review of the Research papers it is concluded that in most of the cases steering knuckle faces a problem that once it is damaged it has to be replaced by other. So, here is a scope for us to improve. We can make a spindle that is integrated with steering knuckle and check for its improved performance.

## Acknowledgement

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#### REFERENCES

- Mehrdad Zoroufi and Ali Fatemi, "Fatigue Life Comparisons of Competing Manufacturing Processes: A Study of Steering Knuckle", The University of Toledo, 2003
- [2] Chang Yong Songa, Jongsoo Lee, "Reliability based design optimization of knuckle component using conservative method of moving least square meta-models.", Science Direct, 2010
- [3] Wan Mansor Wan Muhamad, Indra Sujatmika, Hisham Hamid, & Faris Tarlochan, "Design Improvement of Steering Knuckle Component Using Shape Optimization", International Journal of Advanced Computer Science, Feb. 2012.
- [4] Viraj Rajendra Kulkarni, Amey Gangaram Tambe, "Optimization and Finite Element Analysis of Steering Knuckle", Altair Technology Conference, Dec 2013.
- [5] Mahesh P. Sharma, Denish S. Mevawala, Harsh Joshi, Devendra A. Patel, "Static Analysis of Steering Knuckle and Its Shape Optimization", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 2014
- [6] B.Babu, M.Prabhu, P.Dharmaraj, R.Sampath, "Stress Analysis of Steering Knuckle of Automobile Steering System", International Journal of Research in Engineering and Technology, March 2014