International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
National Conference on Emerging Research Trends in Engineering and Technology
(NCERT- 02nd & 03rd November 2015)

RESEARCH ARTICLE OPEN ACCESS

Optimization of steering knuckle for off-road buggy

S. J. Deshmukh[1], P. J. Bhadange[2]
PG Scholar, CAD/CAM, Dr. Sau Kamalatai Gawai Institute of Engineering & Technology, Darapur
Assistant Professor, CAD/CAM, Dr. Sau Kamalatai Gawai Institute of Engineering & Technology, Darapur

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 opportunities, in the design and production of a steering knuckle. This can be achieved by performing a detailed load analysis. Therefore, this study has been dealt with two steps. First part of the study involves modelling of the steering knuckle with the design parameters using the latest modelling software, and also it includes the determination of loads acting on the steering knuckle as a function of time. This is done for finding out the minimum stress area. Then the stress analysis was performed using analysis software. The steering knuckle can be modelled, and analyzed under the actual load conditions. This may also improve the depth knowledge of its function and performance in terms of durability and quality.
Keywords: Steering knuckle, stress analysis and Finite Element Analysis (FEA).

I. INTRODUCTION

A. INTRODUCTION TO STREENING KNUCKLE

The steering knuckle is the connection between the tie rod, stub axle and axle housing. Steering knuckle is connected to the axle housing by using king pin. Another end is connected to the tie rod. Then the wheel hub is fixed over the knuckle using a bearing. The function of the steering knuckle is to convert linear motion of the tie rod into angular motion of the stub axle.

The lighter steering knuckle resulting greater power and less the vibration because of the inertia is less. The steering knuckle carries the power thrust from tie rod to the stub axle and hence it must be very strong, rigid and also as light as possible. In the case of automobile vehicle, during steering and turning the steering knuckle is subjected to compressive and tension loads and due to the wheel rotation it is also subjected to torsional load.

Steering knuckle for automobile applications is typically manufactured either by forging or from casting. However, castings could have blow-holes which are detrimental from durability and fatigue points of view. The fact that forgings produce blow-hole-free and better parts gives them an advantage over cast parts.

Due to its large volume production, it is only logical that optimization of the steering knuckle for its weight or volume will result in large-scale savings. It can also achieve the objective of reducing the weight of the vehicle component, thus reducing inertia loads, reducing vehicle weight and improving vehicle performance and fuel economy.

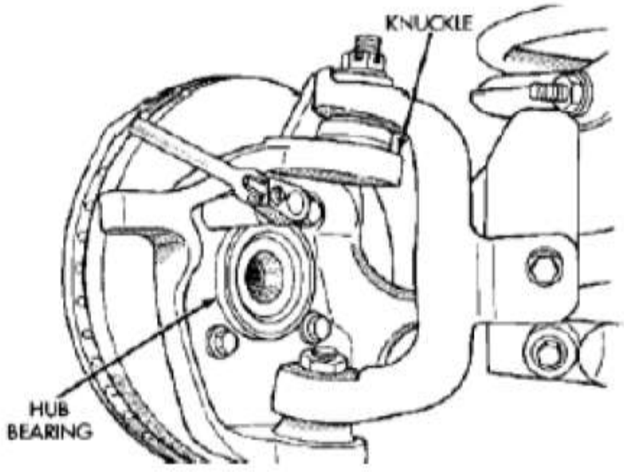


Fig 1 Steering knuckle with the wheel hub

B. STATIC ANALYSIS OF STREEING KNUCKLE

To observe maximum stresses and deformation of steering knuckle when different forces such as braking force, load transfer during acceleration and braking etc. are applied on it static analysis is performed.

C. OPTIMIZATION OF STREENING KNUCKLE

Optimization methods are developed for manufacturing lighter vehicle. Optimization can be defined as the automatic process to make a system or component as good as possible based on an objective function and subject to certain design constraints. There are many different methods or algorithms that can be used to optimize a structure, on OptiStruct is implemented some algorithms based on Gradient Method. There are four types of optimization process namely

1. Shape optimization which provides optimization of fillets and other outer dimensions.
2. Size optimization which provides optimum thickness of the component

II. OBJECTIVE

As today's automobile vehicle, required to have higher speed and power, their steering knuckle have higher strength and stiffness, but must be lighter in weight and size. In developing power output vehicle, importance is placed on the weight of the linier and angular parts steering arm, tie rod, pitman arm etc. The overall performance of the steering system is affected by higher inertia forces, generated by the moving parts of the vehicle. Therefore, it should always be investigated to avoid any failure of the vehicle in the long run.

The following are the main problems which are found in the manufacturing of the knuckle:

1. Due to uneven stress distribution over steering knuckle, its life reduces.
2. This affects the overall performance of an automobile vehicle.
3. Due to the lack of knowledge of stress distribution the material wastage may occur.

III. METHODOLOGY

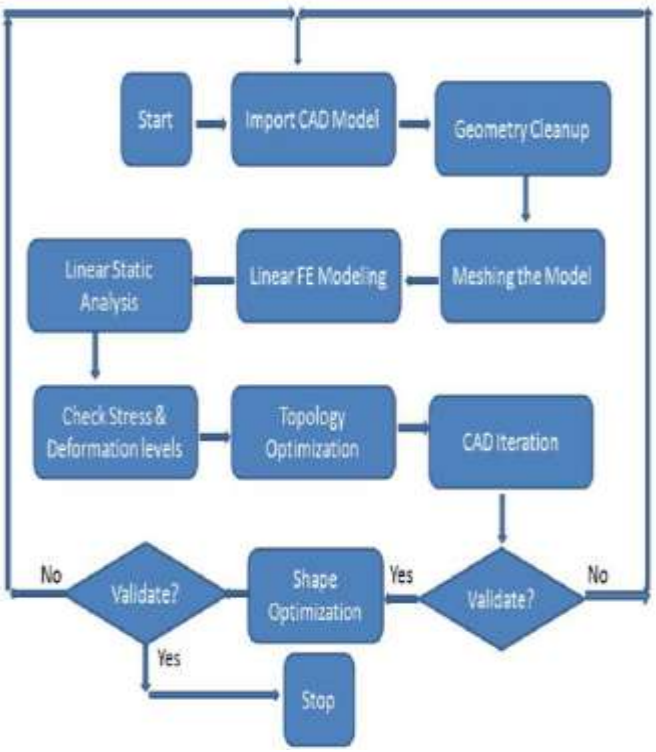


Fig 2 Analysis flow chart

A. *MATERIAL SELECTION*

There are several materials used for manufacturing of steering knuckle such as S.G. iron (ductile iron), white cast iron and grey cast iron. But grey cast iron mostly used. Forged steel are most demanding material for this application. Now a day's automobile industry has put effort to use aluminium alloy as an alternative. Due to low weight of this material, it can reduce fuel consumption and CO2 emission. So as per survey best suited material was aluminium alloy. It has low density and compatible yield strength. This material was chosen for designing knuckle by comparing its result with other material.

B. *DESIGN ING OF CAD MODEL*

CAD model of steering knuckle can developed in 3D modeling software such as CATIA V5. It consists of stub hole, brake caliper mounting points, steering tie-rod mounting points, suspension upper and lower A-arm mounting points. Knuckle design mainly depends on suspension geometry and steering geometry.

C. *MESHING OF MODEL*

CAD model of knuckle is imported into Ansys Workbench simulation. Geometry cleanup was performed prior to meshing of model. Finite element model was developed using Ansys Workbench Simulation. For better quality of mesh fine element size is selected.

D. *STATIC ANALYSIS*

To observe maximum stress produce into steering knuckle, model is subjected to extreme conditions and static analysis is carried out in Ansys Workbench.

IV. DESIGN OF STREEING KNUCKLE

A. CALCULATION OF LOAD

1) *AXIAL LOADS:* The two major loads acting on the knuckle are Tensile and Compressive loads. The stresses due to these loads can be determined using the following formulas ,

Tensile Load (Pt) = Tensile Stress X Area

Compressive Load (Pc) = Compressive Stress X Area

2) *INERTIA LOADS:* This load is due to the inertia of the moving parts. To calculate the inertia force, first two harmonies are taken into consideration. It is given by,

Inertia load(F_a) = $\omega^2 R\left(\cos\theta + R/L \cos(2\theta)\right)$

3) *BENDING LOADS:* This load is due to the weight of the vehicle which is acting on the knuckle. This force trends to bend the steering knuckle outwards, away from the centre line. It is alternating one, and at high speed, it is considerable.

Total inertia bending force is given by,

$$F_b = \frac{\rho A_i L^2 \sin(\theta+\phi)}{2} N$$

B. CALCULATION OF STRESSES

1) *STRESSES DUE TO INERTIA BENDING FORCE:* Inertia bending load sets up a stress which would be tensile on one side of the knuckle and compressive on another side and that these stresses change sign each half revolution. The bending moment at any section 'x' m from the small end is given by,

$$M = \frac{x}{3}\left[1 - \frac{x^2}{L^2}\right]F_b$$

The stress is calculated by using the formula,

$$\sigma_b = M/Z$$

$$Z = I/(2.5 \times t)$$

$$I = 419 \times t^4$$

V. FINITE ELEMENT ANALYSIS OF STREEING KNUCKLE

A. ANALYSIS PROCEDURE

1) PRE-PROCESSING: In pre-processing we need to select the element types, element real constants, material properties, the import geometry and meshing.

2) *PROCESSING:* In processing we defining boundary condition and loading condition. Then we need to solve model for give conditions.

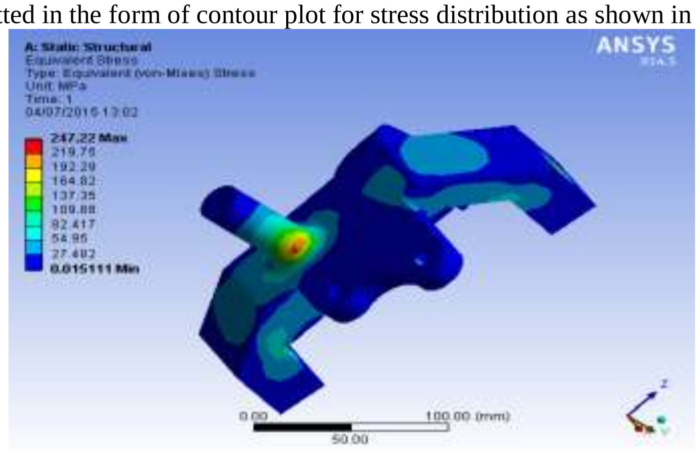
B. POST-PROCESSING

After the solution is completed, the post-processing step gives the results of the static analysis.

- Primary data available
- Nodal displacements (UX, UY, UZ, ROTX, ROTY, ROTZ)
- Derived data available
- Nodal and element stresses
- Nodal and element strains
- Element forces
- Nodal reaction forces Etc

VI. RESULT

The results are plotted in the form of contour plot for stress distribution as shown in the figure.



VII. CONCLUSION

The steering knuckle can be model and analyse using Catia. The various parameters such as Nodal displacements, Stress distribution are completely analysed and studied. This study shows that the areas where the stress concentration is maximum due to the applied load and the portions that has to considered in the design of steering knuckle in order to avoid frequent failures to improve its reliability.

REFERENCES

[1]. Athavale, S. and Sajanpawar, P. R., 1991, "Studies on Some Modelling Aspects in the Finite Element Analysis of Small Gasoline Engine Components," Small Engine Technology Conference Proceedings, Society of Automotive Engineers of Japan, Tokyo, PP. 379-389.
[2]. Farzin h. Montazersadgh and Ali Fatemi, 2007, "Dynamic Load and Stress Analysis of a Crankshaft", SAE International.
[3]. R. L. Jhala, K. D. Kothari and S.S. Khandare , 2009, "Component Fatigue Behaviors And Life Predictions Of A Steering Knuckle Using Finite Element Analysis" Proceedings of the International MultiConferenceofEngineers.
[4]. Lee, S. B., "Structural Fatigue Tests of Automobile Components under Constant Amplitude Loadings," Fatigue Life Analysis and Prediction, Proceedings, International Conference and Exposition on Fatigue, Goel, V. S., Ed., American Society of Metals, 1986, pp. 177-186.
[5]. Rice, R. C., ed., 1997, "SAE Fatigue Design Handbook", Society of Automotive Engineers, Warrendale, 3rd Edition.
[6]. Savaidis, G., "Analysis of Fatigue Behavior of a Vehicle Axle Steering Arm Based on Local Stresses and Strains," Material wissenschaft und Werkstoff technik, Vol. 32, No. 4, 2001, pp. 362, 368.