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Design, Analysis of Car Knuckel by using ANSYS Workbench

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Abstract: Steering knuckle is an indispensable part of an automobile vehicle, integrating different subsystems like suspension, brakes and steering. Being the pivot point of the vehicle, it undergoes diverse stacking under rigorous conditions resulting in failure of the component. The objective of this paper is to perform static structural analysis on the knuckle under diverse loadings. This is achieved by designing a generic steering knuckle of a car in CATIA V5R20 and performing the finite element analysis using ANSYS Workbench 14.5. The analysis is carried out under maximum loading condition, braking and bump maneuvering.
Keywords: Steering knuckle, Weight optimization, finite element analysis, structural analysis

I. INTRODUCTION

A steering knuckle is a part of automotive suspension system that detaches the vehicle from roughness and vibrations while keeping the tires in contact with the road surface. Hence, the steering knuckle should be strong enough to endure loads during various maneuvers such as cornering, accelerating, and braking and road roughness. Most Common type of suspension system is Macpherson Suspension System. In this steering knuckle is connected to the axle housing by using kingpin, one end is connected to the strut while another end is connected to the steering link or "tie rod". The wheel hub is fixed over the knuckle by 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. Variety of materials is utilized to produce steering knuckle, from cast iron to alloy steels. But because of the booming aluminum industry, most of the automakers are relying on the aluminum alloys for better strength for comparatively lesser weight of the component. Because of low material weight, the component will contribute toward overall mass reduction and decrease in use of fuel and CO_2 production. In addition, to light-weight material utilization, many researchers are using optimization techniques such as: topology optimization, shape optimization and size optimization. [1]

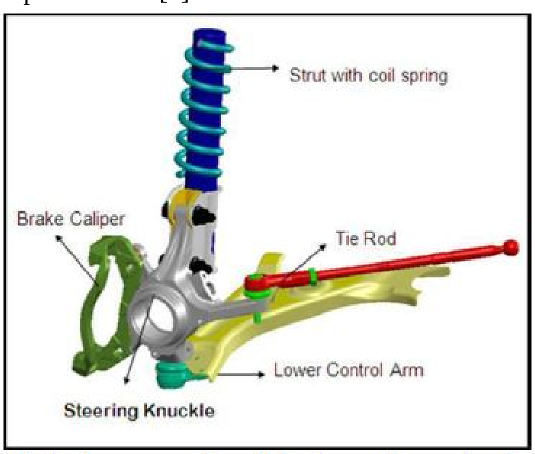

Fig 1: - A representation of Macpherson Suspension System

Mass or weight reduction is becoming a core highlighted issue in automobile manufacturing industry to improve fuel efficiency thereby reducing emissions. Weight reduction has been achieved through advances in materials, improved design and analysis methods, fabrication processes and optimization techniques, etc. Design optimization should be implemented to obtain a minimum weight with maximum or feasible performance, based on removal of conflicting constraints, design boundaries, and design uncertainties, such as design clearance and material defects.

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The steering knuckle on a vehicle is a joint that allows the steering arm to turn the front wheels. It 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. 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. A knuckle design is dependent on the suspension, brake and steering subassembly design of the particular vehicle and hence gives flexibility to optimize it in terms of weight and durability. Inspire of the large design variations, steering knuckles are divided into two main types - with a hub or with a spindle. Among the vehicle structural components, the knuckle is one of the important parts in the suspension system. A reduction in the weight of suspension components also improves the vehicle's handling performance. It plays a crucial role in minimizing the vertical and roll motion of the vehicle body when it is driven on a rough road. A knuckle component is required to support the load and torque induced by bumping, braking, and acceleration and also helps in steering the tire connecting tie rod and rotating at the kingpin's axis centre. Under operating condition, it is subjected to dynamic forces transmitted from strut and wheel. Steering Knuckle is subjected to time varying loads during its service life which may lead to fatigue failure. The steering knuckle accounts for maximum amount of weight of all suspension components, which expedites the necessity of weight reduction. In the design optimization of the knuckle component, weight should be minimized, while design factors such as strength, stiffness and durability should be satisfied with design targets. An effective design is one which performs the required task efficiently and is safe under extreme operating conditions, while being economical in the material used as well as the manufacturing process needed yet having an aesthetic appeal. Analysis aids in understanding the behavior of a component under a particular loading cycle for both failures and redundancies. Therefore, analysis gives us a mathematical model which indicates scope for optimization and weight reduction for an overdesigned component.

II. OBJECTIVE

1) The main objective of this project is development of structural design and weight reduction of vehicle knuckle using shape optimization which will reduce the cost and to avoid complex steering assembly which will enhance it performance.
2) To study original Knuckle.
3) Structural analysis is carried out using finite element analysis.

III. HAND CALCULATION

For calculating breaking force acting on one wheel we have to distribute weight of vehicle for four wheels so that we get vehicle weight acting on one wheel. i. e. 1480/4 = 370 kg for one wheel

Breaking force = 1.5g (g = 9.81m^2/s)

=1.5*9.81 = 14.715 m/s^2

=14.715 *370

= 5444.55kgm^2/s

=5444.55 N

Moment = breaking force * perpendicular distance

= 5444.55* 94

= 511787.7 Nmm (for one wheel)

This moment is acting on steering knuckle where brake caliper is mounted. Brake caliper is mounted at three locations therefore distributing moment at three points,

Moment = 51187.7/3

= 170596 Nmm

A. *Physical and Mechanical Properties of Cast Iron*

Young Modulus	1.1e^{5}MPa
Poisson's Ratio	0.28
Density	7200Kg/m^3
Ultimate tensile strength	240MPa
Yield Strength	280MPa

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B. Force

For calculating force acting on steering knuckle, we required loading conditions which is given as follows

LOADING CONDITIONS	
Braking Force	1.5g
Lateral Force	1.5g
Steering Force	50N
Load on knuckle hub in X direction	3g
Load on knuckle hub in Y direction	3g
Load on knuckle hub in Z direction	1g

Table 2: loading conditions

Since all load in X, Y, and Z direction are perpendicular to each other, the resultant of all the forces s given by,

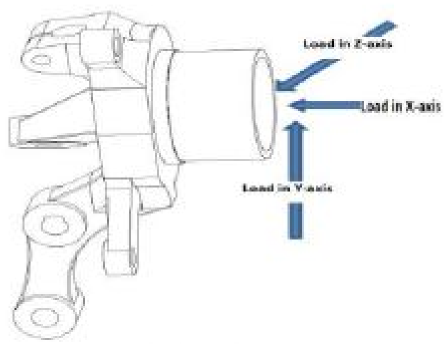

Fig.2: Direction of load

$$F = \sqrt{X^2 + Y^2 + Z^2}$$

X = Y = 3g = 3*9.81*370 = 10889.1 kgm/s2 ie N

Z = 1g = 1*9.81*370 = 3629.7 N

$$F = \sqrt{10889.1^2 + 10889.1^2 + 3629.7^2}$$

= 15821.5 N

IV. FINITE ELEMENT ANALYSIS

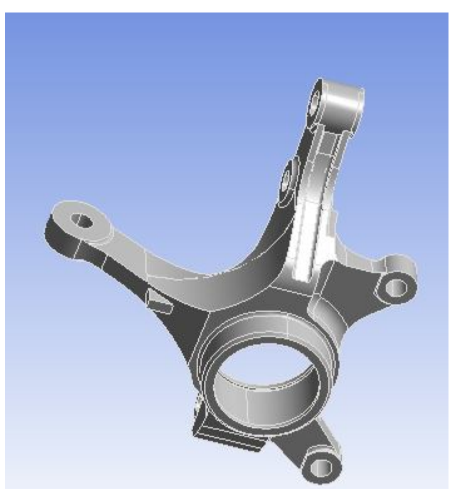

Fig.3 3D model imported in ANSYS

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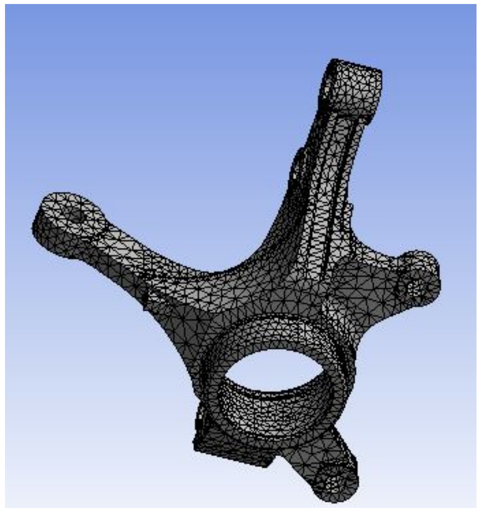

Fig.4 Meshing of Model

No. of Nodes	45143
No. of Elements	25690

Table3. Meshing details of part

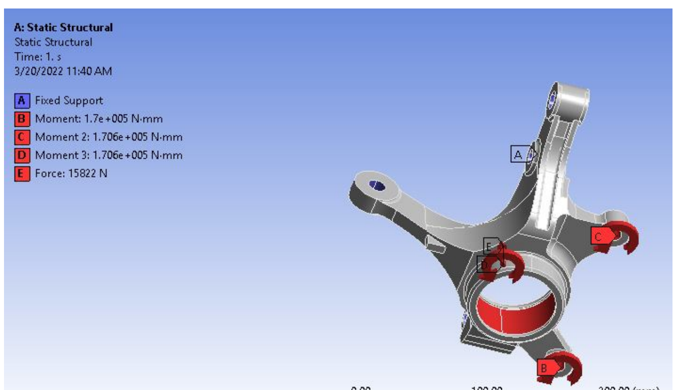

Fig.5 Boundary Condition on Knuckle

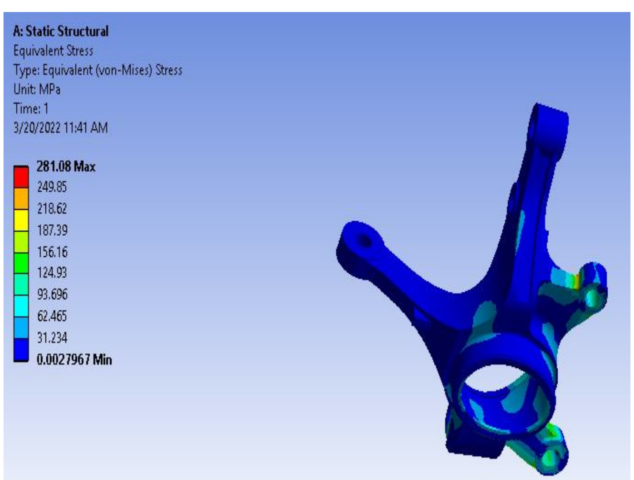

Fig.6 Stress induced in knuckle of cast iron due to applied boundary condition

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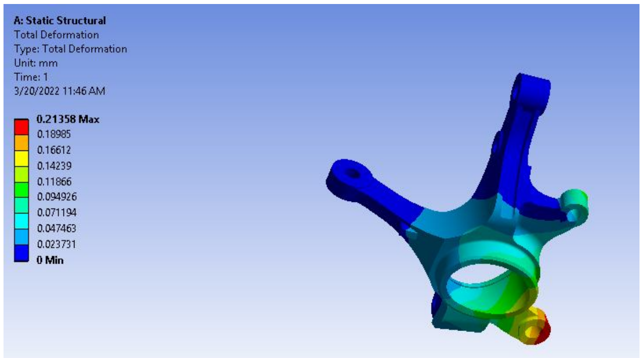


Fig. 7 deformation in knuckle of cast iron due to applied boundary condition

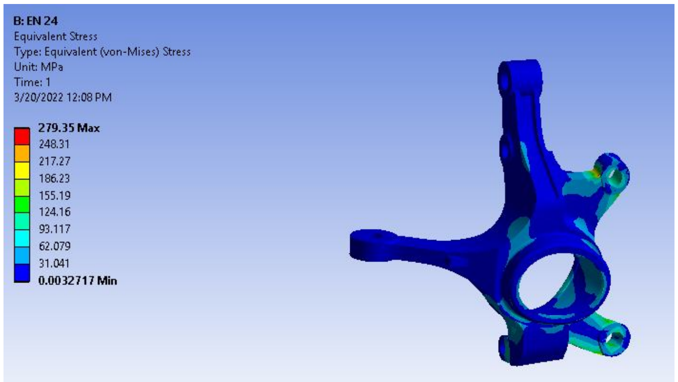


Fig.8 Stress induced in knuckle of EN24 due to applied boundary condition

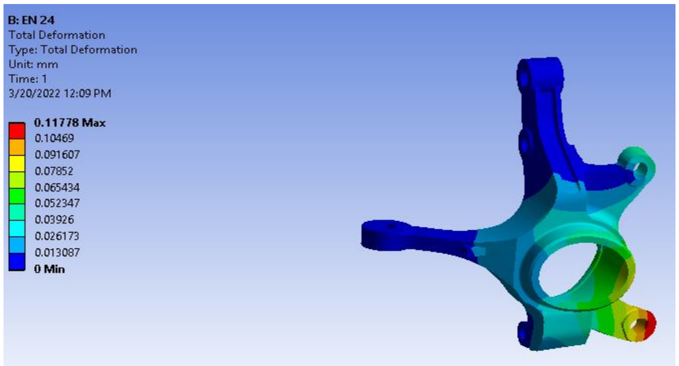


Fig. 9 deformation in knuckle of EN24 due to applied boundary condition

V. RESULT TABLE

Sr. No.	Material	Stress (MPa)	Deformation (mm)	Weight (Kg)
1	Cast iron	281.08	0.2135	2.564
2	EN 24	279.35	0.1178	2.795

VI. CONCLUSION

From the simulation results, it have been found that regardless of the material selected the maximum stress induced in the steering knuckle remains same, but the maximum displacement varies. Material EN 24 having minimum deformation so we can replace cast iron with EN24 material for knuckle.

REFERENCES

[1] "Design and Multi-Axial Load Analysis of Automobile Steering Knuckle", Syed Hassaan Abdullah , Mahad Moiz Ullah ,Obaidullah Sharief ,International Journal of Innovative Science and Research Technology, Volume 3, Issue 6, June – 2018.

[2] "FEA & Optimization of steering knuckle of ATV", Ameya bhusari, Aditya Chavan, Sushrut Karmarkar, International Journal of Mechanical And Production Engineering, ISSN: 2320-2092, Volume- 3, Issue-12, Dec.-2015.

[3] "Structural Analysis of Steering Knuckle for Weight Reduction", Purushottam Dumbre, A. K. Mishra, V. S. Aher, International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 6, June 2014).

[4] "Optimization and Finite Element Analysis of Steering Knuckle", Poonam P. Tagade, Anil R. Sahu, H. C. Kutarmare, International Journal of Computer Applications (0975 – 8887) International Conference on Quality Up-gradation in Engineering, Science and Technology (ICQUEST2015).

[5] "Design and analysis of AL 7075 steering knuckle components", C.Aravinth, M.V.Ram Pradeep, International Journal of Pure and Applied Mathematics, Volume 118 No. 24 2018.

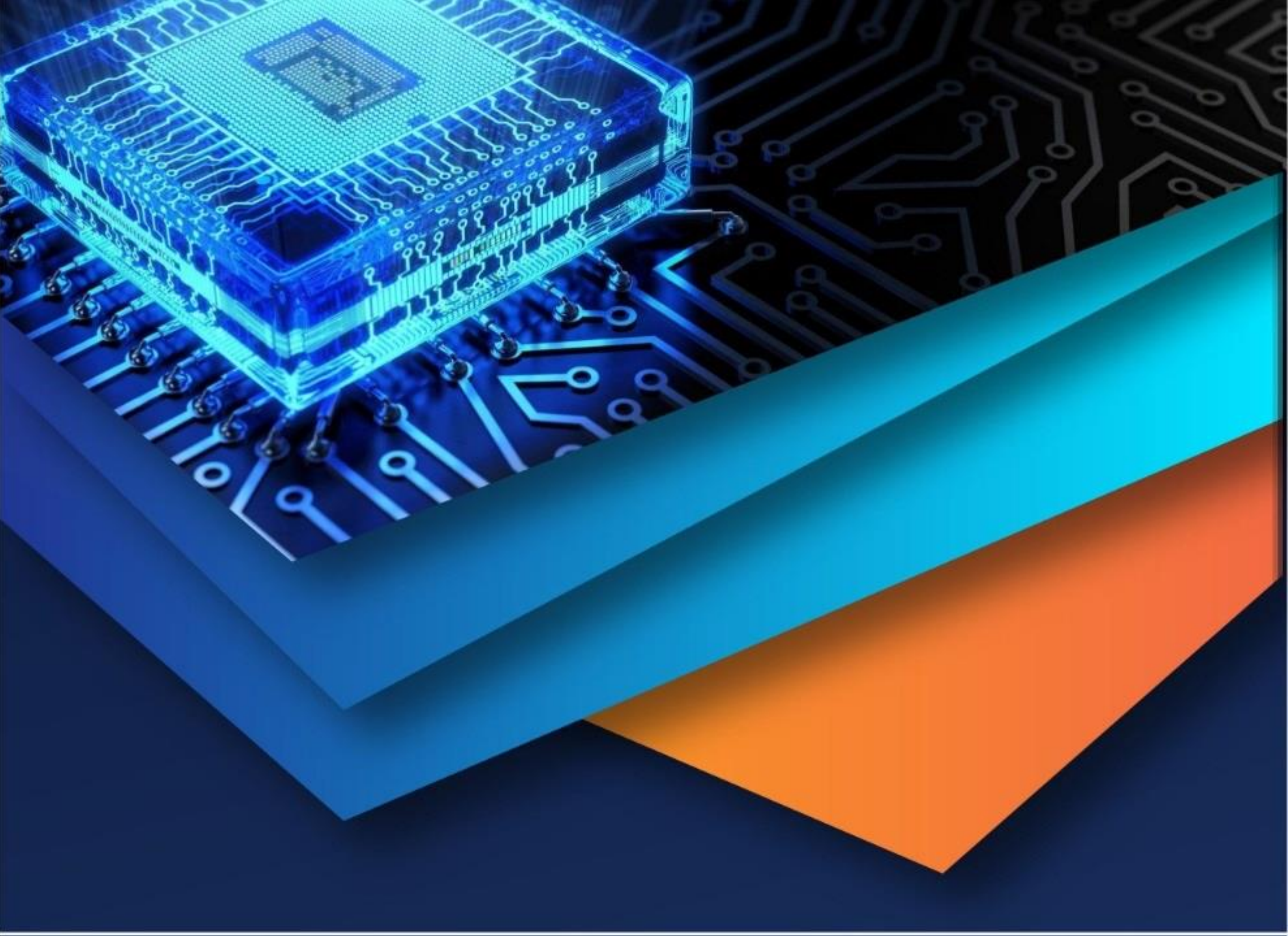
[6] "Design and Analysis of Steering Knuckle Component", Sanjay Yadav, Ravi Kumar Mishra, Varish Ansar1, Shyam Bihari Lal, International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 04, April-2016.

[7] "Design and Development of Steering Knuckle with Spindle and its Optimization- A Review", Mr. Ankur V. Kamble, Prof. S. S. Patil,

[8] Analysis of Steering Knuckle of All Terrain Vehicles (ATV) Using Finite Element Analysis, S V Dusane, M K Dipke and M A Kumbhalkar IOP Conf. Series: Materials Science and Engineering 149 (2016) 012133, IConAMMA-2016.

[9] "Structural Analysis of Steering Knuckle", Mr.B.Saravanan, H.Kebin, V.Mani, A.Nirmal bharath, International Journal of Scientific Development and Research (IJSDR), Volume 4, Issue 3.

[10] "Design and ANSYS analysis of Components of Wheel Assembly of SAE Car", Sameer Santosh Mahadik, International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.



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