Design and Numerical Analysis of steering knuckle for ATV

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ABSTRACT

Steering knuckle is the most stress sustaining and critical component of ATV. It is a Steering knuckle is the pivot point of the steering and suspension system which allows the steering arm to turn the front wheels. The knuckle is modeled in Solid works software andaj analysis is carried out in Ansys workbench. The knuckle is tested under different loading conditions like Bump, Cornering and Braking. For carrying out the analysis two types of materials are chosen. They are Mild steel AISI 1018, Al-6082-T6 and Grey Cast iron. After analysis the material that has less deformation and good factor of safety is selected and further the analysis was done.

Keywords: *Knuckle, Factor of safety, Total deformation, Cornering, Braking, Structural steel, Al-6082-T6, Grey Cast Iron.*

INTRODUCTION

The wheel assembly of an ATV generally comprises of a wheel rim attached to a hub and fastened using 4 bolts. Further the brake rotor is also mounted on this hub and through the hollow axis of this hub the spindle from the upright passes which supports the hub. The hub is mounted on the spindle using 2 roller bearings designed as per the requirement.The hub and upright are designed custom to reduce the weight of the wheel assembly and provide appropriate strength to the wheel assembly components. The components are designed to ensure the safety of the driver and also functional. The advanced optimization techniques help to explore the light weight

architecture. The process of designing light weight Knuckle from scratch which can be applicable for many casting components. The objective is to verify model for all the required extreme loads & the durability load which helps for significant mass reduction from model

I. Material selection and Design procedure for steering knuckle

A Steering Knuckle is one of the critical components of vehicle which connects brake, suspension, wheel hub and steering system to the chassis. It undergoes varying loads subjected to different circumstances, while not distressing vehicle steering performance and other desired vehicle characteristics.

The forces acting on the steering knuckle are due to forces created by the tire due to static or dynamic conditions when vehicle is stationary or in running conditions. Analysis of steering knuckle is done in ANSYS for these forces which are acting on it. Forces are due to static load of vehicle, steering effort, breaking force and due to constraints of the vehicle. Cad model created in solid works in imported into ANSYS for analysis.

Material selection

We had three most preferred material options used for steering knuckle like structural steel ,aluminium alloy and grey cast iron to carry forward our design procedure. Material to be selected should have properties and characteristics such as tough, ductile, malleable and good tensile strength. Also selected material should be suitable to be used as knuckle, which principally designed as a support, so it needs materials which suit the properties, and also availability. Three essential criteria for material selection are mechanical, chemical, and physical properties. Such as white cast iron, S.G. (ductile metal), and grey cast iron that is preferred to be material of the steering knuckle.

Properties of Structural Steel:

Fe	C	Mn	P
98.60%	0.29%	1.03%	0.04%

Table-1 structural steel composition

Properties:

• Density = 7870 kg/m3.

• Tensile yield strength = 250 MPa.

• Ultimate tensile strength =460 MPa.

• Young's modulus = 200 GPa.

• Shear Modulus = 77 GPa.

Properties of Aluminium Alloy:

Al	Si	Mg	Mn	Fe	Cr	Zn	Cu	Ti
95.2-98.3	0.7-1.3	0.6-12	0.4-.10	0.05	0-0.025	0-0.2	0-0.1	0.1

Table2. Aluminium- alloy composition

The properties of alloy material are as follows:

• Density = 2710 kg/m3.

• Tensile yield strength = 270 MPa.

• Ultimate tensile strength = 330 MPa.

• Young's modulus = 71 GPa.

• Shear Modulus = 26 GPa.

Properties of Grey Cast iron:

Fe	C	Si	Mg	P	S
93.2-94.1%	3.2-3.5%	1.8-2.4%	0.5-0.9%	<=2%	<=2%

Table-3 Grey Cast Iron composition

The properties of grey cast iron:

• Density = 7200 kg/m3.

• Tensile yield strength = 0.

• Ultimate tensile strength = 240 MPa.

• Young's modulus = 110 GPa.

• Shear Modulus = 42 GPa

Static Analysis

The load type which will be given is Static load, Moment braking force, and Cornering force. This simulation will be conducted in extreme condition to Accommodate big force that could actually happen. There are four types of load as follows:

1. Static Load
2. Cornering Load
3. Braking Load
4. Moment Braking Load

Static load is the amount of weight that is held by knuckle ;the braking force is longitudinal load transfer during braking, then cornering is the force that pushes when knuckle starts to cornering. Moment braking force is applied in brake mounting, the braking moment is calculated by multiplying brake force with distance from center point of the knuckle to the center point of brake mounting. Knuckle is designed to withstand the car and the driver's mass, which is approximately 370 Kg for four wheels.

Load Calculation

Total weight of the vehicle = 370 Kg.

Weight on front portion of vehicle = 50% = 185 Kg.

Weight on rear portion of vehicle = 50% = 185 Kg.

For one wheel = (185/2) = 92.5 Kg.

Loading types:

Bump condition = 3G = (3*9.81*92.5) =2722.275 N.

Cornering condition= 3G = (3*9.81*92.5) = 2722.275 N.

Braking force =1.5G = (1.5*9.81*92.5) = 1361.137 N.

Force acting up on each brake mount =(1361.137/2) = 680.568 N.

Distance from knuckle centre to brake mount = 80 mm.

Moment acting up on each mount = (brake force per Mount*perpendicular distance)

=(680.568*80) = 54445.5 N-mm.

Moment on upper brake mounting point = 54445.5 N-mm.

Moment on lower brake mounting point = 54445.5 N-mm.

II. MODELING AND ANALYSIS

In the present work the knuckle is modeled in Solid works and further the analysis was carried out in Ansys workbench. During modeling the kingpin inclination is taken as 4-5 degrees for positive steering of the vehicle. The holes provided at the hard points are 15mm diameter which is suitable to use all the Original Equipment Manufacturer ball joints.

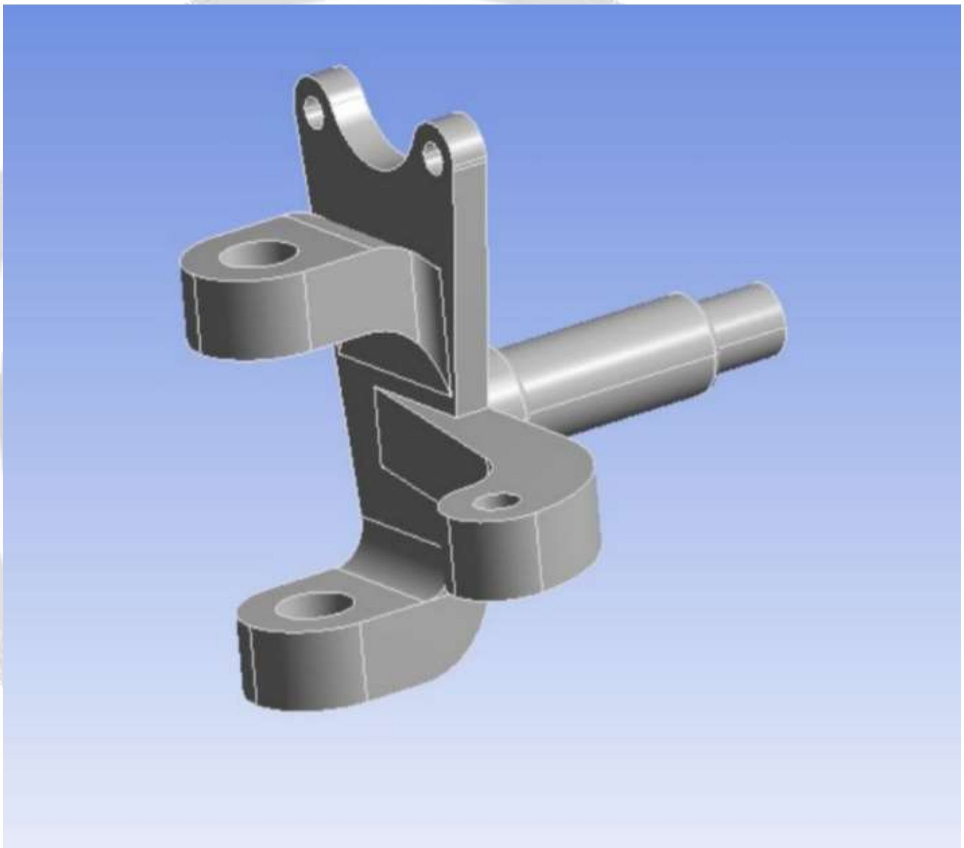


Fig: CAD Model of the steering knuckle

Analysis of structural steel:

The figure below shows stress distribution and total deformation of structural steel on ANSYS workbench.

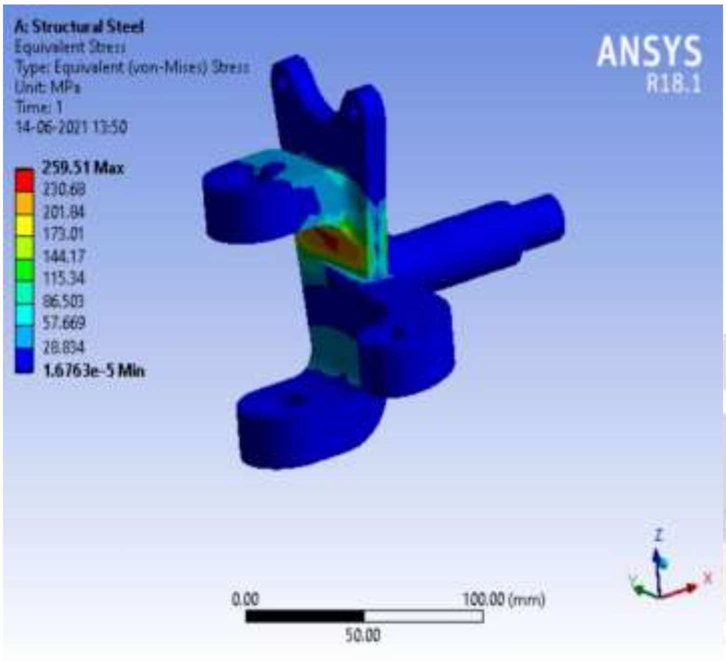


Fig: stress distribution of structural steel

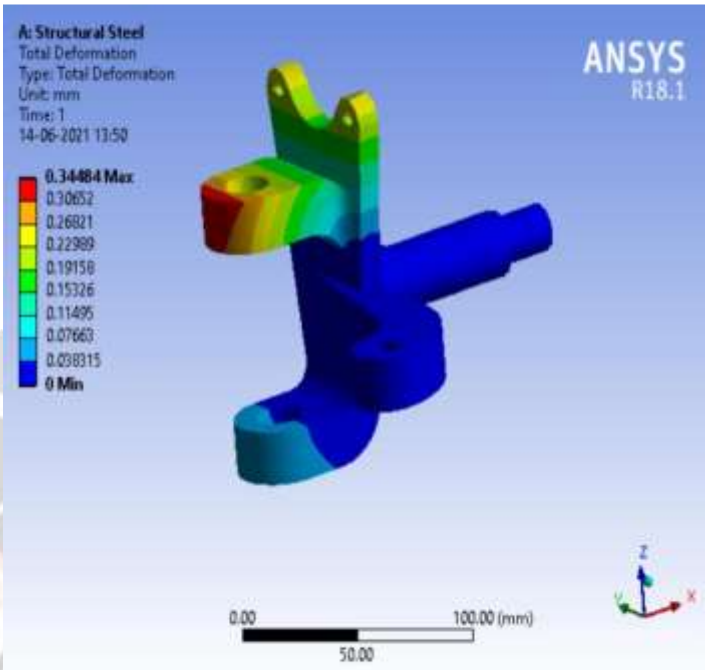


Fig: total deformation

Analysis of Aluminium alloy :

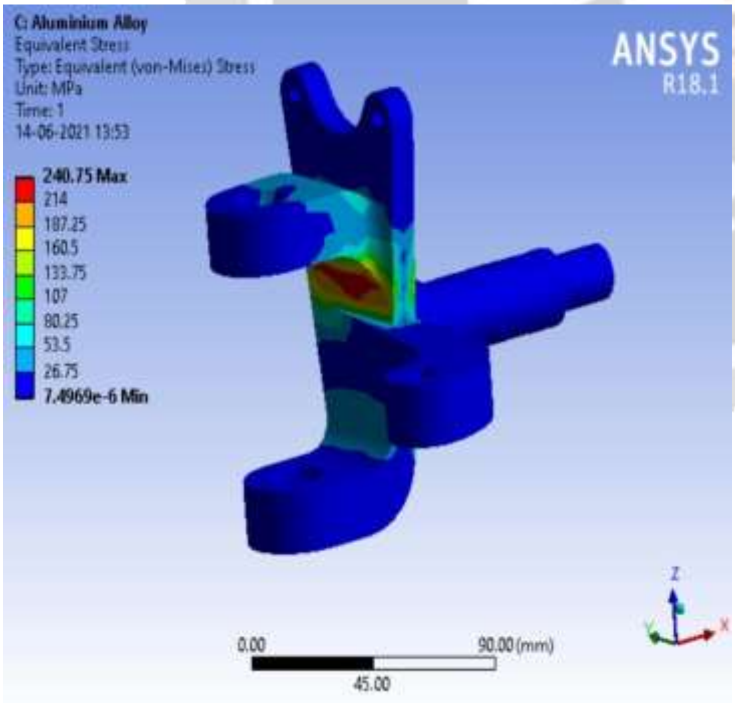


Fig: stress distribution of Aluminium alloy

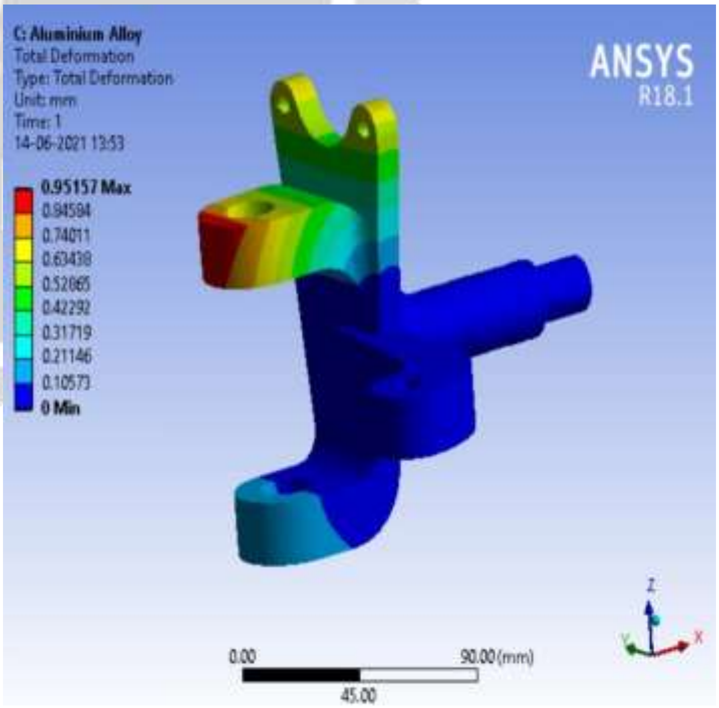


Fig: total deformation of Aluminium allo

Analysis of Grey Cast iron :

Fig: stress distribution of Grey Cast iron

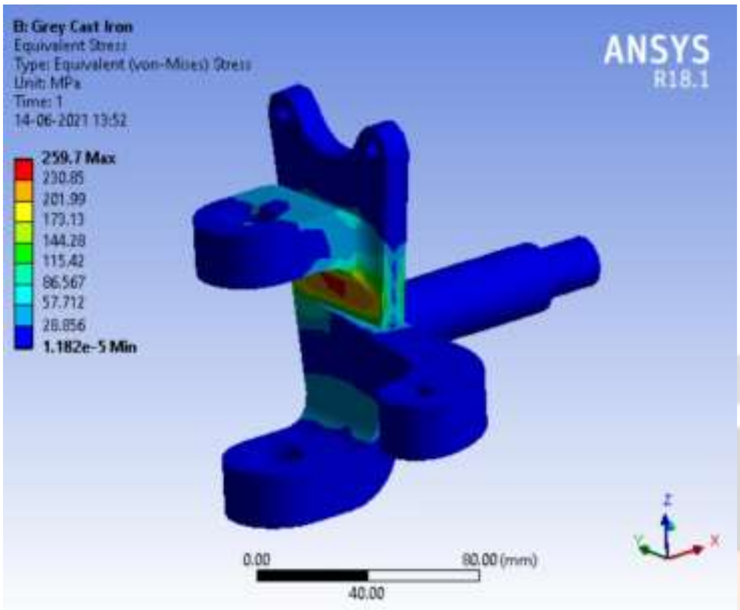


Fig: total deformation of GCI

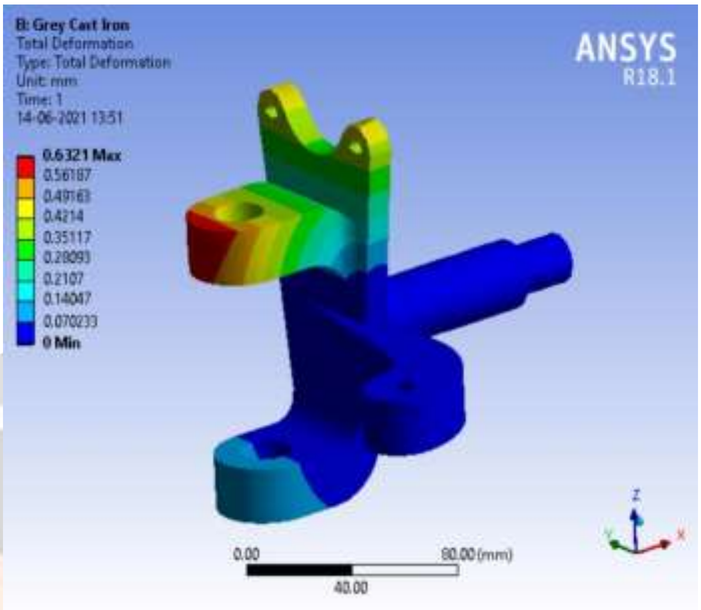
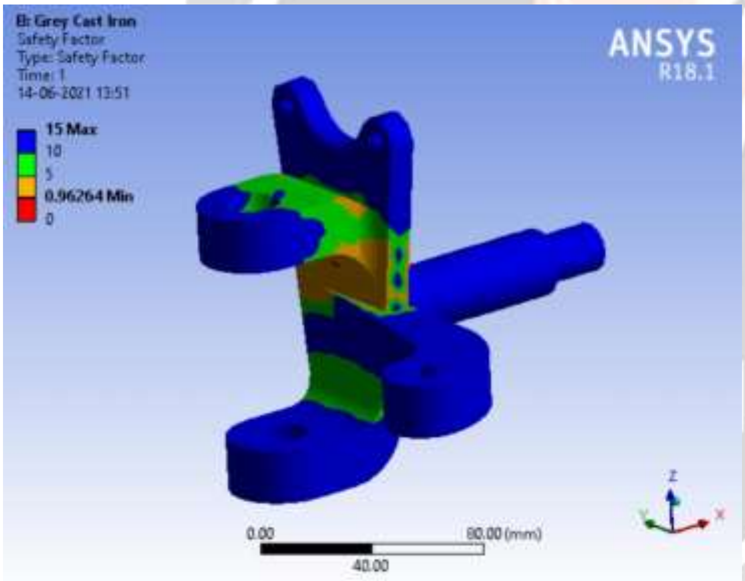


Fig safety factor



III. RESULTS AND DISCUSSION

Structural steel:

The stress distribution and total deformation of structural steel

Maximum equivalent stress = 259.51 MPa

Maximum total deformation = 0.34484 mm

Aluminium alloy:

The stress distribution and total deformation of Aluminium alloy

Maximum equivalent Stress = 240.75 MPa.

Maximum total deformation = 0.95157 mm.

Grey cast iron:

The stress distribution and total deformation of Grey cast iron material.

Maximum Stress distribution = 209.7 MPa.

Maximum Total Deformation = 0.6321 mm.

Figure of safety factor shows the safety factor number gets 15 for Maximum and 1 for the minimum. 5 is safety enough, because the minimum target is 3. It’s as expected before, that stress is spreaded evenly in the knuckle, and this situation didn't make the only little area that holds so the displacement of the knuckle is minimum. And because of it, this knuckle gets high safety factor

IV. CONCLUSION

the result above, the range of safety factor is discovered about 5 until 15; this shows that the knuckle design is very safe to withstand a load of 2722.27N and 1361.137 N for cornering force, and moment braking force, and there is no significant deflection happened after load. The right choice of material determines the strength of the knuckle. Steel is suitable for knuckle material because of its mechanical properties, which is hard and tough, ideal for the knuckles property needs.

V. REFERENCES

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