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DESIGN AND ANALYSIS OF REAR WHEEL HUB & STEERING KNUCKLE

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***Abstract*—The paper describes process of design and fatigue analysis for rear wheel hub & steering knuckle. Wheel hub & steering knuckle in automotive system are attached wheel to motor shaft (axle) and provide the support to the tie rods, connect the trailing arm from chassis to the rear wheel, fastening of brake caliper respectively. while we designing the wheel hub & steering knuckle that time have to work on mainly overall shape, material specification, size, surface finish and appearance, easy to fastening & handling. Because rear wheel hub & steering knuckle is undergoing radial load, axial load, tangential load, fatigue load during running condition in the various automotive system. The Finite element analysis (FEA) is used after designing process for checking factor of safety and what would be possible changes that can provide adequate design of it. And by using FEA we can select the exact material from the others by which we can made light weight wheel hub & steering knuckle with adequate properties so, it will survive against different load condition with higher factor of safety.**

***key words*: wheel hub & steering knuckle, material selection, Design, Finite element analysis (FEA), light weight, factor of safety.**

I. INTRODUCTION

The main aim behind the study of design and analysis for rear wheel hub & steering knuckle is to what importance of wheel hub & steering knuckle in automotive system and how can we make adequate design of it with required material. And in every automotive we have to count wheel hub & steering knuckle as a critical part because both are help to connect chassis to wheel. So, we can't imagine any automotive system without wheel hub & steering knuckle because while transmitting the motion from power plant (engine) to wheel the wheel hub & steering knuckle must be necessary. Wheel hub is located between brake caliper and knuckle. While knuckle is located between trailing arm (rear suspension system only). For 3-d modelling of hub and knuckle we use Solid works. After modelling we are going to tested wheel hub & steering knuckle again all various load condition by performing stress-strain analysis using of ANSYS 16.0 Workbench. The reason behind conducting of stress-strain analysis for while ATV is running on the off road that time wheel hub & steering knuckle are undergoing various torque, thrust, and different load condition So, we can make adequate changes in the design for higher factor of safety.

II. DESIGN OF WHEEL HUB & STEERING KNUCKLE

A. SELECTION OF MATERAIL

While we designing any part of automotive system its involves so many things likewise material selection, cross section determination, adequate strength, light weight, higher factor of safety. Among them material selection is very important because its affect total cost, power transmission efficiency, density, material availability total weight, manufacturing methods (i.e. while we using Al for wheel hub & steering knuckle but casting of Al is like impossible so due to that we have to go for CNC or VMC machining). For the final selection of material is showing below with considering all affecting variable.

We are going to participate in SAE BAJA 2016 event (sae baja is off road ATV championship). And there are so many prize for light weight design and light weight is also give advantages in Maneuverablitiy race. Below table shows various material wheel hub & steering knuckle.

Material for wheel hub	Tensile ultimate (MPa)	Tensile Yield (MPa)	Young modulus (GPa)	Density (Kg/mm^3)
AISI 1026	490	415	205	7858
Al alloy	310	276	68.9	2880

Table 1 Material Comparison for wheel hub

Material for steering knuckle	Tensile ultimate (MPa)	Tensile Yield (MPa)	Young modulus (GPa)	Density (Kg/mm^3)
Al alloy 2011 T3	310	280	70	2770

Table 2 Material Comparison for steering knuckle

As per the information from table we are going to select AISI 1026 material for wheel hub because it is easily available, cheap, adequate mechanical properties form the other material.

And Al alloy also costly and casting is not possible so at the end CNC/VMC machining cost will be added. There will be negligible difference in weight of wheel hub by using Al alloy instead of AISI 1026.

For the steering knuckle we are going to use Al alloy 2011 T3 the main reason behind selecting the material is light weight with adequate strength. Now days mostly automotive company make their steering knuckle from Al alloy 2011 T3 (with poison ratio 0.33). For the alloy all chemical properties of steering knuckle are given below.

Chemical materials	Percentage (%)
Silicon (Si)	0.40 % Max
Iron (Fe)	0.70 % Max
Copper (Cu)	5.0 - 6.0 %
Lead (Pb)	0.20 – 0.60 %
Bismuth (Bi)	0.20 – 0.60 %
Zinc (Zn)	0.30 %
Aluminum (Al)	91.2 – 94.6 %
Other(Total)	0.15 %

Table 3 Chemical properties of Al alloy 2011 T3

B. DESIGN OF STEERING KNUCKLE & WHEEL HUB

Design of wheel hub is very crucial part because we have to search standard dimensions of wheel bearing available. Wheel bearings are allowing to rotate to wheels with minimum friction, and they also support weight of vehicle. Mostly a tapered roller bearings are used because it will sustain both radial and axial load. If wheel bearing failure occur that time wheel separate from the vehicle and driver can be loss the control over steering. Design of hub is given below:

*

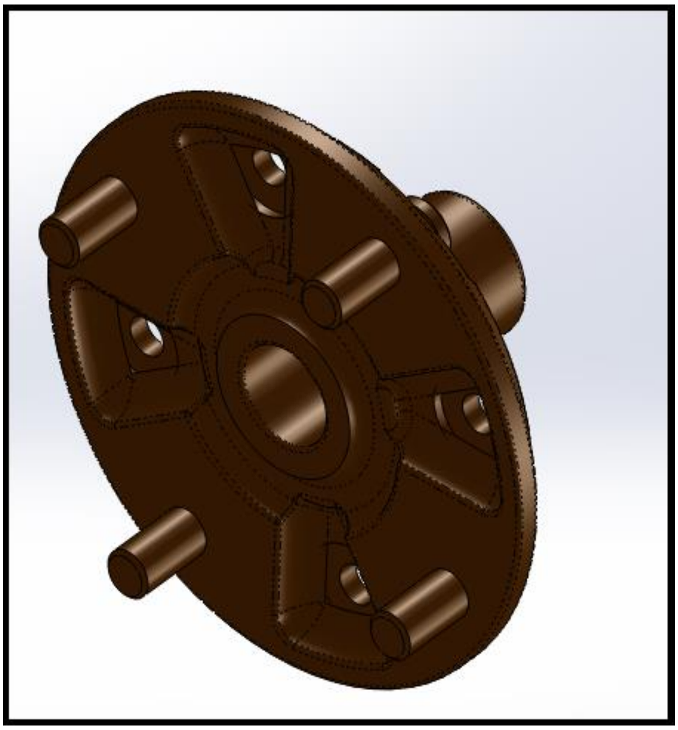
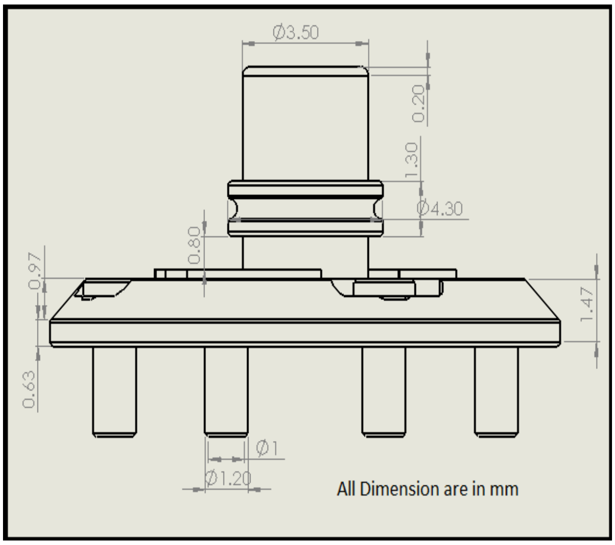


Fig 1 3-D modelling of wheel hub



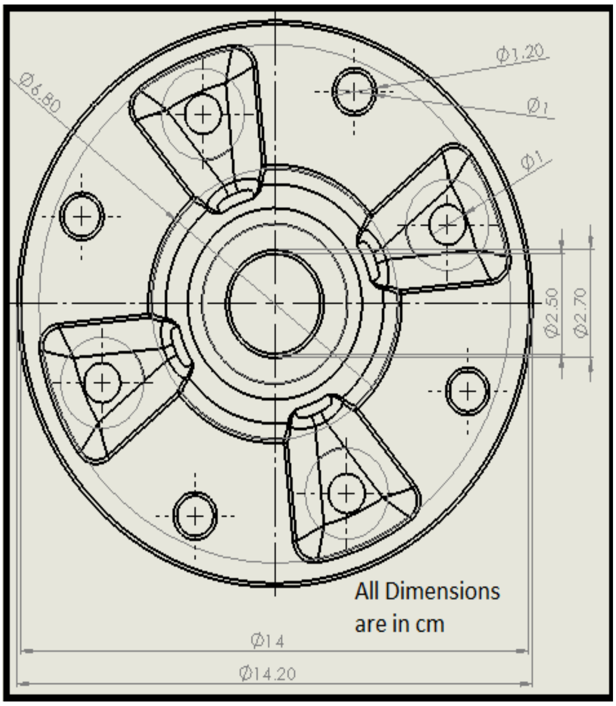
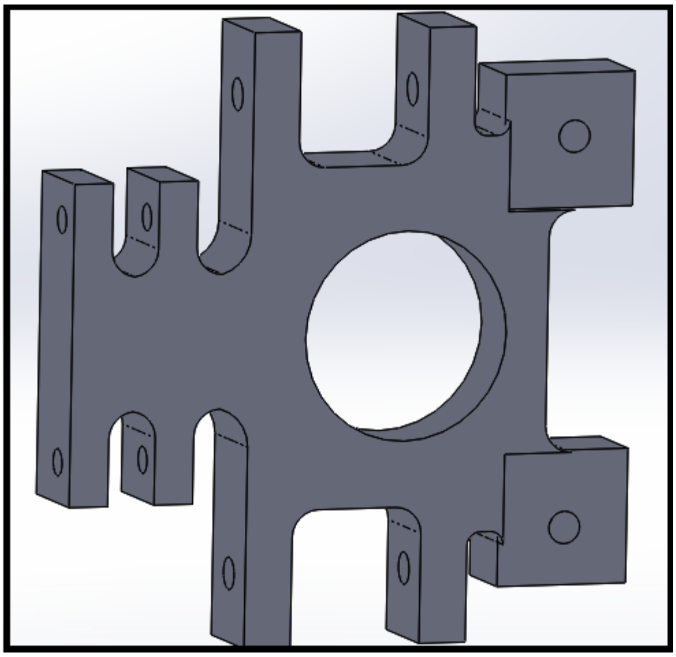


Fig 2 2-D Diagram of wheel hub with exact dimensions (cm)

For wheel hub & steering knuckle 3-D models are done into Solid works software. Steering knuckle design is given below with 2-D & 3-D sketches for better understanding.



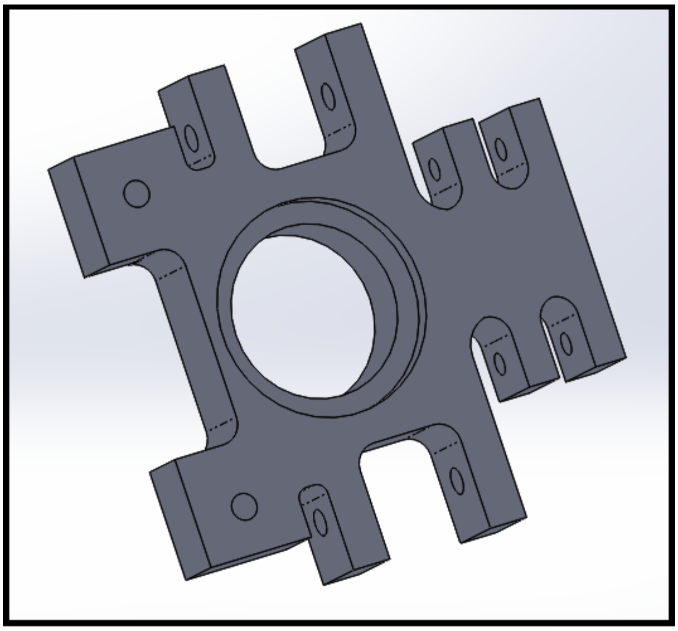


Fig 3 3-D diagram of steering knuckle

For manufacturing of steering knuckle we are going to use VMC machining so below down manufacturing 2-D drawing sketch with exact dimensions is given:

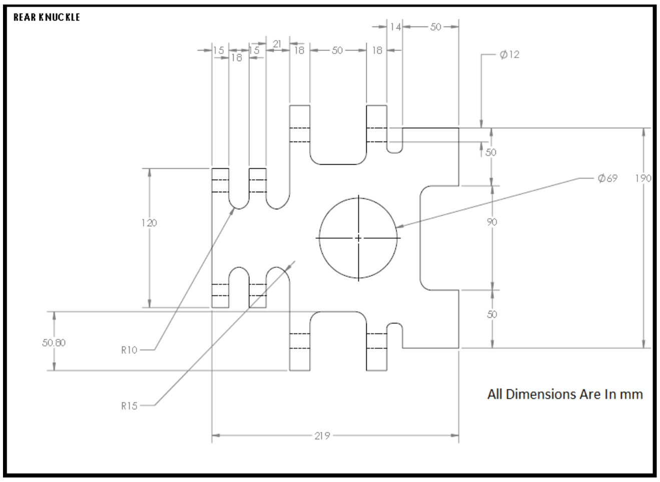


Fig 4 2-D diagram of steering knuckle with dimensions

III. FINITE ELEMENT ANALYSIS (FEA)

I. FEA OF WHEEL HUB

After finalizing 3-D models of wheel hub and steering knuckle we are going to perform FEA analysis against loading condition to check factor of safety against and strength. And we also determine the life of cycle for both.

LOADING CONDITIONS:

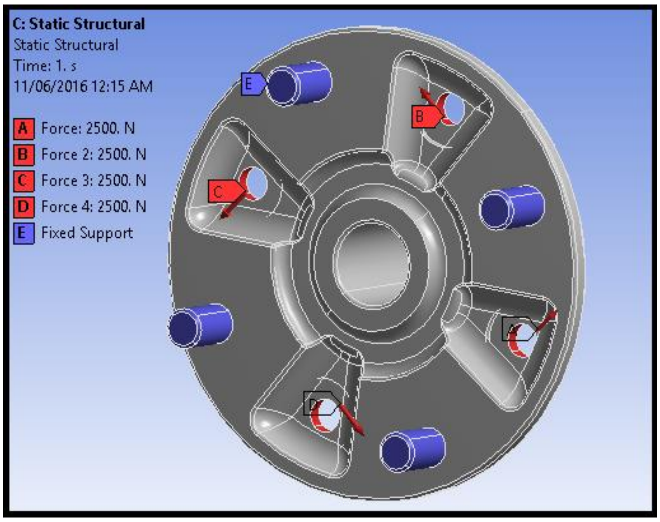


Fig 5 loading conditions for wheel hub

While we applying breaks that time brake pads are trying to stop wheel but tendency of wheel is rotate after applying break due to its moment of inertia. So, we applied radial force of 2500 N at positons of bolt where brake plate is mounted and fixed support is providing at positon of bolt where wheel rim is going to be mounting.

Results:

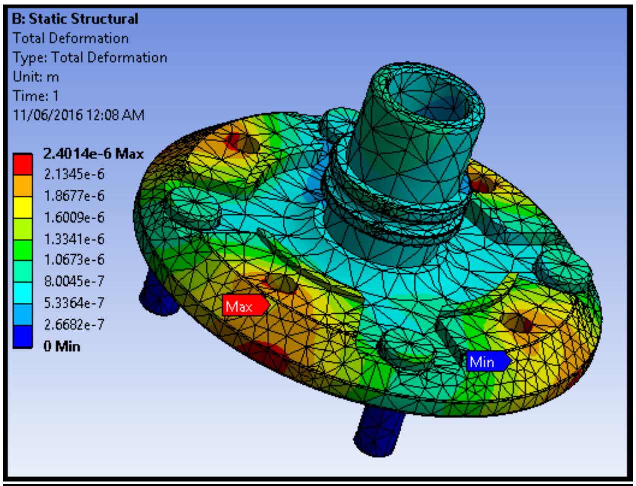


Fig 6 total deformation of wheel hub (AISI 1026)

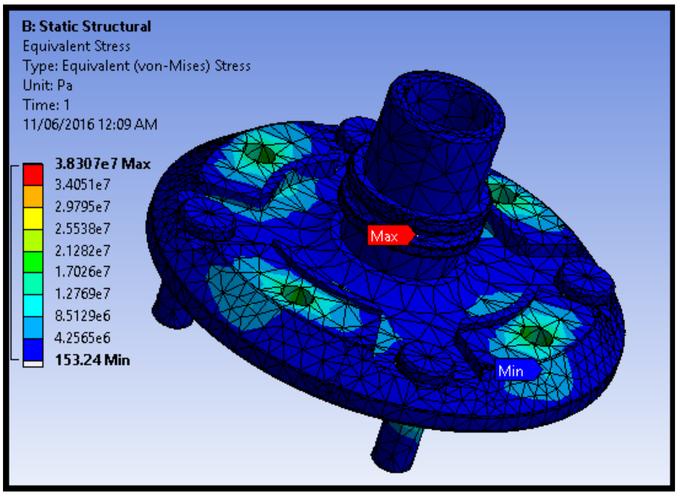


Fig 7 Maximum vonmises stress (AISI 1026)

Total deformation = 2.4 mm
Maximum vonmises stress = 38 (N/mm^2)
Factor of safety = 1.5

So, we can say that our design is safe against failure. And weight of wheel hub is around 1.7 kg if we make it from AISI 1026. Now we are going to check the same load condition with other material Al alloy.

The loading conditions is going to same but material properties are going to change. which is shown in below figures.

Results:

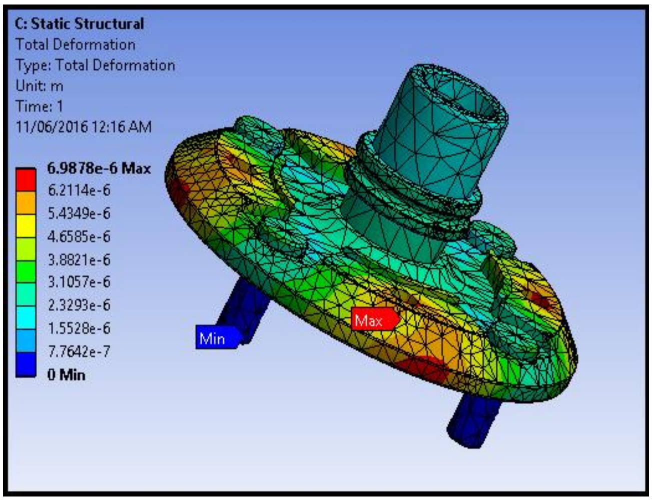


Fig 8 Total deformation of wheel hub (Al alloy)

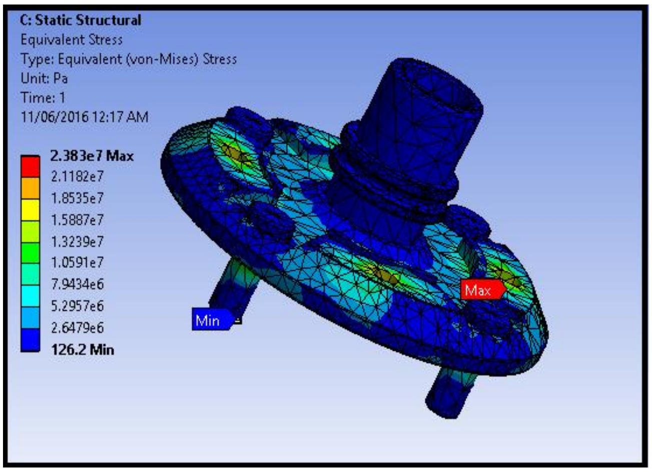


Fig 9 Maximum vonmises stress (Al alloy)

Total deformation = 7.0 mm
Maximum vonmises stress = 238 N/mm^2
Factor of safety = 1.3

So, we can say that our design is safe against failure. And weight of wheel hub is around 1.5 kg if we make it from Al alloy. We are not using this material because deformation high than first one. We are not using Al alloy instead of AISI 1026 because deformation is high in Al alloy made wheel hub and factor of safety is also less than AISI 1026. That's why we are going to manufacture wheel hub from AISI 1026.

IV.FEA OF STEERING KNUCKLE

Loading conditions:

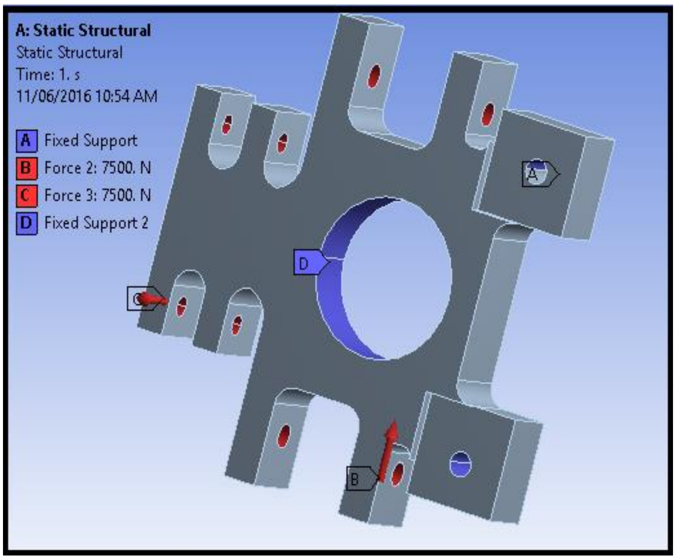


Fig 10 loading conditions of steering knuckle

As we can see in the sketch that various loading conditions are showing. At square cross section brake pads are going to mount. After that upper and lower trailing arm are going to mounted by using various sizes of rubber bushes. At last two tie rods are going to mount. According to that we apply load to every point and fixed at brake pads mounting point and rear axle mounting hole.

Results:

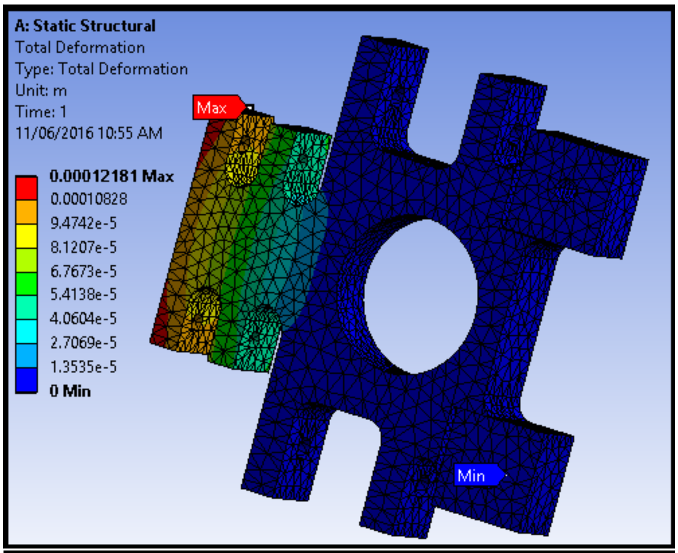


Fig 11 Total deformation of steering knuckle (Al alloy 2011 T3)

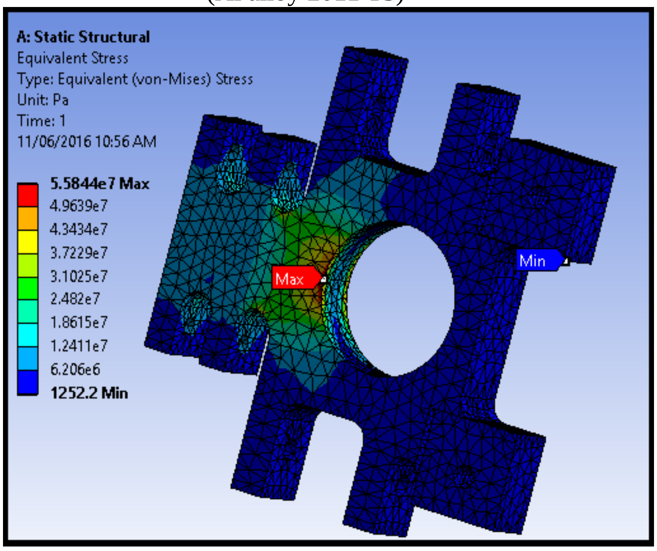


Fig 12 Maximum vonmises stress (Al alloy 2011 T3)

Total deformation = 0.121 mm
Maximum vonmises stress = 558 N/mm^2
Factor of safety ≈ 2.0

Here from the result we can say that our design is safe against failure. And weight of steering knuckle is around 1.4 kg if we make it from (Al alloy 2011 T3). Now we are going manufacture knuckle by using VMC manufacturing process and reason for using this machining process is high accuracy with good surface finish and also machining process is fast without wasting so much of raw material.

So, this is the FINITE ELEMENT ANALYSIS of wheel hub and steering along with its design.

V. CONCLUSION

We can conclude from this paper is that when we designing any part material selection is very important and by FINITE ELEMENT ANALYSIS (FEA) we can check its strength, rigidity and factor of safety for our product. It FEA is very important when we design steering knuckle & wheel hub because both are very critical and crucial in the automobile system. And using of 3-D modelling software we can know about the weight of designed part, modification is fast, time & cost saving process. By use of FEA we don’t have to perform Destructive test again various load condition and is also time saving analysis process, we can also know about weak cross section of part so we can take precautions from failure of it. So using Solid Works and ANSYS types software helpful to make adequate design with high strength, rigidity, light weight and with higher factor of safety.

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