# High Performance Steering Knuckle

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**Abstract -** *The steering knuckle is the most common part of any four wheeled vehicle, it's found in the front, connecting the front hub to the front suspension arms and is also responsible for brake caliper mounts and a steering arm. The steering knuckle is accountable for many vital tasks such as holding the weight of the vehicle, withstand cornering and braking forces. The design of a steering knuckle affects the characteristics of the suspension geometry as it determines the steering axis inclination (king pin inclination), caster etc. this study involves reimaging the design of a steering knuckle to reduce its weight while improving its performance characteristics, the knuckle is designed in 3 steps, the design constraints is collected from steering, suspension and brake assembly requirements, its modelled in Creo parametric 5.0 and then tested in Ansys workbench 19.2. The initial ideation is validated and improved upon, when the design philosophy is finalized a detailed model is used for analysis for testing the strengths and weakness, after the analysis material can be added or removed for under designed or over designed elements respectively. This steering knuckle is designed to be light weight and to perform under off road conditions on a Baja race vehicle therefore withstanding at least 200 hours of runtime (testing + race) for aspects of the entire paper in the following prescribed sequence.*

***Key Words*: Steering Knuckle, King Pin Inclination, Caster, Ansys, Creo**

## 1. INTRODUCTION

The steering knuckle is one of the most crucial part in the vehicle. It is attached to the suspension components; the steering knuckle holds the front wheel and allows it to pivot. It is used as a connecting point between suspension and steering. Even slight damage of the steering knuckle can affect the proper wheel alignment and disturb the stability of the vehicle. The main function fulfilled by the knuckle is that it converts the linear motion of tie rod into angular motion for stub axle. An ideal knuckle should be strong, rigid and lightweight. The knuckle has to bear various loads such as axial load, inertial load, bending load and stresses generated due to the mentioned loads acting on it. This knuckle is designed for the vehicle weight of 160 kg and the material used is Al7075. Conventional automobiles have a steering knuckle which is typically constructed as a one-piece forged or cast unit. Such integral units may include a wheel bearing, brake calliper mounting and points of attachment for suspension components. Although these knuckles have satisfactory performance, it is desirable to provide enhanced structural and cost optimization. It is mainly desirable to reduce the weight of the steering knuckle assembly since, weight reductions in this area provides two important advantages, firstly reducing total vehicle weight which improves performance and fuel efficiency and secondly reducing suspension unsprung mass desired to enhance vehicle ride and handling. In addition to this, there is a third desirable factor i.e. to provide an improved steering knuckle assembly which can be produced at a lower cost than current designs.

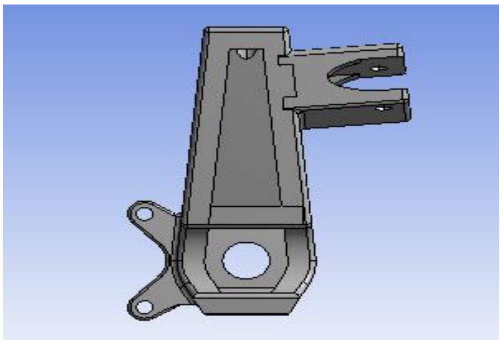
## 2. DESIGN

This design is an improved version of the previous generations that were designed for the same operation. Two major factors were looked at while coming to the concept of this knuckle, weight and endurance.

The model aims to improve the design in such a way that it shows a greater endurance and also saves a fraction of weight. The design was made in Creo Parametric 5.0 around the same constraints such that it proves to be a better part that acquires a similar space within the wheel. The knuckle has three points of contact, the brake mounts, steering and the control arms and a well through which the stub axel is fed around which the hub rotates.

The design was analyzed on Ansys 19.2 keeping a cylindrical support at the mounting posts of upper and lower control arm such that the knuckle remains free to rotate around its axis by virtue of steering input which is 1000N. A load of 1500N was applied to the brake caliper mounts and vertical load of 1400N was also taken into account which is due to the vehicle weight with driver.

The material chosen for the knuckle is Aluminum 7075 which has a Yield Strength of 480 MPa, an Ultimate Tensile Strength of 560 MPa and a Youngs Modulus of 70 GPa.



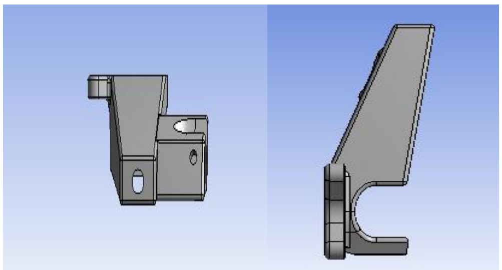


**Fig -1**: Front view, Top view and Side view

### 3. MATERIAL SELECTION

The Material selected for the project is aluminium since the forces are lower, and also it helps keep the weight lighter (the material properties are listed below)

**Table -1:** Material properties

| Material Property | value | unit |
|---|---|---|
| Youngs modulus | 70 | GPa |
| Poisson's ratio | 0.32 | |
| Sheer modulus | 26 | GPa |
| Tensile strength (yield) | 480 | MPa |
| Tensile strength (Ultimate) | 560 | MPa |
| Density | 3.0 | g/cm^3 |

### 4. ANALYSIS

### 4.1 Meshing

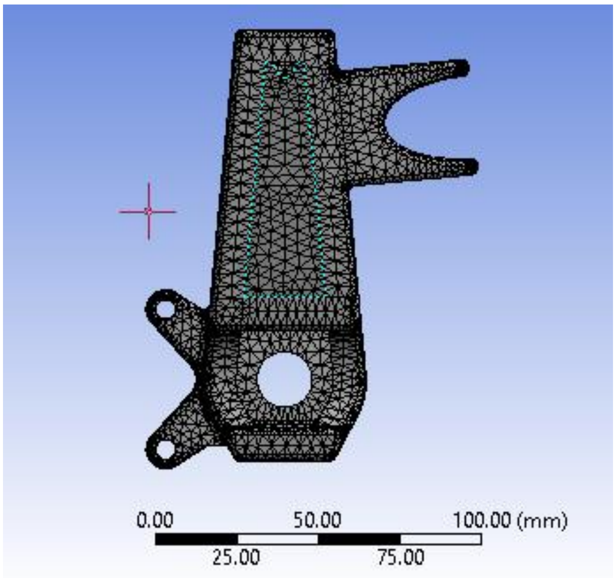



**Fig -2**: Meshing on Ansys 19.2

The Meshing was done on ANSYS 19.2. Element size was taken 2mm throughout the body since it is a small object and analysis time will not have a significant effect. There were no specific refinements given in the mesh since the structural error was negligible. Span angle centre was set to fine with slow transition and high smoothing. The resulting mesh generated 317519 Nodes and 217631 Elements which can be considered a high quality mesh.

### 4.2 Analysis

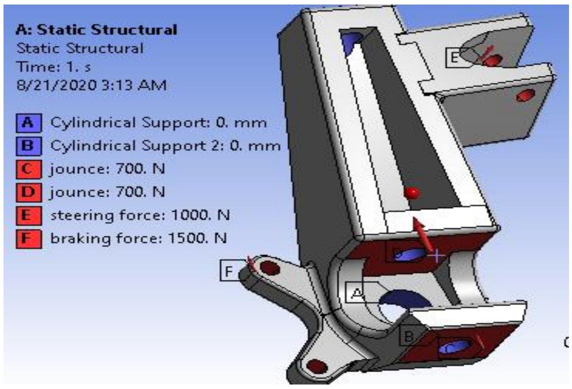



**Fig -3**: Various loads acting on the knuckle

The analysis is performed in ANSYS 19.2 keeping in mind the following considerations and constraints-

1. The forces are applied on 3 components which are: brake caliper mounts (forces according to braking torque), steering arm (forces according to steering force) and Jounce load which is calculated according the weight of the vehicle applied on the Lower control arm mounts. The values of which are 1500N, 1000N and 1400N respectively. It is considered that the jounce will be divided to 4 parts since the total weight is supported on 4 wheels.
2. The mounting for stub axle was constrained, the suspension mounting for both the arms have been cylindrically supported keeping it free only in axial direction allowing it to move according to the steering motion.
3. Deformation could occur at the horizontal axis with respect to the force of the vehicle weight. This could result in bending of the knuckle.

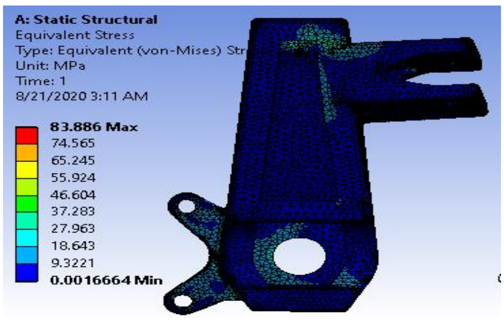



**Fig -4:** Equivalent (von-mises) stress

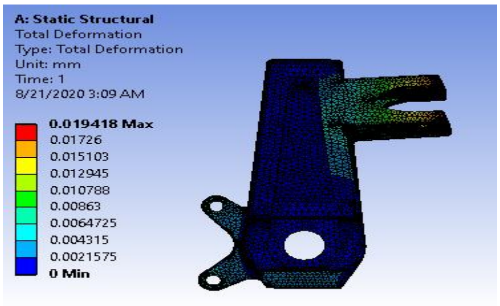



**Fig -5: Total** deformation

## 5. RESULT

The design proves to provide better weight characteristics by 24% (400g to 300g) which improves cornering as the knuckle adds to the unsprung mass of the vehicle, lighter components further reduce the overall weight of the vehicle which improves acceleration, braking and weight to power ratio

## 6. CONCLUSION

The knuckle is modelled in Creo parametric 5.0 and analysis is done on Ansys workbench 19.2. Shape optimization method is used in reducing the weight which improves on the weight characteristics while not bringing any significant change in the stiffness of the structure. The reduced weight lowers the unsprung mass of the vehicle hence improving the ride quality.

## REFERENCES

1. Sanjay Yadav, Ravi Kumar Mishra, Varish Ansari, Shyam Bihari Lal, "Design and Analysis of Steering Knuckle Component" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 5 Issue 04, April-2016

2. Sharad Kumar Chandrakar, Dheeraj Lal Soni and Shohel Gardia -"FEA of A Steering Knuckle for Life Prediction" (International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 6, Number 5 (2013), pp. 681-688.

3. Avinash Singh-"Off Road Suspension Design: Ride and Handling of BAJA buggies"Printed and published in U.S.A by Amazon, Inc.

4. Joijode Vrushabh Umesh and Yadav Abhishek- "Designing and Optimization of Wheel Assembly of a Formula Student Car" (International Journal of Current Engineering and Technology E-ISSN 2277 –4106, P-ISSN 2347 – 5161)

5. V.B Bhandari, Design of Machine Elements, McGraw- Hill Education, 2012.

6. Fundamental of vehicle dynamics, Thomas D. Gillespie, 1992, ISBN 1560911999, 9781560911999

## BIOGRAPHIES

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