Design and Analysis of a steering Rack of an ATV for different materials under static loading conditions

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Abstract: Steering system constitutes an important role in the ergonomics of the vehicle. There are various types of steering system used in different ATV's. Rack and Pinion type of steering system are widely used in ATV's because of their lighter weights and comfort feeling of the driver. The rack and pinion steering systems are also used in lower automotive vehicles and also in light duty vehicles in the world. It constitutes about 50 percent of steering system in worldwide automotive steering sector .The steering rack can be made from various types of materials like PCC, BRASS, MILD STEEL, various alloys containing different configurations at different conditions as per requirement of operations. Rack is also used in door opening and closing of mechanical components. The main aim of this paper is to decide the proper material for the steering rack and to compare its analysis reports for various materials taken under considerations. Designing software CATIA & SOLIDWORKS. Analysis in ANSYS 16.0 edition. Main geometry for design considered for physical product is Ackerman steering geometry.

Keywords: STEERING RACK, Materials , static loading

Introduction:

Rack and Pinion steering system are used in various vehicles in which rack is subjected to various loading conditions and various shear forces acting on it. There are various types of materials considered safe for the manufacturing of rack. The main aim of rack is to transmit rotary motion received from pinion to the linear motion and respectively control the motion of steering knuckle to control the directions of the respective left or right wheel in the angle of the required steering geometry.

Material selection:

The basic materials selected for the testing are

1. Plain Carbon Steel
2. AISI 4130
3. Brass
4. Rubber polymer (synthetic)

There were various materials available for study but the classification of materials chosen was done accordingly to the most distinct categories to be considered for clear difference between materials.

Design:

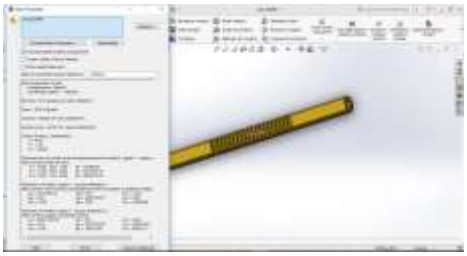
The design of rack was done in Solidworks. The design specifications are as follows
Module=2
Rack Length= 300 mm
Diameter of rack= 22 mm
Minimum Number of teeth on rack= 20 for 44 degree of turn of front wheel.
Rack subjected to force= 294.5 N

Designing Model:

1. **Plain Carbon Steel:**

Mass 766.32 grams

2. **Brass:**

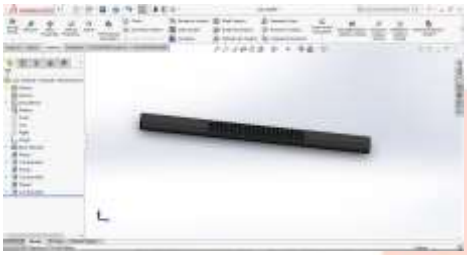


Mass 835.10 grams

3. **AISI 4130:**

Mass 771.24 grams

4. **Rubber:**



Mass 98.25 grams

The above all designs show that the weight of rack changes with change in material properties and configurations.

Analysis Reports:

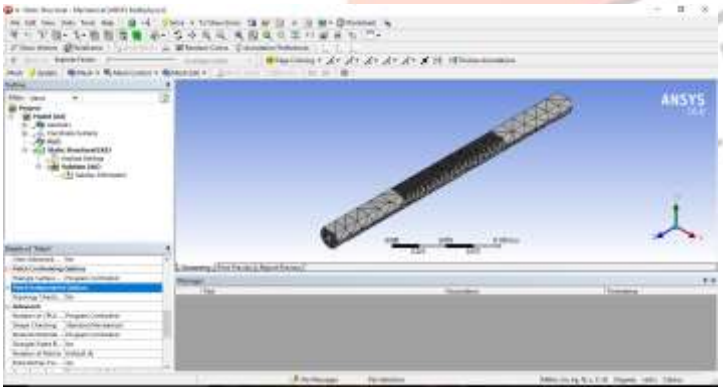
ANSYS is used as analysis software. The various static structural reports generated for different materials are as follows

1. **Plain Carbon Steel :**

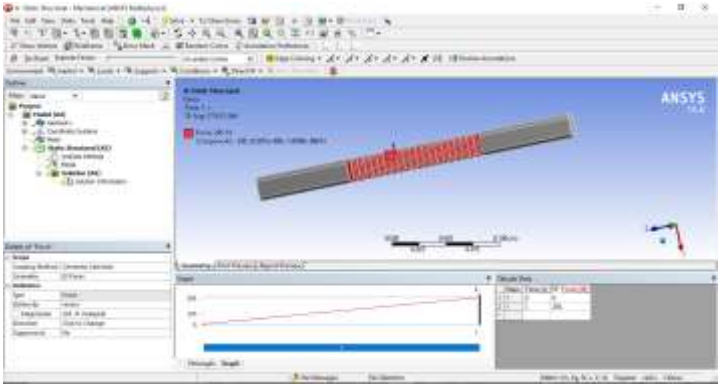
   Meshing type: Coarse mesh

   Nodes= 4926

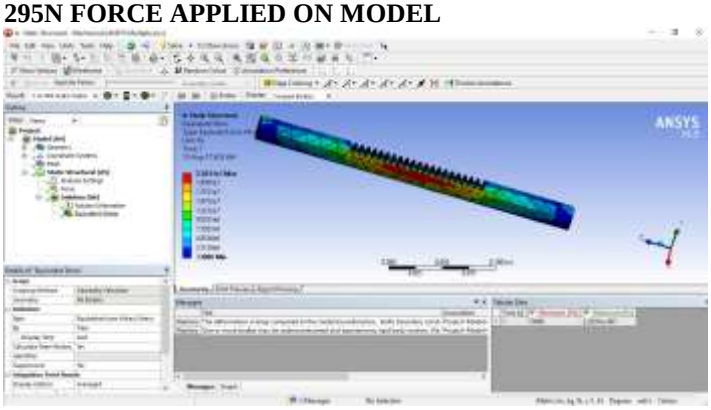
   Elements=2572



MESH MODEL OF PCC

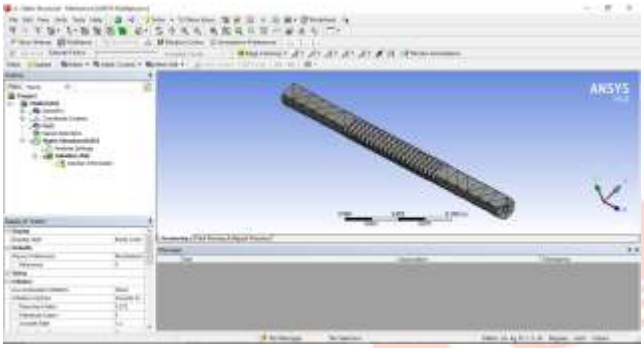


295N FORCE APPLIED ON MODEL

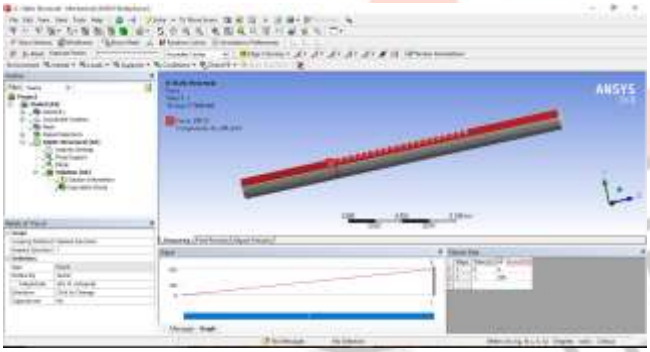


EQUIVALENT STRESS REPORT

2. **Brass:**
   Meshing type: Coarse mesh
   Nodes= 4926
   Elements=2572



MESH MODEL OF BRASS RACK



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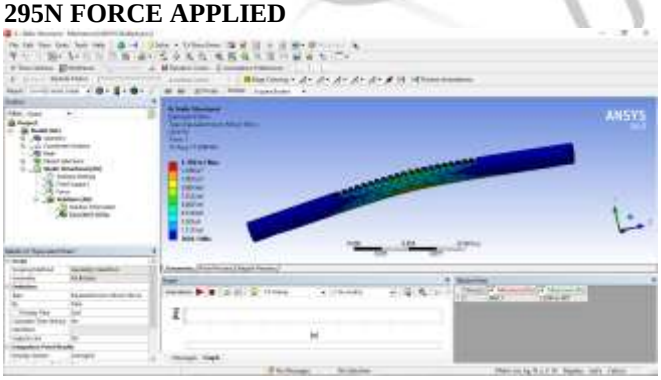
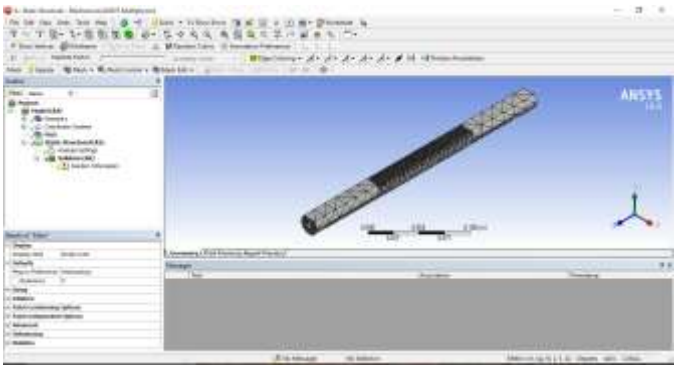
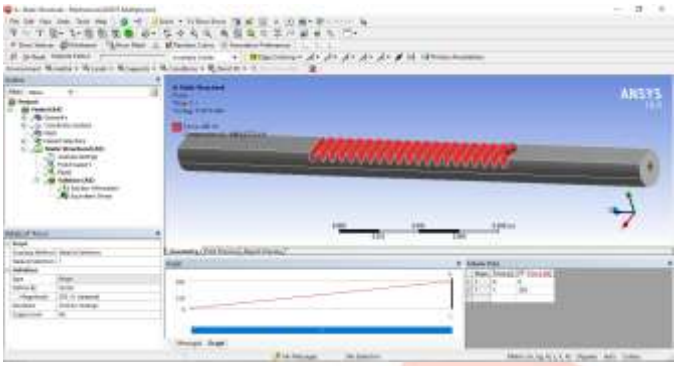


TOTAL DEFORMATION OF BRASS RACK

3. **RUBBER :**
   Meshing type: Coarse mesh
   Nodes= 4926
   Elements=2572



MESH MODEL OF RUBBER RACK



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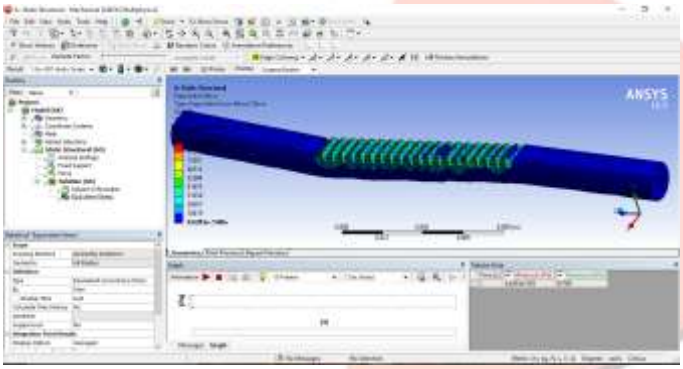
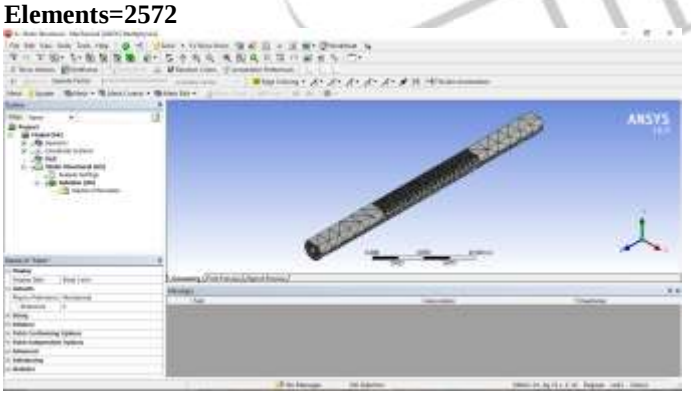
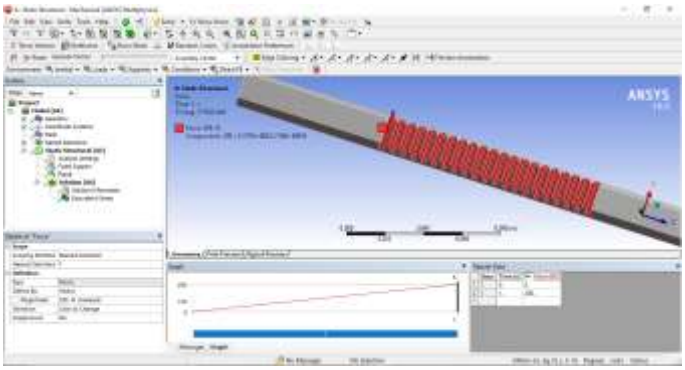


TOTAL DEFORMATION OF RUBBER RACK

4. **AISI 4130**
   Meshing type: Coarse mesh
   Nodes= 4926
   Elements=2572



MESH MODEL OF AISI 4130 RACK



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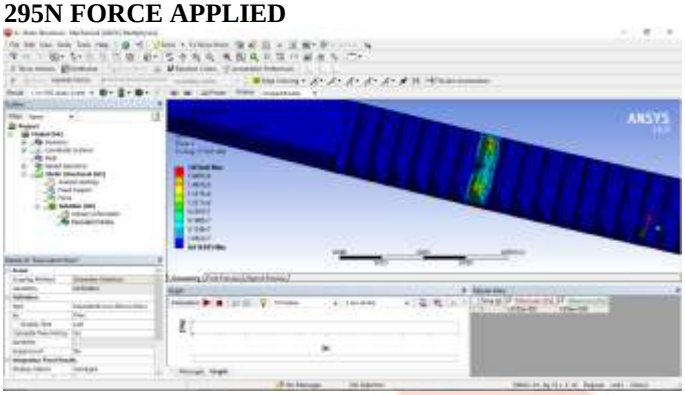

TOTAL DEFORMATION OF AISI 4130 RACK

Conclusion:

The above design and analysis reports proves that the Rubber & Brass are not suitable materials for the rack as they won't sustain the required amount of force under loading conditions. AISI 4130 & PLAIN CARBON STEEL can be used as material for the manufacturing of rack according to the analysis reports above mentioned. The reports also prove that the weight of rack is purely affected by the selection of material .

REFERENCES:

1. Gillespie, Thomas D., Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc., Pennsylvania, 1992
2. Vehicle Dynamics Terminology- SAEJ670, Revise 07-1976.
3. Material Science V.D. Kodgire .
4. Design of machine elements V.B. Bhandari
5. William F. Milliken and Douglas L. Milliken, 1995, "Race Car Vehicle Dynamics", Society of Automotive Engineers, Inc.