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Adjustable Pull-Rod Suspension System

Swaraj Kashid[1], Gaurav Parate[2], Gaurav Gaikwad[3]

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Abstract – The main criteria of this project was to design a length-adjustable pull-rod for a double-wishbone pull-rod suspension for an FSAE automotive. Pull-rod suspension and push-rod suspension confer with a specialized kind of automotive suspension that is supported by a double-wishbone system. The modeling of components is finished in the SOLIDWORKS software system. Later, the structural analysis for the component was executed on ANSYS software system. This study helps to understand the stresses, strains, and total deformation which are focused on inbound areas. Also, the factor of safety is determined. These parameters can facilitate deciding if this component is safe for use.

***Key Words*: Formula student, Pullrod analysis, Double wishbone suspension, ANSYS, Solidworks, Turnbuckle**

1. INTRODUCTION

The function of an ideal suspension is to handle the bump, rebound, and load transfer forces in a dynamic state. And a pull-rod plays an important role in this. One end of the pull-rod is mounted on the upper wishbone which points down towards the bell crank. Pull-rod is an assembly which when the vehicle goes over a bump pulls the mechanism downwards putting the pull-rod in tension, Pull-rod acts in the same direction of cornering load of outer wheel and hence transfers the motion to the damper. This keeps the mechanism stable and in contact with the ground.

The length of the pull-rod designed in this project can easily be adjusted by a spanner without the need of actually disassembling it from the entire wheel assembly. The length of the pull-rod designed in this project can easily be adjusted by a spanner without the need of actually disassembling it from the entire suspension assembly. This project is done for the ease of manipulation of the pull rod's length while adjusting the weight distribution of the car.

2. Design and Modeling of Pull-rod

These are the dimensions of the pull-rod. The assembly consists of three components, two billets at the end and a coupler.

A coupler is made by assembling two hexagonal M8 bolts and a nut.

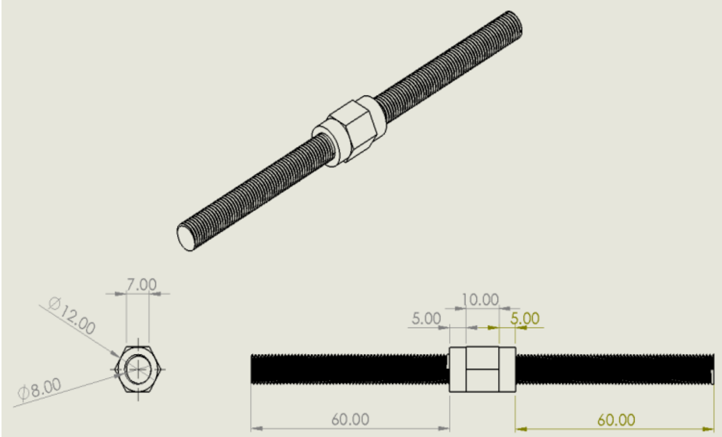

Figure 1: Coupler

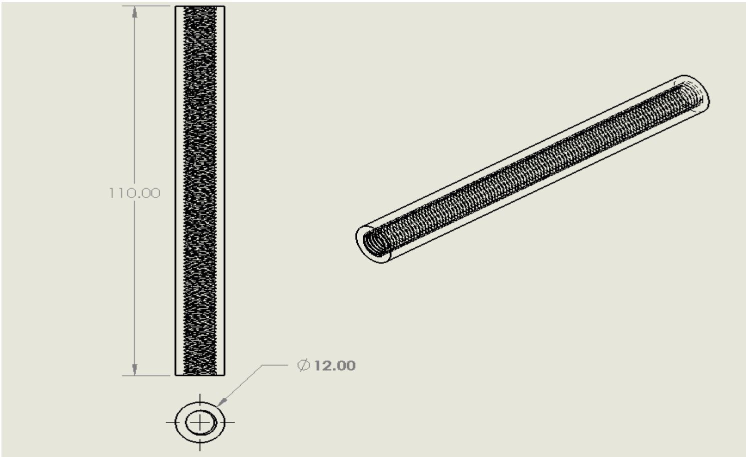

Figure 2: Billet

2.1. Following are the properties of Bolt:

1]Pitch (p): distance from a point on the screw thread to a corresponding point on the next thread measured parallel to the axis.

2]Nominal Diameter (d): The largest diameter of the bolt.

2]Helix angle (α): The angle is the angle made by the helix of the thread with a plane perpendicular to the axis of the screw.

$$\tan\alpha = p/(\pi * d_m)$$

3]Mean diameter (d_m): Mean diameter is given by,

$$d_m = d - 0.5p$$

Bolt Nominal Diameter (mm)	8
Pitch (mm)	1
Stress Area (mm^2)	39.2
Property Class	4.8
Minimum Ultimate Load (N)	15400
Minimum Tensile Strength (MPa)	420

Table 1: Properties of Bolts

2.2. To determine the torque required to raise the load:

- The bolt is considered as an inclined plane with α as the inclination.
- The load W always acts in a vertically downward direction. As the load W is raised, it moves up the inclined plane and when the load is lowered, it moves down the inclined plane.
- To raise the load force P is acting at the mean radius of the screw. The force P is multiplied by the mean radius (dm/2) gives the torque required to raise or lower the load.

Hence the torque becomes,

$$M= W(dm/2) \tan(\alpha+\Phi)$$

The moment on coupler should be only considered while a car is in static position.

3. Design Calculations
Maximum Forces in Static State

Weight to raise the Load ,W =350N
Major diameter of thread= 8 mm

dm = d-0.5p=8-0.5(1)
=7.5mm
tanα= p/(π*dm)
= 1/ (3.14*7.5)
α = 2.43°
tan Φ = μ
= 0.15 or Φ=8.531°
Effort require to lift the load, P
= W tan(α+Φ)
=62.944N

Moment required to lift the load=P*d_m/2
= 236.04N-mm

The Maximum stress a bolt of coupler have to bear= load/area = 1150/[(π/4)* d^2m]
= 29.336N/mm^2

4. Static Structural Analysis
4.1. Static Forces

For static analysis Moment of 240N is applied on the coupler and one end of the billet is fixed and a remote displacement on the opposite end.

Force applied on threads of the coupler in opposite direction=350Ns.

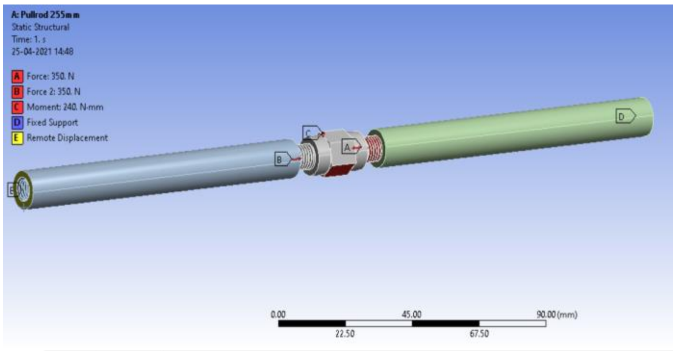

Figure 3: Static Forces

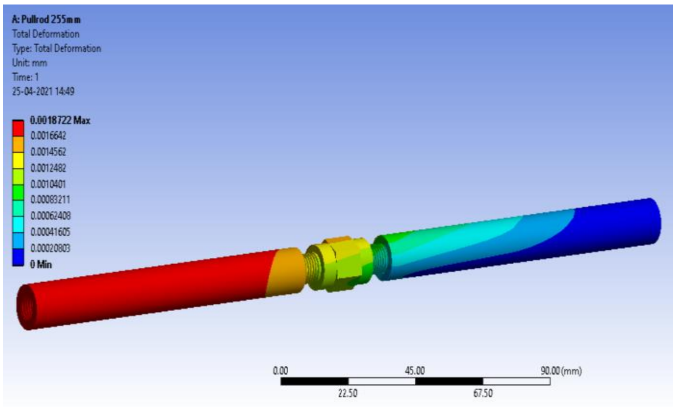

Figure 4: Total Deformation

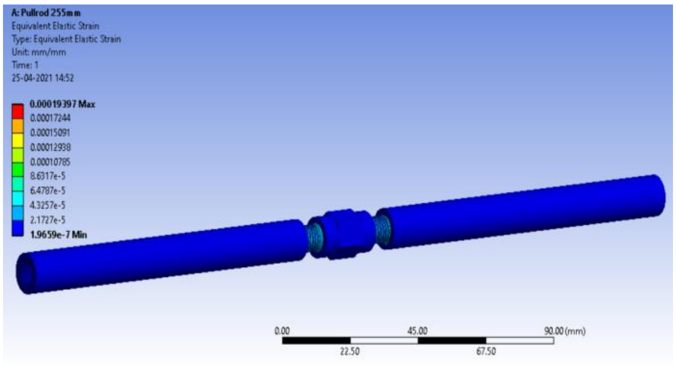

Figure 5: Equivalent Elastic Strain

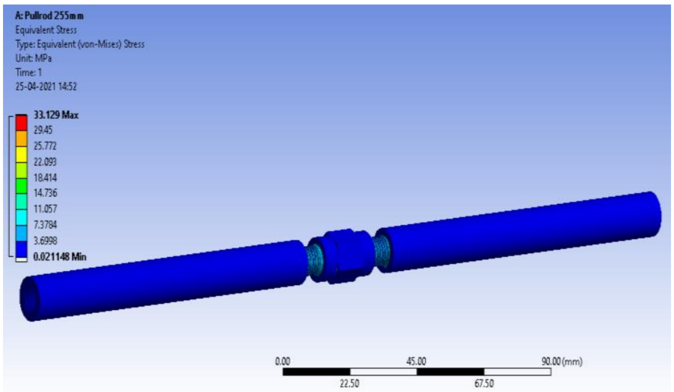

Figure 6: Equivalent Elastic Stress

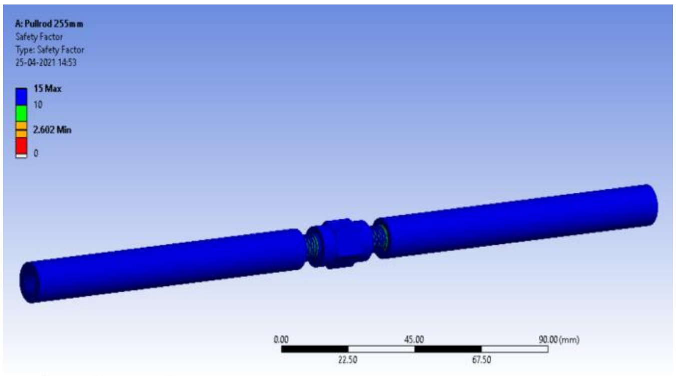

Figure 7: Factor Of Safety

4.2. Dynamic Forces

For dynamic analysis threshold forces of 1150N are assigned on threads of a coupler.

Fixed support at one end of the billet and a remote displacement to the opposite end.

Dynamic forces are considered up to the threshold to analyze the load-bearing capability of part.

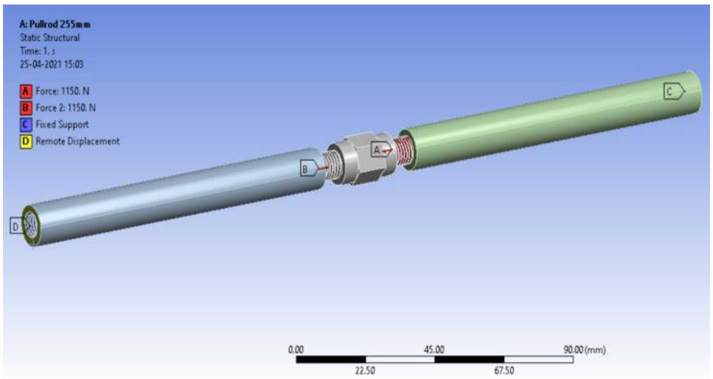

Figure 8: Dynamic Forces

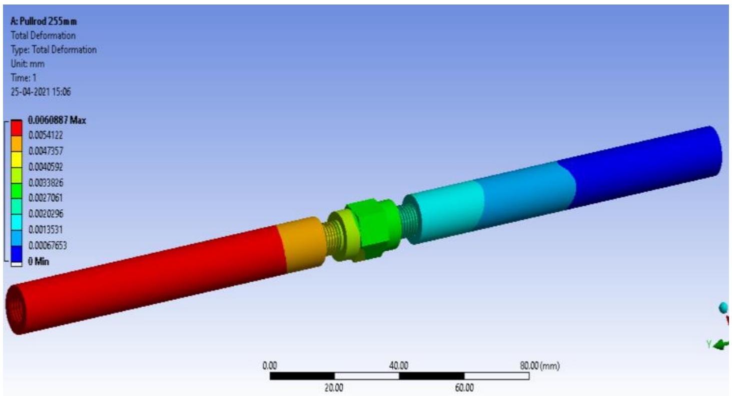

Figure 9: Total Deformation

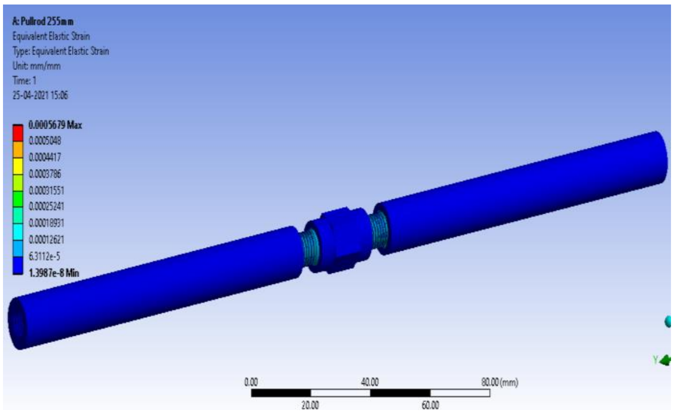

Figure 10: Equivalent Elastic Strain

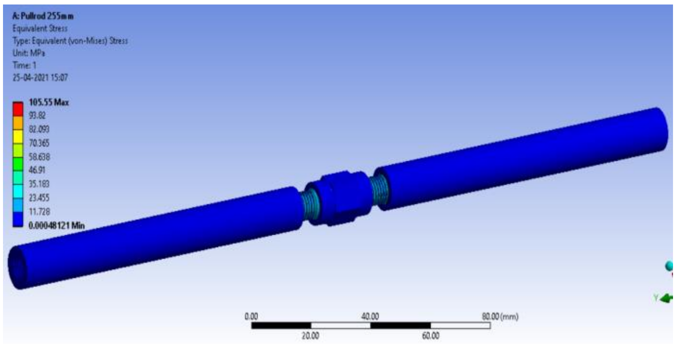

Figure 11: Equivalent Elastic Stress

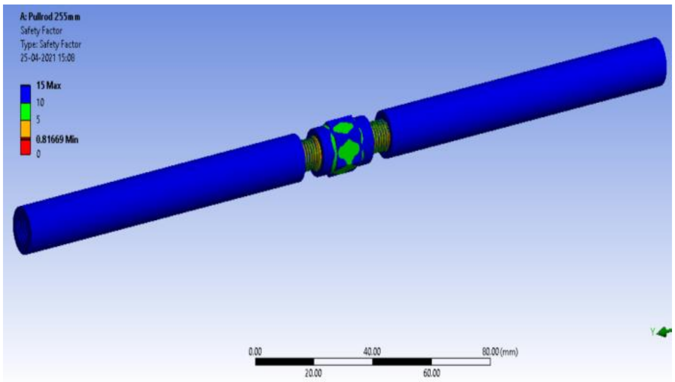

Figure 12: Factor of Safety

STATE	Value	Static	Dynamic
Total Deformation (mm)	Min	0	0
	Max	0.0018722	6.0887e-003
Equivalent Elastic Strain (mm)	Min	1.9659e-7	1.3987e-008
	Max	0.00019397	5.679e-004
Equivalent Elastic Stress (MPa)	Min	0.021148	4.8121e-004
	Max	33.129	105.55
Safety Factor	Average	2.62	0.81669
	Max	15	15

Table 2: Result Of Analysis

5. CONCLUSION

This article presents a new form of design for adjustable pull-rod which is used in FSAE vehicle suspension. Along with the static structural analysis in ANSYS. The concept of analysis for design validation is elaborated in this paper.

Pull-rod's length can be adjusted without disassembling any of its ends. Analysis done shows that pull-rod can resist the force up to 2300N and hence provides a better resilience. The average value of factor of safety varies between 2.62 to 15.

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