Design and Analysis of Suspension System with Different Material for SUPRA SAE INDIA 2018

Ankit Patil, Saahil Patil, Monik Shah, Nitin Sall

Abstract— In automotive sector there are various strategies invented to improve driver as well as passenger's comfort and safety during ride. Suspension is an important part of vehicle which carries whole static and dynamic conditions. This system provides better stability, handling and road holding capacity to the vehicle. This work introduces to design and analysis of suspension system of student formula race car SUPRA SAE INDIA 2018 competition. The main intention of the work is to use different materials for wishbone arm, for the analysis and to obtain sufficient result. The materials which are recommended as per SUPRA rulebook are alloy steel AISI 4130, AISI 4131 and AISI 4140. The model of wishbone arm in suspension system is made on Solid works 2015 and further structural analysis of wishbone arm is carried out on ANSYS 17.2, followed by dynamic analysis on Lotus Shark v4.03. Depending on their properties, cost and analysis result we will select the best material suit for the both static and dynamic conditions of the vehicle.

Index Terms— Wishbone arm, Solid Works 2015, ANSYS 17.2, Lotus Shark v4.03

1 Introduction

Suspension system is referred to the spring, shock absorber and linkages that connect the vehicle to vehicle and allow relative motion between the wheels and vehicle body. Suspension system also keep the driver or operator isolated from bump, road vibration, etc. [1]. Suspension system is an important part of the vehicle. The motion of car body is control by the suspension arm. All the accelerations either lateral or longitudinal must be part to ground through the tires, which are held in contact with the ground by the suspension system. The suspension system keeps the largest contact tire patch at all-time [2]. The type of suspension system is use to decide how forces are transferred from the tire to the chassis [3]. At the time of braking and acceleration the forces on wishbone arms. The control arm suspension consists of upper and lower arm. The upper arm and lower arm have different structure based on the model and purpose of the vehicle. The four bar link mechanism formed by unequal arm lengths perform to change in camber of vehicle as it rolls, which helps to keep contact patch square on ground level, increasing the ultimate cornering capacity of vehicle. It will be reducing the wear of outer edge of tire [4]. The lower arm carries more load than the upper arm because of its position. The weight of vehicle impact on the working of suspension system. A large sprung weight to unsprung weight ratio can also impact vehicle control [5]. The double wishbone type of suspension system is used for SUPRA SAE INDIA vehicle. The wishbone model is made by modeling software and structural analysis is done on ANYSIS.

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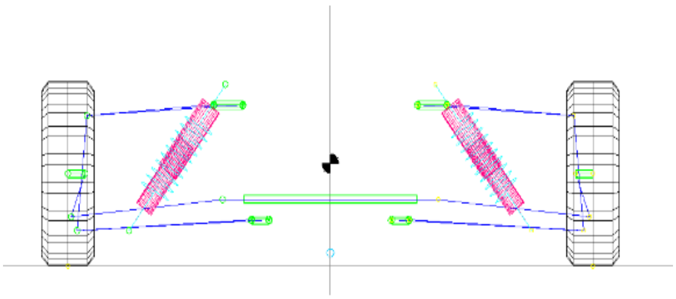
2 Design

Now-a-days in most of the car the double wishbone, multilink type suspension and McPherson suspension design is used. Suspension system used for the high speed vehicle is generally a double wishbone type. Two wishbone arms, upper and lower arms in-between the spring and damper connected. While designing components of suspension requirement of proper double arm wishbone type is very important. The dimensions we have to assume and use as per rulebook. Different type of
suspension and steering model file is available in Lotus shark Software. The actual suspension system wireframe model is easily available in the lotus shark v4.03. Software shows all the parameters of suspension system and dimensions modified according to the assumptions. The below fig. shows the front

Fig. 1. Suspension model in Lotus Shark software

view of the car with the suspension system and connections.

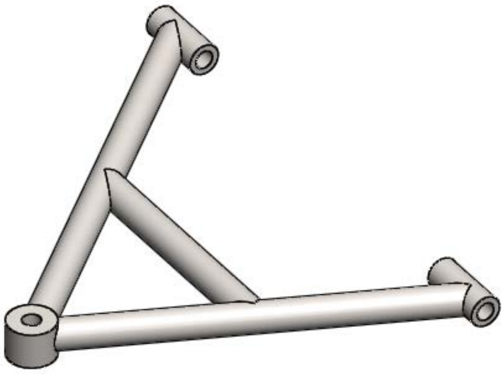


Each wheel contains two wishbones with one spring and damper on each side. The shape of wishbone arm is similar to an alphabet A therefore it is also called as A-arm. The basic arm is made on solid works software which is use for our competition vehicle. The wheel base of our car is approximate 2250 mm and the wheel track is 75% of the wheelbase which we using for our vehicle. The wheel base of our car is approximate 2250 mm and the wheel track is 75% of the wheelbase.

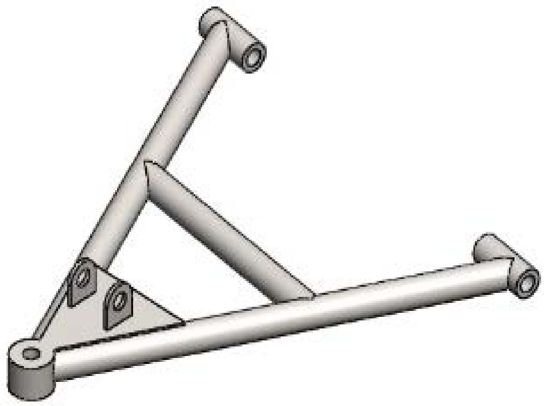
In solid works we have made both arms of wishbone that are upper and lower arms. The models shown below,

Fig. 2. CAD model of upper arm

Fig. 3. CAD model of lower arm



3 LOAD CONDITIONS



The formula one cars are made only for high speed purposes. At the time of turning with high speed led to development of more centrifugal force on the vehicle body. Turning is always linked with lateral transfer of vehicle weight. The braking and acceleration led to transfer of weight of vehicle along the longitudinal axis [1]. In dynamic condition, the lateral and longitudinal transfer will develop maximum load on a single wheel. In static condition, the sum of whole weight of the vehicle and unsprung mass is considered as a load. These forces are transmitted as reaction forces on the chassis through the A-Arm, which act as axial forces on each member. The first case was calculated using what was assumed to be worst case loading conditions of 1g's lateral acceleration, 1.5g longitude acceleration, and 2.0g's of bump after calculating these forces through certain formula we get the value of forces and these value are fed into analyses software, like ANSYS which takes into account yield and buckling, and also includes deflection of the A-Arms [6].

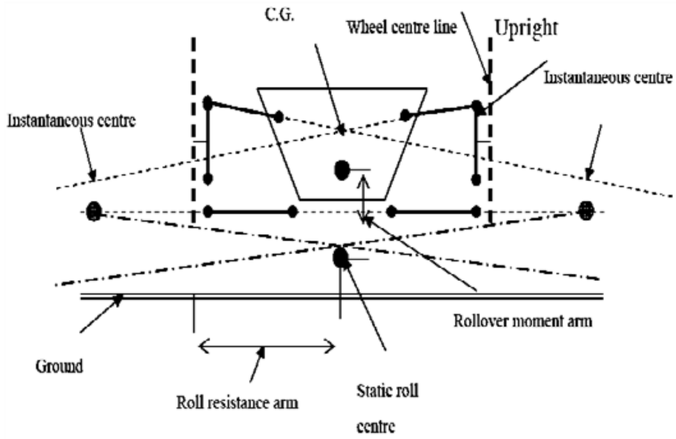


Fig. 4. Instantaneous centre / roll centre

4 MATERIALS

Wishbone arm materials: Alloy steel AISI 4130, AISI 4131, AISI 4140.
Dimension:
Outer diameter = 1inch
Thickness = 0.065

4.1 Alloy steel AISI 4130

Density	: 7850 kg/m3
Hardness Brinell	: 197
Hardness Rockwell	: 92
Ultimate tensile strength	: 670 MPa
Yield tensile strength	: 460 MPa
Modulus of elasticity	: 210 GPa
Bulk modulus	: 140 GPa
Shear modulus	: 80 GPa
Poisson ratio	: 0.28

4.2 Alloy steel AISI 4131

Density	: 7700 kg/m3
Hardness Brinell	: 224
Hardness Rockwell	: 92
Ultimate tensile strength	: 665 MPa
Yield tensile strength	: 440 MPa
Modulus of elasticity	: 200 GPa
Bulk modulus	: 140 GPa
Shear modulus	: 80 GPa
Poisson ratio	: 0.28

4.3 Alloy steel AISI 4140

Density	: 7850 kg/m3
Hardness Brinell	: 240
Hardness Rockwell	: 92
Ultimate tensile strength	: 655 MPa
Yield tensile strength	: 415 MPa
Modulus of elasticity	: 190 GPa
Bulk modulus	: 140 GPa
Shear modulus	: 80 GPa
Poisson ratio	: 0.28

5 Analysis

The wishbone arm is analyzed in ANSYS software as per dimension obtained from solidworks 2015. In ANSYS software static structural analysis has been performed. We had focused on finding out stress, strain and displacement induced in wishbone arm. The mashing size of arm is 2 mm [6].

The maximum accelerations are:
± 2g vertical loading (Fv)
± 1g lateral (turning) (Fc)
± 1.5g longitudinal (braking and acceleration) (Fa)

Factor of safety 1.2 for upper arm
Fv = 3600N
Fc = 1200N
Fa = 1200N

Factor of safety 1.5 for lower arm
Fy = 4500N
Fc = 1500N
Fa = 2250N

Considering the fix where wishbone connected to chassis and force applied where wishbone joint together front upright.

5.1 Upper arm

The upper arm is typically A-arm, and is shorter than the lower link, which is lower arm. Upper wishbone arm is directly connected to the chassis and upright. This arm carries less load than the lower arm.

5.1.1 Alloy Steel AISI 4130

Tensile strength = 670 MPa
FOS = 1.2
Stress = 558.33 MPa

5.1.2 Alloy Steel AISI 4131

Tensile strength = 665 MPa
FOS = 1.2
Stress = 554.167 MPa

5.1.3 Alloy Steel AISI 4140

Tensile strength = 655 MPa
FOS = 1.2
Stress = 545.83 MPa

5.1.4 Stress analysis

The figures below show the comparison of stress induced on wishbone arm for three different materials using ANSYS 17.2.

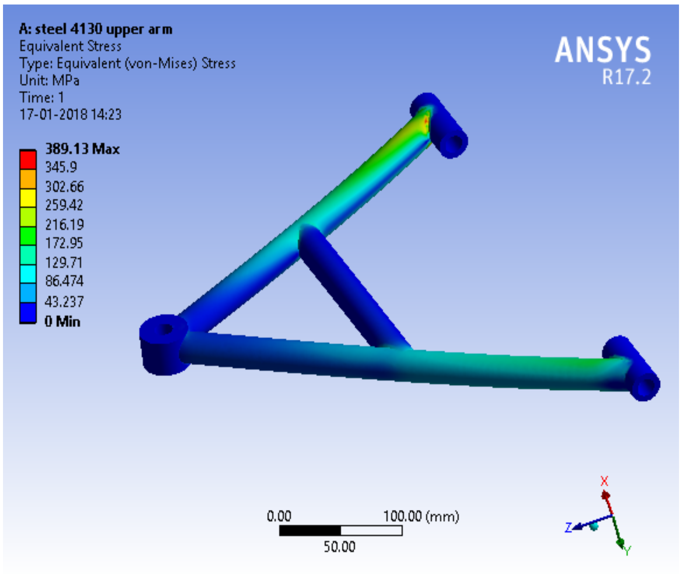


Fig. 5. Analysis stress (AISI 4130)

The maximum force is induced at a point where the wishbone arm is connected to chassis mounting brackets. The stress reduces from chassis mountings to upright mounting point. As seen from above result the maximum stress in the arm is 389.13 MPa which is less than allowable stress 558.33 MPa. Hence, the design is safe on applied loads.

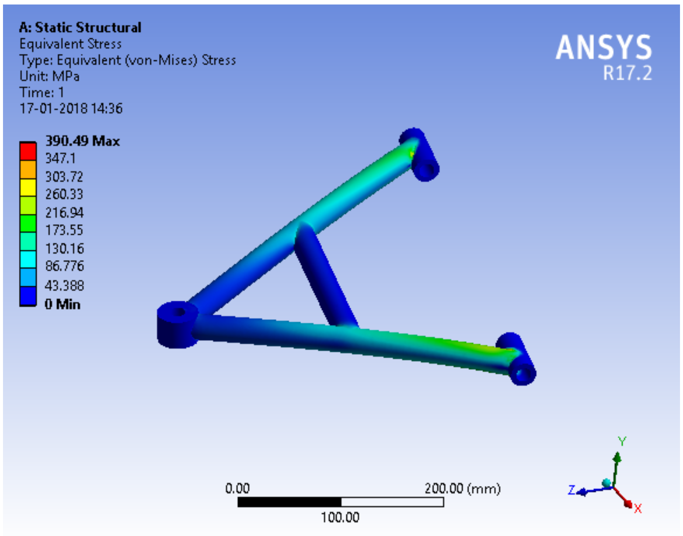


Fig. 6. Analysis stress (AISI 4131)

As seen from above result the maximum stress in the arm is 390.49 MPa which is less than allowable stress 554.167 MPa. Hence, the design is safe on applied loads. The maximum stress developed in this is a bit higher than the material AISI 4130.

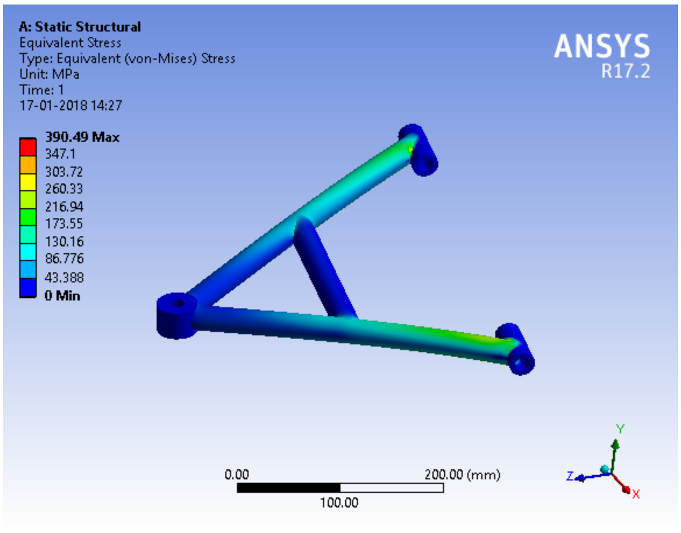


Fig. 7. Analysis stress (AISI 4140)

Here, the maximum stress in the arm is 390.49 MPa which is less than allowable stress 545.83 MPa. Hence, the design is safe. The maximum stress developed in the material is similar to that of AISI 4131.

Material	Maximum stress (MPa)
AISI 4130	389.13
AISI 4131	390.49
AISI 4140	390.49

Table 1. Results of stress

5.1.5 Strain analysis

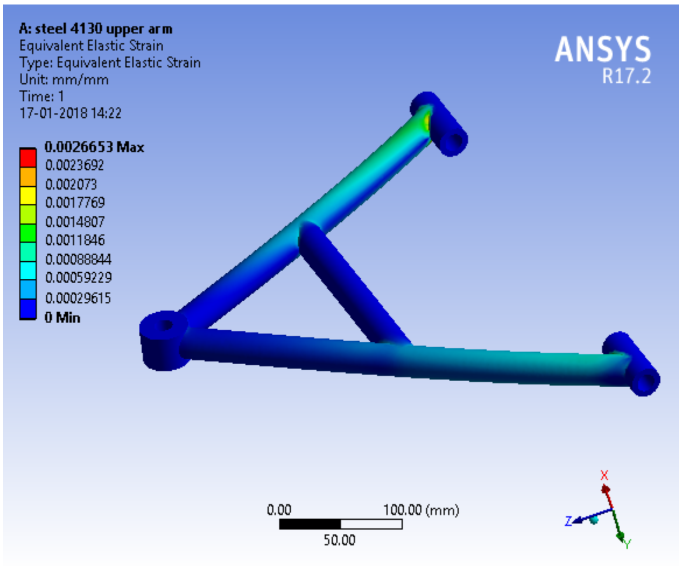


Fig. 8. Analysis strain (AISI 4130)

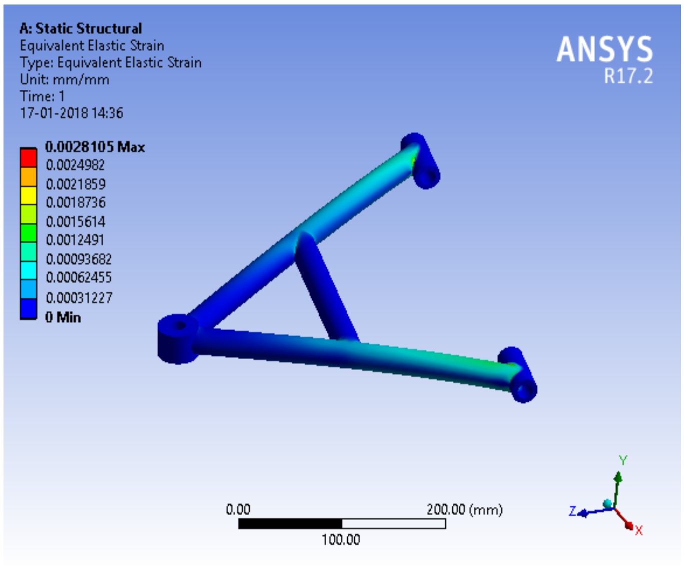


Fig. 9. Analysis strain (AISI 4131)

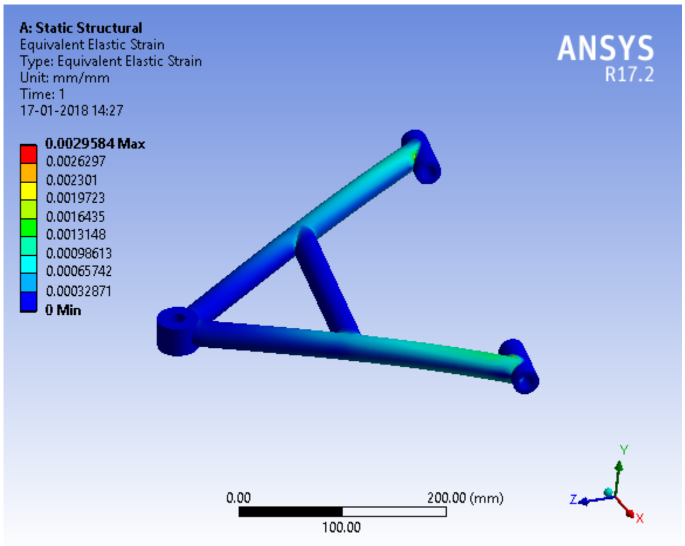


Fig. 10. Analysis strain (AISI 4140)

From the above analysis we can see that the maximum strain is induce in both linkages nearby the mountings brackets of wishbone on chassis. In the another end connected to the upright, the strain induced is negligible.

Material	Maximum strain
AISI 4130	0.0023692
AISI 4131	0.0028105
AISI 4140	0.0029584

Table 2. Results of strain

5.1.6 Deformation

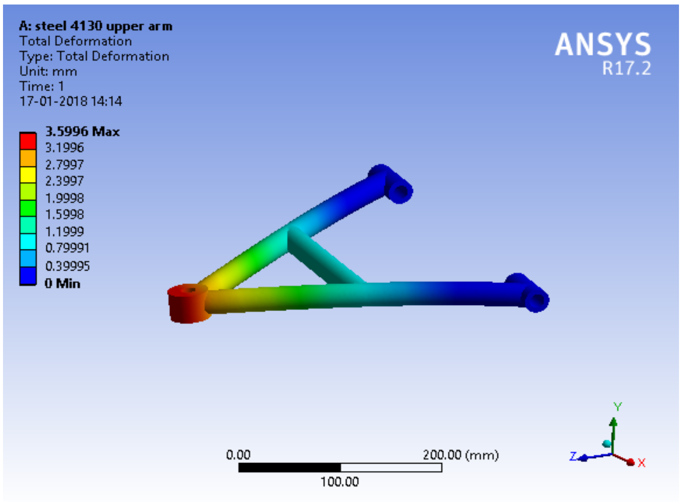


Fig. 11. Analysis deformation (AISI 4130)

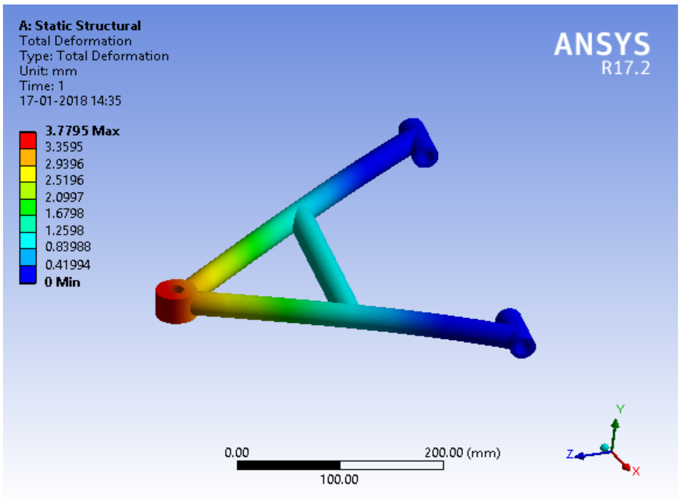


Fig. 12. Analysis deformation (AISI 4131)

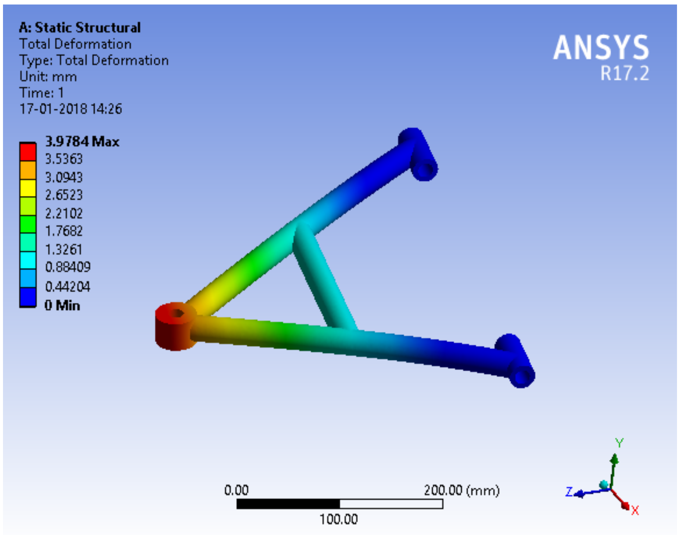


Fig. 13. Analysis deformation (AISI 4140)

From the three figures the analysis shows that the maximum deformation is taking place in material AISI 4140 and maximum minimum deformation is in AISI 4130. So from this both materials we choose the material having less deformation is AISI 4130.

Material	Maximum deformation (mm)
AISI 4130	3.5996
AISI 4131	3.7795
AISI 4140	3.9784

Table 3. Results of strain

6 Conclusion

The wishbone arm of suspension system is used to control the wheel travel therefore the material selection and geometry are important factors to reduce stresses. For the analysis the material such as alloy steel AISI 4130, AISI 4131 and AISI 4140 are used. The calculated stresses are 389.13 MPa for AISI 4130, 390.49 MPa for AISI 4131 and AISI 4140. From the above three results we conclude that Alloy steel AISI 4130 gives less stress, strain and deformation than other materials, so we have used 4130 for making the wishbone arm.

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