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Design and Analysis of Upright for FSAE Vehicle

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Abstract :Formula student is a platform for automotive enthusiasts where students from various colleges and universities design and manufacture an open cockpit formula style racecar. In formula racing car components experience immense load on each and every component, so it is necessary that the component should able to withstand that amount of load without compromising on vehicles performance. This paper addresses static analysis of upright for formula SAE vehicle under different maneuvering conditions.The upright has been designed using 3D modelling software SOLIDWORKS.

Keywords—SOLIDWORKS,UPRIGHT,STATIC ANALYSIS,RACECAR

I. INTRODUCTION

Formula student is platform for automotive enthusiast where student from various colleges and universities design and manufacture open cockpit formula style racecar.It is student design competition where students design and manufacture rule compliant car to compete with each other.

Wheel assembly provides physical connection from the wheels to suspension links and provide mounting and installation for brake caliper. It acts as a rigid supporting element to all suspension systems and assists in maintaining the suspension geometry during various maneuvers.

Upright must be strong enough to withstand forces between tire and contact patch because all these forces are go through upright during running of car.It is sustain all forces because any failure of upright makes car un-drivable.

II. TERMS REALTED TO UPRIGHT

A) Caster: It is angle made by steering axis with the verticle of tire.It generates self centering force due to mechanical trail.It also generates negative value of camber on outer wheel during cornering.Greater the value of this angle greater will be straight line stability and more will be driver feedback.[1]

B) King pin inclination: It is angle made by steering axis with the vertical when view from front of car.It affects tire wear due scrub radius and also induce positive camber on outer tire[1]

C) Camber: Camber is the inward or outward tilt of the front tires as viewed from the front.When wheel is leaned towards car then it is called as negative camber.Value of camber angle is determined by tire wear rate and tire temperature.[1]

D) Steering arm:It decides geometry of steering on car.

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III. CAD MODEL OF DESIGN

The upright were design by using 3D modelling software SOLIDWORKS.Various iterations were made to obtain design shown below on basis of geometry constraints.

IV. MATERIAL SELECTION

The material selected for upright is mild steel(AISI 1020)as it has high strength and has more fatigue life as compared to aluminium also it is more easily available and has better manufacturability.It is also cheaper than aluminum.The properties use for analysis are as follows:

Property	Value	Units
Elastic Modulus	200000	N/mm^2
Poisson's Ratio	0.29	N/A
Shear Modulus	77000	N/mm^2
Mass Density	7900	kg/m^3
Tensile Strength	420.507	N/mm^2
Compressive Strength		N/mm^2
Yield Strength	351.571	N/mm^2

V. STATIC ANALYSIS

A. Static loads and Boundary conditions:

The specification of vehicle for calculation of forces on contact patch of tire for static analysis of upright:

Mass of car with driver:260kg
Height of center of gravity(C.G):280mm
Static front rear weight distribution:46.7/53.3
Lateral load transfer distribution:49.85/50.15
Wheel base:1545mm
Track width front:1118mm
Track width rear:1170mm
Wheel diameter:460mm
Lateral acceleration:1.8gs
Longitudinal acceleration:1.6gs
Effective radius of brake disk:67.5mm

$$Lateral\ load\ transfer(N) = \frac{Lateral\ acceleration\ (g) \times Weight(N) \times cg\ height(m)}{Track\ width(m)}$$

$$Longitudinal\ load\ transfer(N) = Acceleration\ (g) \times \frac{Weight(N) \times cg\ height(m)}{Wheelbase(m)}$$

Load in x direction=longitudinal acceleration× load on wheel……..[2]
Load in y direction=lateral acceleration× load on wheel..[2]
Load in z direction=bump forces…[2]
Braking force on mount =load in x during deceleration×wheel radius(1/effective radius)……[2]

Maximum loads	upright
Tire X	2000N
Tire Y	2000N(towards center)
Tire Z	2000N
on caliper mount	7500N

VI. BOUNDARY CONDITIONS

The upper and lower ball joint point on upright were given as fixed hinge support. Also toe link point on upright and all remaining bolting points were given as fixed hinge support.

Nut bolts connection in analysis were given as rigid connection.[3]

VII. DESIGN OF PREVIOUS UPRIGHT AND ITS FAILURE ANALYSIS

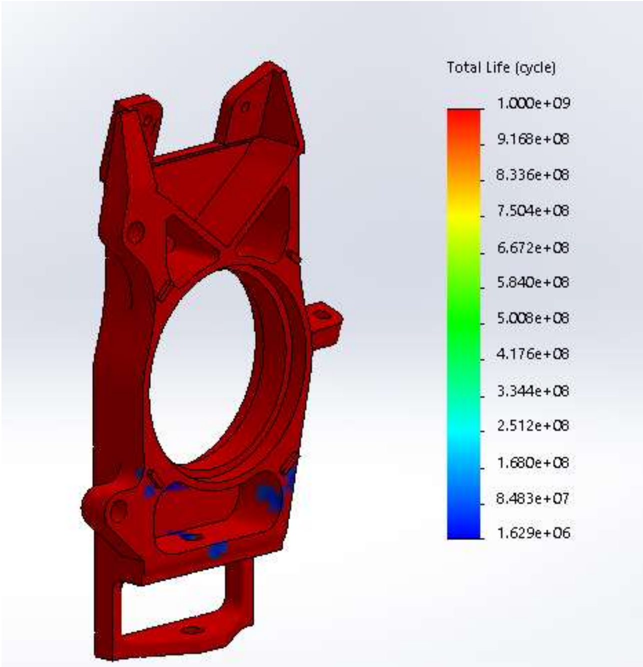

FIGURE . Total life calculation

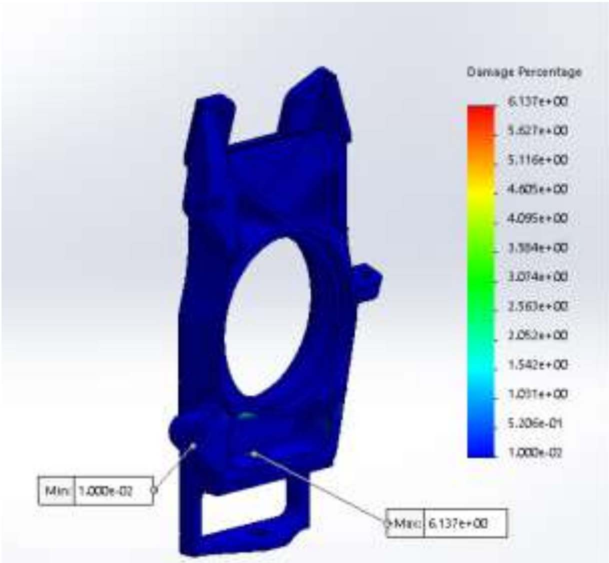

FIGURE . Damage percentage

We can say that above upright has some fatigue limit upto which it can sustain all the loads on it without initialization of crack on its surface.

After certain cycle upright has probability that it can fail near the region of lower ball joint as we can see from result that in lower region it has more probability of damage which is approximately equal to 6.1%.

VIII. STATIC ANALYSIS REPORT

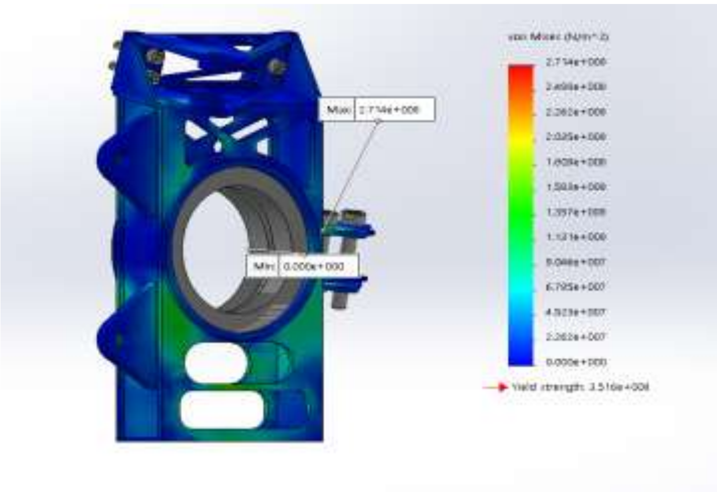

FIGURE 1.STRESS ANALYSIS IN CORNERING

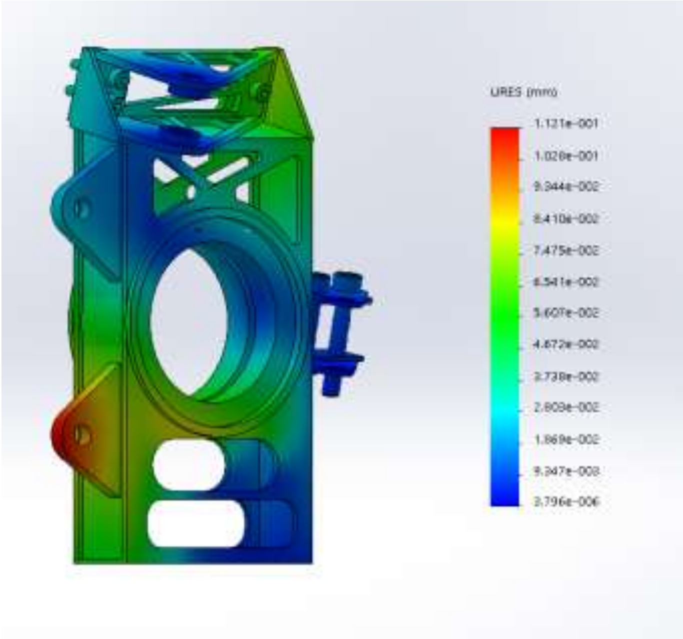

FIGURE 3.DEFORMATION IN BRAKING

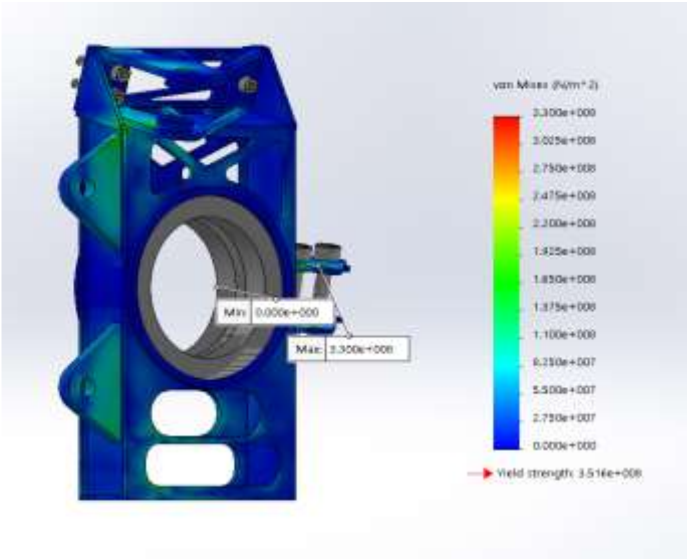

FIGURE 3.STRESS ANALYSIS IN BRAKING

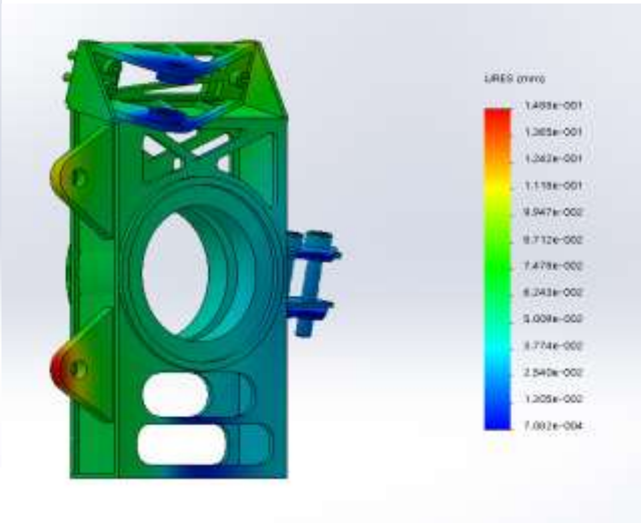

FIGURE 4.DEFORMATION IN BRAKING

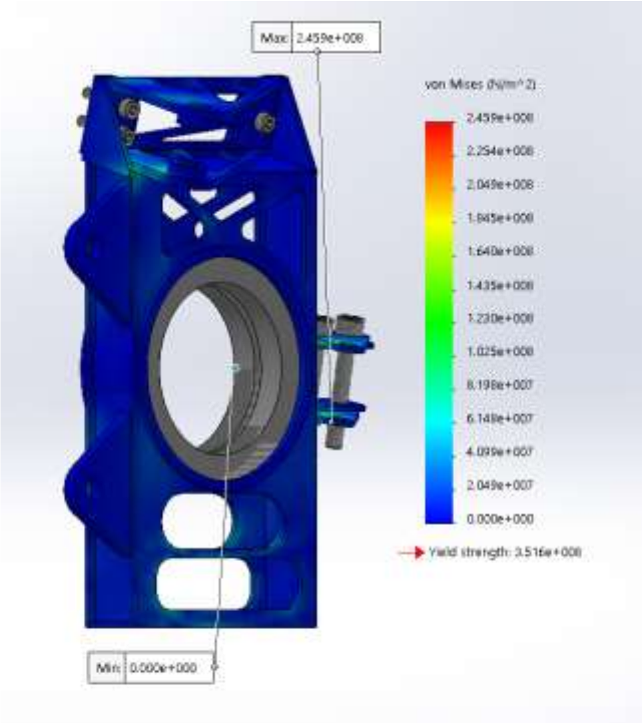

FIGURE 5.STRESS ANALYSIS IN BUMP

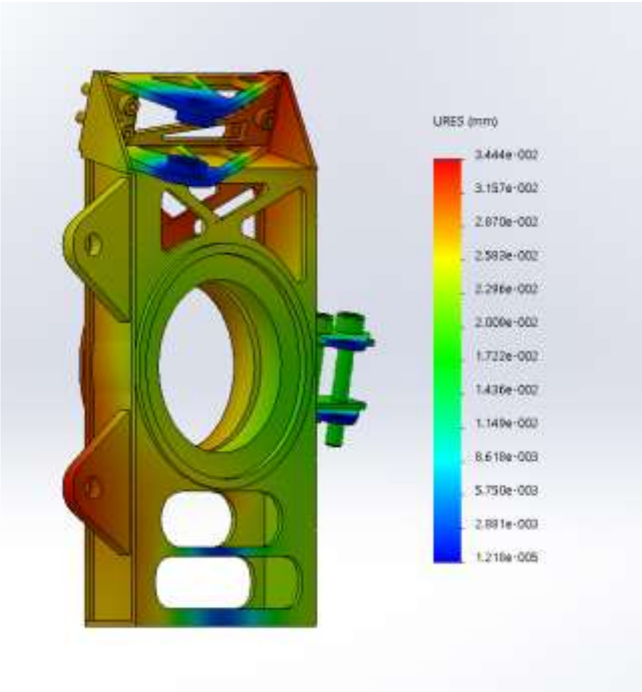

FIGURE 6.DEFORMATION IN BUMP

IX. RESULT

Upright had different values of factor of safety under different maneuverings

1. In bump upright had factor of safety of 1.4
2. In cornering upright had factor of safety of 1.3
3. In braking upright had factor of safety of 1.1

IX.CONCLUSION

The purpose of this paper is not only design and manufacture upright for fsae car but also to provide depth of knowledge and methodology regarding the design and analysis of upright.

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