International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 15
May 2018

Design of Suspension System of Formula Car

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Abstract:

A Formula One car is a single-seat, open cockpit, open-wheel racing car with substantial front and rear wings, and an engine positioned behind the driver, intended to be used in competition at Formula One racing events. The regulations governing the cars are unique to the championship. In order to produce a competitive vehicle with good suspension performance, many areas need to be studied and tested. This paper introduces several concepts of suspension system components design, their analysis and fabrication method.

Once design of suspension system components is completed, Stress distributions, displacements during static analysis were conducted to investigate the effects of working loads on the suspension system components. Theoretical analysis was used to test the conditions of various load combinations. These results were used to determine what stiffness is actually achieved for the designed component.

Qualitycomponentsfabricationisthekeytoanysuccessfulprojectbuild.Avehicle's suspension is a place where all forces acting are damped and transferred to the chassis. Any stresses acting on an automobile must flow through is components and ultimately reach the wheel. The wheel is directly attached to the suspension system components. Hence their quality is so important that the fabrication that makes up the suspension system components is done right and using the right tools, material and technique.

1. INTRODUCTION:

In cars, a twofold wishbone (or upper and lower An arm) suspension is a free suspension configuration utilizing two (at times parallel) wishbone-molded arms to find the wheel. Every wishbone or arm has two mounting focuses to the case and one joint at the knuckle. The safeguard and curl spring mount to the wishbones to control vertical development. Twofold wishbone outlines enable the architect to painstakingly control the movement of the wheel all through suspension travel, controlling such parameters as camber edge, caster edge, toe design, move focus tallness, clean range, scrape and that's just the beginning. The twofold wishbone suspension can likewise be alluded to as "twofold An arms," however the arms themselves can be A-formed, L-molded, or even a solitary bar linkage.

Preferences incorporate that it gives the architect more free parameters than some different sorts do. It is genuinely simple to work out the impact of moving each joint, so the kinematics of the suspension can be tuned effectively and wheel movement can be upgraded. It is additionally simple to work out the heaps that distinctive parts will be subjected to which permits more enhanced lightweight parts to be planned. They likewise give expanding negative camber increase the distance to full jerk travel, not at all like the MacPherson swagger, which gives negative camber increase just toward the start of bump travel and afterward switches into positive camber pick up at high bump sums.

Description

Suspension Kinematics:

The movement of the linkages is of essential significance in outlining a suspension framework for a race auto. The linkages must be situated with the end goal that the linearity is kept up all through the working scopes of information and yield parameters of the framework. For instance, amid the suspension incitation there must not be high changes and sudden changes in the parameters like camber edge, move focus position, caster point, mechanical trail, boss slant edge and so forth.

EMPERICAL RELATIONS OF SUSPENSION SYSTEMS:

Determination of Ride rate:

The ride rates are picked perfect to the wheel stacks, that are rates sufficiently hardened with the goal that the outside suspension does not base or contact the knock stops. The essential point is to dodge the bottoming the suspensions as this will cause a sudden change in wheel stacking and irritate the adjust of the auto.

From the FSAE rules the auto must have no less than 25.4mm jerk travel and 25.4mm bounce back movement. Mulling over components of security, the aggregate travel is been 60mm, i.e. 30mm in jerk and 30mm in bounce back, with a ground freedom of 150mm. utilizing the aggregate ride venture to every part of the computations are finished.

K_{RF} = [(F_{LT-f})/(total wheel travel)] = (714.53/60) = **11.9088N/mm**

K_{RR} = [(F_{LT-f})/(total wheel travel)] = (1071.35/60) = **17.8558N/mm**

Determination of Wheel Rate:

Tire and the suspension curl spring are two springs in arrangement. The arrangement blend of two springs, one acting between the undercarriage and the wheel focus, the other acting between wheel focus and ground. The principal speaks to what we call as wheel rate.

The equivalent spring rate of two springs in series is given by (1/KS) = (1/KS1) + (1/KS2)

KW = (KR x KT)/ (KR+KT)

KT = 1250.8 lbs/in (From Hoosier tire specifications)

KWF = [(1250.8)(67.99)/{1250.80+67.99}] = 64.4847lbs/in Or
12N/mm (approximately)

Determination of spring rate:

The spring rate relies on the establishment proportion. In the given FSAE auto the establishment proportion is roughly 1. i.e. the proportion of the movement of spring to the movement of the wheel is around 1.

KS = KW x (IR)2

KSF = 12 x (1)2

KSR = 17 x (1)2

Therefore the front spring rate, KSF = 12N/mm and the rear spring rate, KSR = 17N/mm.

DESIGN OF SUSPENSION SYSTEM

Powers are computed taking a gander at various dealing with circumstances viz. increasing speed, braking, cornering and knock. If there should be an occurrence of speeding up or braking longitudinal load exchange happens. Amid cornering parallel load exchange happens. Knock powers happen when a knock is taken. In the accompanying section the relating powers will be figured.

Static loads:

Each wheel underpins an offer of aggregate mass at its corner. Henceforth it is important to know the measure of load on each wheel. This can be computed in light of the situation of focal point of gravity. The longitudinal position of the focal point of gravity and the stature of the focal point of gravity starting from the earliest stage recorded to figure the heaps following up on each wheel.

The general mass of the auto around turned out to be 400kg. At first the longitudinal position of the focal point of gravity is thought about. It is at a separation of 0.6308m from the back hub and is 340mm over the ground.

Loads of wheel during Bump:

Equation one knock power can be up to 10 G which implies the heap on each wheel can progress toward becoming 10 times the static load on that wheel. For the FSAE auto knock powers are thought to be 2 G or littler. The primary reason is that the FSAE auto has no vast streamlined powers. Moreover speeds are much lower in a hurry kart circuit, so knocks are taken slower. Table 2 how the greatest knock compel values per wheel.

Hence maximum bump force for each wheel is tabulated below.

Normal Loads during bump

Normal Loads during bump

Front wheel (each)	1570N
Rear wheel (each)	2354N

Loads on wheel while Braking and Accelerating:

The auto weight will be 400 kg, together with the driver mass of 80 kg .Without stack exchange, 40% of this mass will be on the front haggles will be on the back wheels. Amid braking or quickening the front/raise stack circulation will change.

Loads on wheel while Cornering:

Horizontal load exchange happens while cornering. The power harmony on the back of the auto amid cornering at steady speed is portrayed beneath

The equilibrium of moments around CG:

$\Sigma Mcg = 0$

1/2 .tr .FN-i-r +hcg.(Flat-i-r + Flat-o-r) - ½.tr.FN-o-r=0

The equilibrium in vertical direction: $\Sigma F_z = 0$

FN-i-r+FN-o-r – Fg-r=00

Modeling of Suspension System:

Fig 1.6 Lower Arms

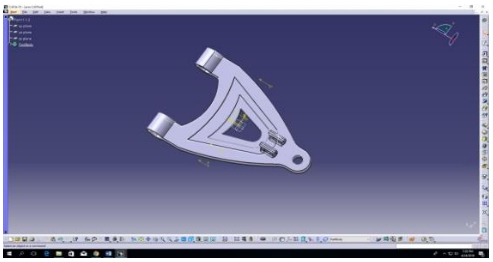


Fig 1.7 Upper arm

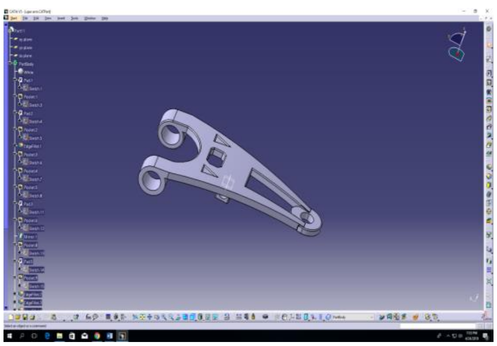


Fig 1.8 Hub:

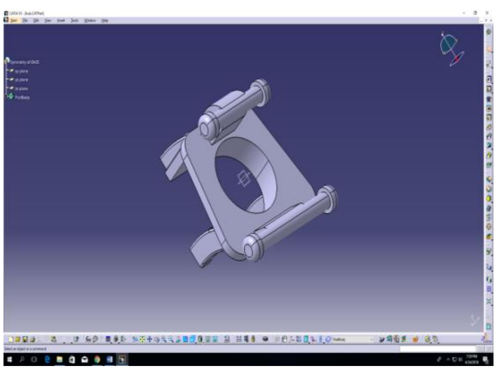


Fig 1.9 Suspension Spring:

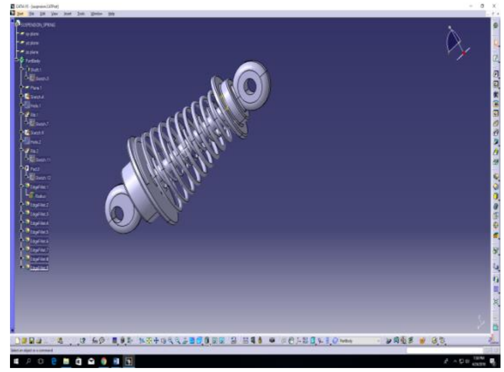


Fig 1.10 Wheel Joint Hub:

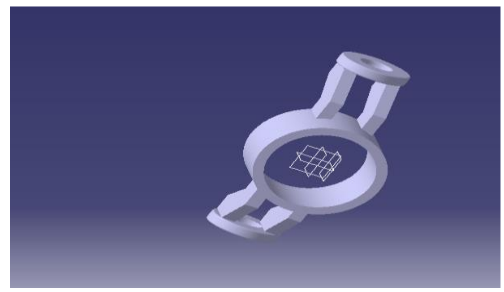
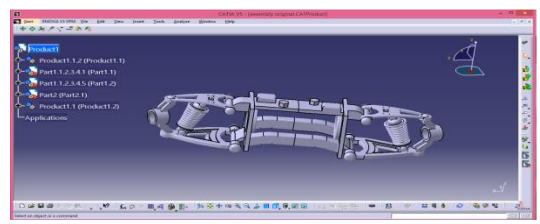


Fig 1.11 Assembled Suspension System:



Ansys:

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.

5. A typical ANSYS analysis has three distinct steps.

6. Pre Processor (Build the Model).

Suspension

In this chapter, the results obtained for the analysis of Suspension system for the original profile and Static Structural analysis are discussed. And also explained the graphs plotted by comparing those results.

Material Data

AISI 1065 carbon steel

Density 7.85e-006 kg mm^-3

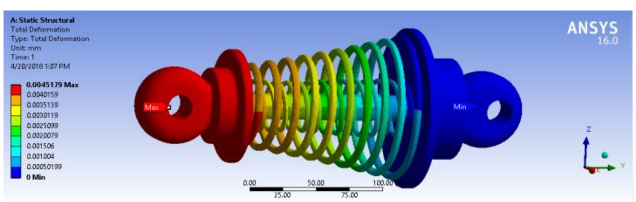
Young's Modulus MPa 1.4e+005

Poisson's Ratio 0.3

Bulk Modulus MPa 1.1667e+005

Shear Modulus MPa 53846

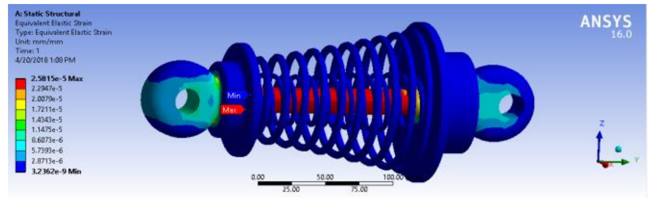
Fig:Total Deformation



Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]
1.	0.	4.5179e-003

Fig: Equivalent Elastic Strain

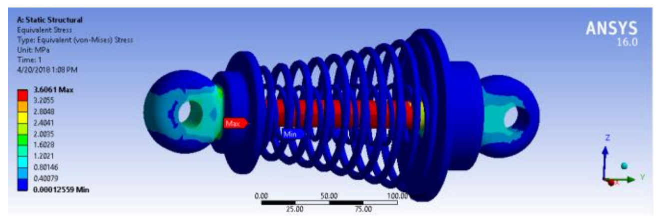


TABLE

Equivalent Elastic Strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	3.2362e-009	2.5815e-005

Fig 1.16 Equivalent Stress



TABLE

Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	1.2559e-004	3.6061

Lower arm

Material data:

AISI 1040 steel:

Density 7.845e-006 kg mm^-3

Young's Modulus 2.1e+005 MPa

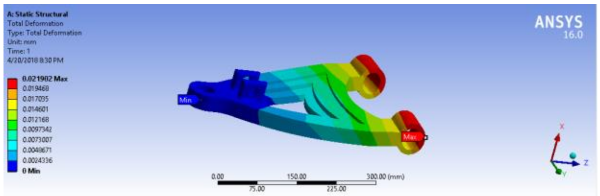
Poisson's Ratio 0.3

Bulk Modulus 1.75e+005MPa

Shear Modulus 80769 MPa

Tensile Yield Strength 415 MPa

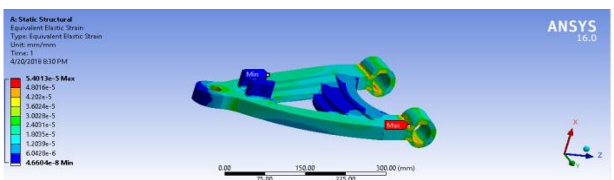
Fig 1.19 Total Deformation



Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]
1.	0.	2.1902e-002

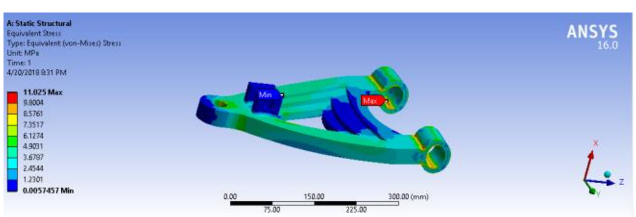
Fig 1.20 Equivalent Elastic Strain



Equivalent Elastic Strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	4.6604e-008	5.4013e-005

Fig 1.21 Equivalent Stresses



Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	5.7457e-003	11.025

Upper arm

In this part, the outcomes got for the examination of Suspension Upper arm framework for the first profile and Static Structural investigation are talked about. And furthermore clarified the charts plotted by looking at those outcomes.

Material Data

AISI 1040 steel

Density 7.845e-006 kg mm^-3

Young's Modulus 2.1e+005MPa

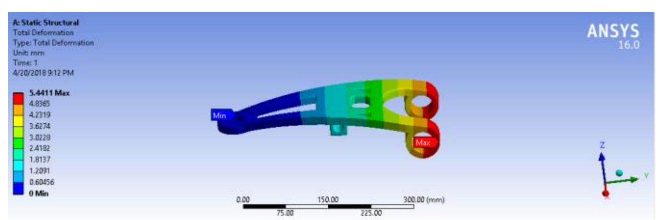
Poisson's Ratio 0.3

Bulk Modulus 1.75e+005 MPa

Shear Modulus 80769 MPa

Tensile Yield Strength 415 MPa

Fig 1.24 Total Deformations

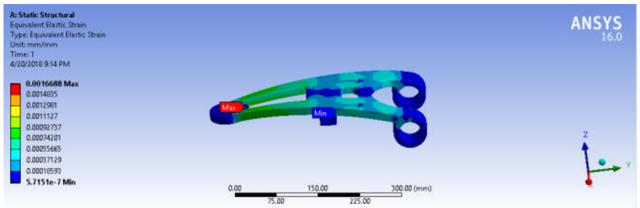


Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]

1.	0.	5.4411

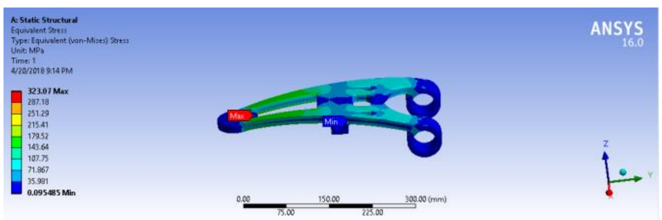
Fig 1.25 Equivalent Elastic Strains



Equivalent Elastic Strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	5.7151e-007	1.6688e-003

Fig 1.26 Equivalent Stresses



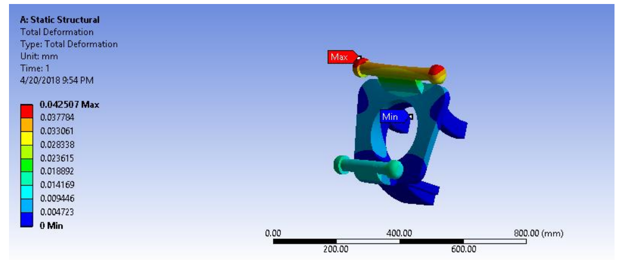
Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	9.5485e-002	323.07

Hub

In this chapter, the results obtained for the analysis of Suspension hub system for the original profile and Static Structural analysis are discussed. And also explained the graphs plotted by comparing those results.

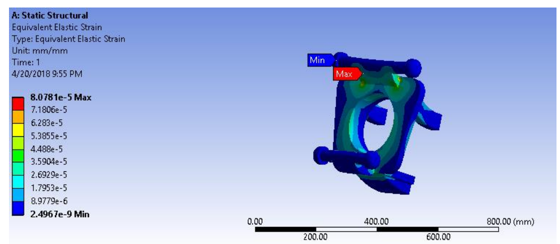
Fig 1.29 Total Deformation



Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]
1.	0.	4.2507e-002

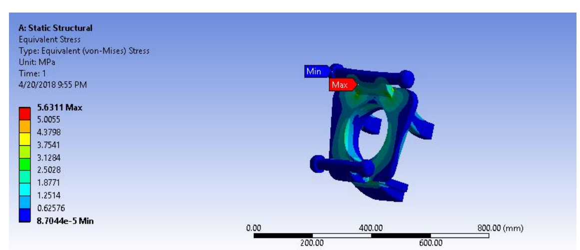
Fig 1.30 Equivalent Elastic Strain



Equivalent Elastic Strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	2.4967e-009	8.0781e-005

Fig 1.31 Equivalent Stress



Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	8.7044e-005	5.6311

CONCLUSIONS:

In FEA we select a few criteria for outline and investigation of lower suspension arm we make the models on CATIA V5 programming. This models imported in the ansys. We select the fine hubs fitting as it gives better outcomes for barrel shaped and bended molded countenances. In the wake of cross section we apply heaps of springs center point and arms, and we found the weaker segment in the models. We talked about above ansys comes about. The most extreme pressure and distortions are gotten as the admissible worry for this materials, it implies that the plan is protected under such stacking. The consequences of both the test are under yield focuses.

In whole examination, our objective was to give detail structure of the outline of suspension. From structure examination we found the kinematic parameters. this examination of the kinematic linkages gave us solidness of the spring for a specific ground leeway (static condition). Bearing quality, supportability of the parts were guaranteed from their relating FE investigation.

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