Design Fabrication and Assembly of Suspension in Hybrid Tadpole Configuration Vehicle

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Abstract - *For this project the vehicle has two front wheels and one rear wheel. The front wheels provide turning, so that the front suspension need to let the wheels turn. The suspension also allows the wheels to move up and down as the car runs over bumps. The type of front suspension for this project is a double wishbone system. It has a pair of A frames, one above the other mounted to the top and bottom of the wheel hub. In order to improve handling and comfort performance, horizontal suspension system is being developed in the vehicle. A suspension system has been proposed to improve the ride comfort. The purpose of a suspension system is to support and increase ride comfort. The aim of the work described in this paper is to illustrate the application of intelligent technique to the control of a continuously damping automotive suspension system.*

Keywords: Spring Damper, shock absorber, suspension, ride height, drivetrain

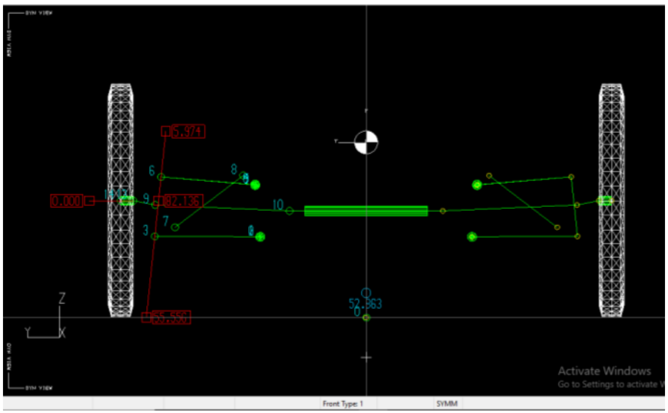
SUSPENSION

What is Suspension System?

It is a system of tires, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. All kinds of forces and movements between the wheels and the ground passes to the body through the suspension. The design of the suspension system is an important part of the overall vehicle design which determines the performance of the racing car. The main objective is to keep the tires in the firmest possible contact with road as long as possible and to provide the best-in-class ride comfort to the passengers.

FRONT SUSPENSION:

The front suspension system consists of a system of short-long arm directly actuated double wishbone suspension. This type of suspension is used because of the length of the upper and lower, vertical suspension movement results in an increase in negative camber. This means that the tires on the outside of a turn stay in better contact with the road, because the negative camber gain that occurs as the body roll helps make sure that the contact patch of the tire is as large as possible. The front of the suspension system is designed using LOTUS SHARK and Solid works.



REAR SUSPENSION

The rear suspension system consists of 2 links that pass-through axle of the rear wheel and the rear part of the chassis. The motion of the rear wheel, and as well as the links, is controlled by the shock absorbers that are actuated via pushrod that is attached to the links near the axle. Using the pushrod actuation provides a better motion ratio for the shockers as compared to the directly actuated one and hence even less stiff springs can be used for the same wheel stiffness.

CALCULATIONS:

PARAMETER	FRONT	REAR
SUSPENSION TYPE	SLA Directly Actuated	2-link Pushrod Actuated
TRACK WIDTH	1066.8mm	-
DAMPER PLACING	Lower arm	Via Pushrod
INSTALLATION RATIO	0.64	1

SPRING RATE	54 N/mm	2 of 27 N/mm in parallel
CASTOR	4	-
KINGPIN INCLINATION	6	-
C.G HEIGHT	419.1mm	
SUSPENSION TRAVEL	76.2mm	76.2mm
TIRES	57-406(20x2.125)	
WEIGHT DISTRIBUTION	45%	55%

LONGITUDINAL CALCULATIONS

DURING DIVING-:

(Mass Transfer) * 'g' * Wheel Base = (Mass of the Car) * Braking g's * 'g' * Centre of Gravity

Mass transfer *g* 1.371 = 260 * 1 * g * 0.419

Longitudinal mass transfer = 82.7 kg

Longitudinal mass transfer on front corner = 41.3 kg

Vertical load on front corner = (260 * 0.45 * g)/2 + 41.3*g = 978.4 N

DURING SQUATTING –:

Mass transfer * g * 1.371 = 260 * 0.24 * g * 0.419

Longitudinal mass transfer on rear = 19 kg

Vertical Load transfer on rear wheel = 260 * 0.55*g+19*g = 1587.6 N

Ride rate (K_r) = max vertical load/wheel travel = 1587.6/50.8 = 31.25 N/mm

Tire rate (K_t) = 75 N/mm

Wheel rate = K_r*K_t / (K_t – K_r) = 53.57N/mm

Installation ratio = 1

Rear Spring Stiffness (K_{SR}) = K_w / (IR)2 = 54 N/mm (two of 27 N/mm connected in parallel)

LATERAL FORCE CALCULATION –:

(Mass Transfer) * 'g' * Track Width = (Front Mass of the Car) * Cornering g's * 'g' * Centre of Gravity

Mass transfer * g *1.066 = (260 * 0.45) *1.4* g * 0.419

Lateral mass transfer (front) = 64.3 kg

Vertical load on front corner = (260 * 0.45/2) * g + 64.3*g = 1203.44 N

Ride rate (K_r) = max vertical load/wheel travel = 1203.44/50.8 = 23.6 N/mm

Tire rate (K_t) = 75 N/mm

Wheel rate = K_r*K_t / (K_t – K_r) = 34.4 N/mm

Installation ratio = 0.64

Front Spring Stiffness (K_{SF}) = K_w / (IR)2 = 54 N/mm

SPRING LENGTH-:

K_{WF} (Wheel rate front) =34.4 N/mm

K_{SF} (Spring stiffness front) =57 N/mm

K_{SR} (Spring stiffness rear) =27 N/mm

K_{WR} (Wheel rate rear) = 53.57 N/mm

Initial Compression = Sprung Corner Weight / Wheel Centre Rate

Front Initial Compression = 232*0.45*9.8/2*34.4 =14.87mm

Rear Initial Compression = 232*0.55*9.8/2*53.57 = 11.67mm

Front Total Wheel Movement = Bump + Initial Compression = 50.8+14.87 = 65.67mm

Rear Total Wheel Movement = 50.8+11.67

=62.47mm

Front Total Spring Movement = Total Wheel Movement*Installation Ratio = 65.67 * 0.64 = 42mm

Rear Total Spring Movement = Total Wheel Movement*Installation Ratio = 62.47 * 1.0 = 62.47mm

SPRING STIFFNESS -

Spring Material - Spring steel grade 2 – IS 4454 part 2 – cold drawn steel wire grade 2

G=78480 N/mm2

Internal Diameter =35mm

FRONT SPRING STIFFNESS –:

By iterations and using spring calculator various other parameters were calculated

Outer Diameter = 49 mm

Diameter of Spring (d)= 7mm

Active number of coils (N) =: 6

Spring Stiffness(S) = G*d^4/8*D^3*N

[D= Mean coil diameter]

= 78480*7^4/8*42^3* = 52.9N/mm

REAR SPRING STIFFNESS -:

By iterations and using spring calculator various other parameters were calculated.

Outer Diameter = 47mm

Diameter of Spring(d) = 6mm

Active number of coils (N) :7

Spring Stiffness(S) = G*d^4/8*D^3*N

[D= Mean coil diameter = 78480*6^4/8*= 26.35N/mm

CONCLUSION

The arm was modelled under the software and an analysis carried out with the ANSYS software and the leading arm show proper working under different loading conditions. The axial load and the load in the direction of the bump travel was considered and the leading arm shows proper structure design with the results shown. The partially transmitted stress is redirected to the frame to reduce the impact to the user or rider by using a triangular link in between the wheel and suspension of the vehicle. When people think of automobile performance, they normally think of horsepower, torque and zero-to-60 acceleration. But all of the power generated by a piston engine useless if the driver can't control the vehicle. That's why automobile engineers turned their attention to the suspension system almost as soon as they had mastered the four-stroke internal combustion engine. The job of a suspension is to maximize the friction between the tire sand the road surface, to provide steering stability with good handling and to ensure the comfort of the passengers. According to Newton's laws of motion, all forces have both magnitude and direction. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude, of course, depends on whether the wheel is striking a giant bump or a tiny speck. Either way, the car wheel experiences a vertical acceleration as it passes over an imperfection. Without an intervening structure, all of wheel's vertical energy is transferred to the frame, which moves in the horizontal direction. In such a situation, the wheels can lose contact with the road completely.

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