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Suspension System of Electric Go-Kart

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Abstract: The main objective of the project is to analyze the entire double wishbone suspension system for go-kart car, as it allows the engineer to carefully control the motion of the wheel throughout suspension travel. A 3d cad model of the double wishbone is prepared by using solid works (cad software) for analyzing the system capable of handling go-kart car while maintaining the ride quality. The topic is focused on designing the above mentioned suspension system considering the dynamics of the vehicle along with minimizing the unsprung mass.
Keywords : Roll center, Stiffness, Spring, Strut, go-kart, double wishbone.

I. INTRODUCTION

Suspension system is the term given to the system of springs, shock absorbers and linkages that connect a vehicle to its wheels. When a tire hits an obstruction, there is a reaction force and the suspension system tries to reduce this force. The size of this reaction force depends on the unsprung mass at each wheel assembly.

In general, the larger the ratio of sprung weight to unsprung weight, the less the body and vehicle occupants are affected by bumps, dips, and other surface imperfections such as small bridges.

A large sprung weight to Unsprung weight ratio can also impact vehicle control double wishbone suspension system consists of two lateral control arms (upper arm andlower arm) usually of unequal length along with a coil over spring and shock absorber. Approach was adopted for all the designing and analyzing work.

Hence, contributions from all members of the team were adopted. For designing a reliable, efficient & safe go-kart

II. SELECTION OF SUSPENSION

The reason for using the suspension is to increase the clearance for the vehicle and if the clearance is increased the go-kart can be used on the normal roads apart from the racing tracks and also during turns if peak turning points are there the possibility of unbalancing of the go kart so to avoid this and to achieve good balancing we opted to use pushrod rod in front and the back side of the go-kart

A. Pushrod suspension

Wheel spindles are supported by an upper and lower 'a' shaped arm.

The lower arm carries most of the load.

If you look head-on at this type of system, parallelogram system that allows the spindles to travel vertically up and down.

This side-to-side motion is known as scrub.

Advantages of push rod suspension

Kinematics can be controlled easily

Provides good camber compensation during vertical movement

Pitching movements can be balanced i,e; anti-dive, anti-squat possible

Toe-in, camber & track change can be controlled optimally due to variety of control parameters

Volume 5 Issue II, February 2017
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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

III. COMPONENT OF SUSPENSION SYSTEM

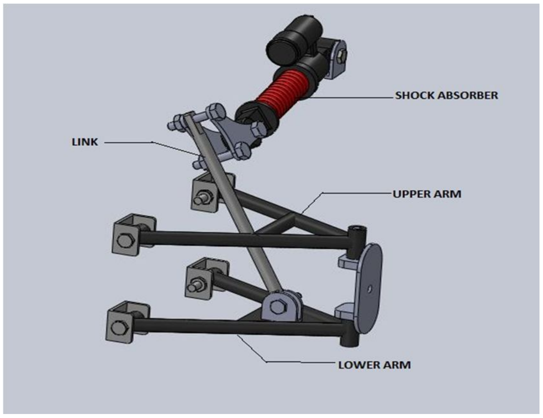

Fig.1 double wishbone suspension

A. Design of suspension spring

Assumptions made

Sprung mass = 260 kg (approx.) Factor for static to dynamic conditions: 2.5

According to the mass distribution of 60:40 (Rear: Front)

Mass per wheel (Front) = 50 kg

Mass per wheel (Rear) = 80 kg

1) Front spring: Angle of Inclination of The Strut =60 (From Horizontal)

Considering the wishbone hinges as the point which Point of attachment of strut = 10" (254 cm) from chassis end ….(from suspension geometry)

Reaction force acting from the ground on the wheel= (Mass per wheel * 9.81) N

= (50 kg * 9.81) N

=490.5 N

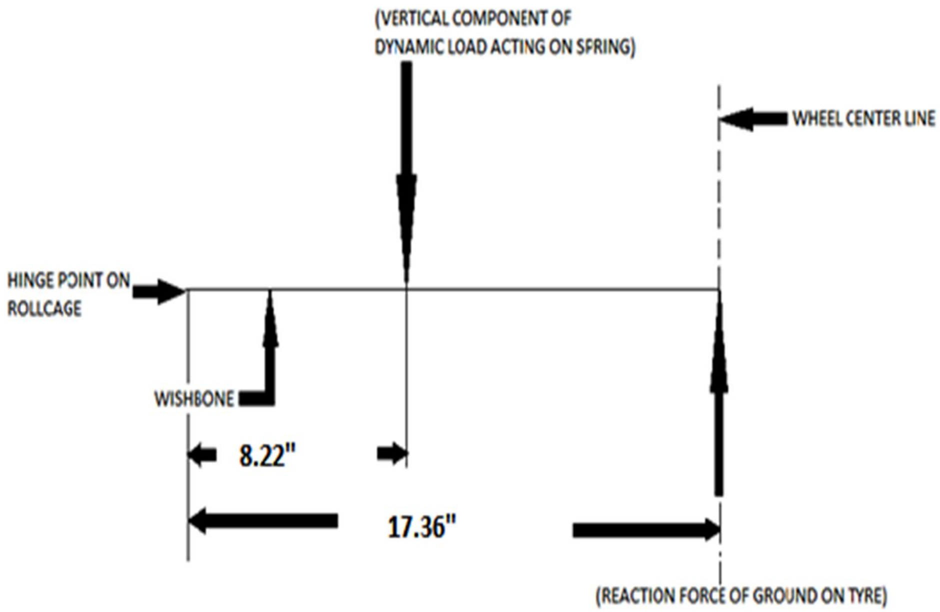

Fig.2 Forces on front wishbone

Moment is taken

Horizontal distance of reaction force from hinge point = 17.36" (44.09 cm) ….from suspension geometry

Horizontal distance of strut attachment point from hinge Point = 8.2" (20.828 cm)

Volume 5 Issue II, February 2017
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By taking moment about hinge points: 490.5 * 17.36 = Spring Force * 8.23
Spring Force = 1034.6 N
Considering the dynamic factor,
Dynamic force acting on the spring = 2586.59 N
According to the ride conditions and road quality it is concluded that the optimum spring travel should be approximately. 4” (10.16 cm)
Hence, Required Spring Stiffness
=Dynamic Spring Force/Spring Deflection
= 2586.59/101.6
=25.46 N/mm
2) Rear spring: Angle of inclination of the strut = 80o (from horizontal)
Point of attachment of strut = 6.5” (16.51 cm) from chassis end …(from suspension geometry)
Reaction force acting from the ground on the wheel= (Mass per wheel * 9.81) N
= (80 kg * 9.81) N

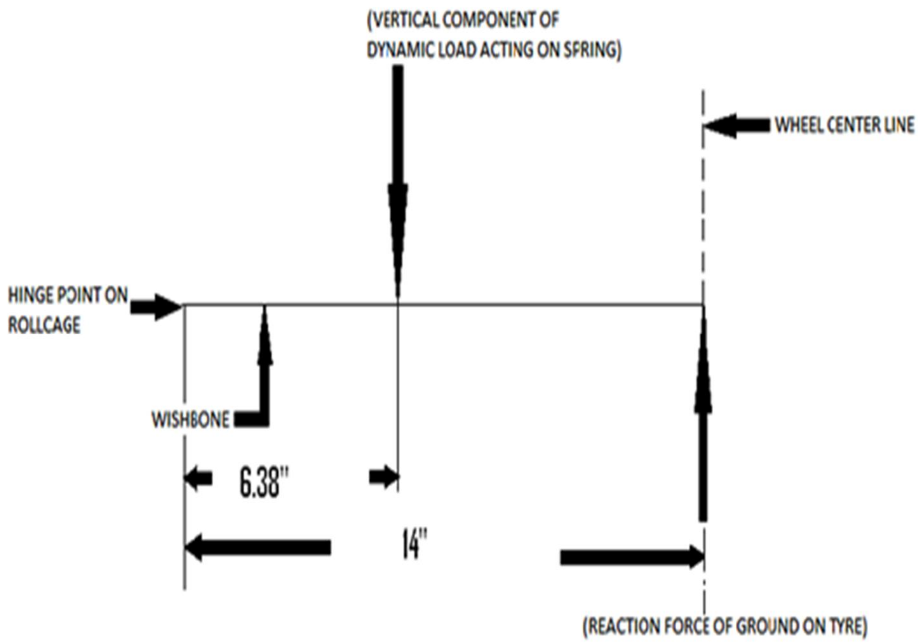

Fig.3 Forces on rear wishbone

Considering the wishbone hinges as the point about which moment is taken;
Horizontal distance of reaction force from hinge point = 14” (35.56 cm) …..(from suspension geometry)
Horizontal distance of strut attachment point from hinge point = 6.38” (16.02 cm)
By taking moment about hinge points: 784.8 * 14 = Spring Force * 6.38
Spring Force = 1722.13 N
Considering the dynamic factor,
Dynamic force acting on the spring = 4305.325 N
According to the ride conditions and road quality it is concluded that the optimum spring travel should be approx. 4” (10.16 cm)
Hence,
Required spring stiffness = 42.375

IV. ANALYSIS OF SPRING

Spring is analyzed in Ansys analysis software so as to determine the actual maximum deflection of spring corresponding to the maximum spring force. Also, the maximum stress value corresponding to the maximum spring force is determined.

Volume 5 Issue II, February 2017
ISSN: 2321-9653

In spring analysis, one end of spring is fixed and vertical load has been applied on the other side

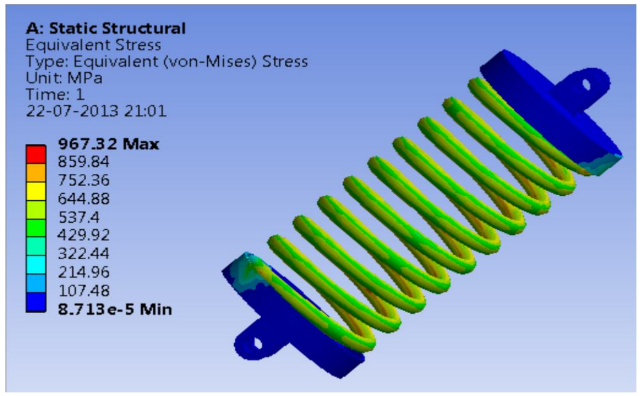

Fig.4 Analysis of Spring in Ansys

TABLE.I
SPRING ANALYSIS RESULTS

Parameters	value
Maximum Force (N)	1500
Maximum Deflection(mm)	106
Maximum Stress (Mpa)	967.32

A .Shock Absorber

A shock absorber (in reality, a shock "damper") is a mechanical or hydraulic device designed to absorb and damp shock impulses. It does this by converting the kinetic energy of the shock into another form of energy (typically heat) which is then dissipated. A shock absorber is a types of dash pot

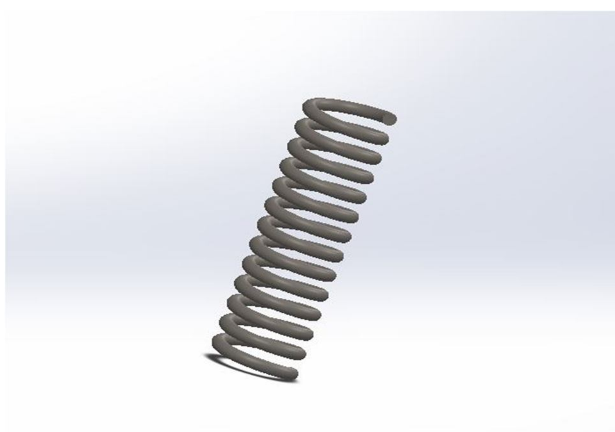

Fig.5 Spring designed in solid works

B. Design of Wishbones

Design of wishbones is the preliminary step to design the suspension system. Initially, the material is selected usingPugh’s Concept of Optimization. Based on the properties of the selected material, the allowable stress is calculated using sheer stress theory of failure. The roll-centre is determined in order to find the tie-rod length.

Volume 5 Issue II, February 2017
ISSN: 2321-9653

TABLE.II
DESIGN PARAMETERS

Sr. No.	Parameter	Front Suspension	Rear Suspension
Material		Grade 4 oil hardened spring steel	
1	Wire diameter	11 mm	11 mm
2	Inner coil diameter	55 mm	55 mm
3	Outer coil diameter	66 mm	66 mm
4	Total number of turns	22	14
5	Free length of strut	365 mm	292 mm
6	Pitch of suspension spring	18 mm	27 mm
7	Eye-to-eye length of strut (unloaded)	456 mm	484 mm
8	Stiffness	25 N/mm	40 N/mm
9	Maximum dynamic spring travel	101.12 mm	100.88 mm

The designed wishbones are modeled using software and then analyzed using Ansys analysis software to find the maximum stress and maximum deflection in the wishbone

The wishbones for the front suspension were designed to withstand the loads in the worst case of loading

The length of the wish bones and the mounting points on the roll cage were chosen depending on the track width, height of the static roll centre and dynamic properties like the roll camber, camber.

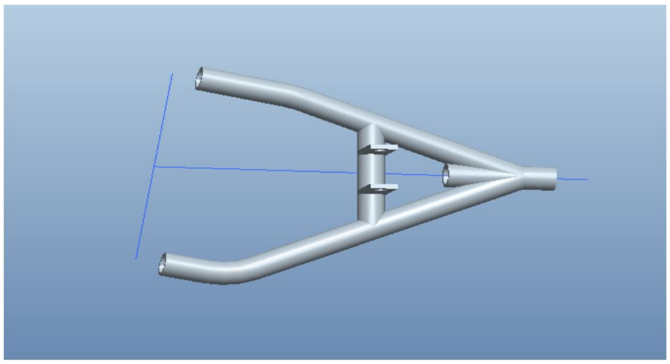

Fig.6 Design of lower arm

Volume 5 Issue II, February 2017
ISSN: 2321-9653

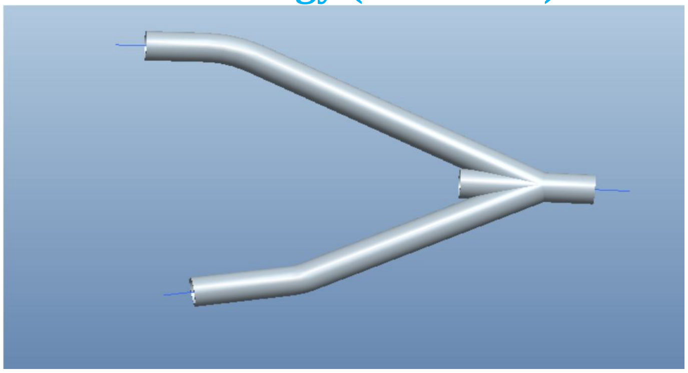

Fig.7 Design of upper arm

V. MATERIAL SELECTION OF WISHBONE

Material consideration for the wishbone becomes the most primary need for design and fabrication. The strength of the material should be well enough to withstand all the loads acting on it in dynamic conditions. The material selection also depends on number of factors such as carbon content, material properties, availability and the most important parameter is the cost

A. Analysis in Ansys

Ansys is engineering simulation software (computer-aided engineering). Various types of analysis like structural analysis, thermal analysis, etc are possible using Ansys analysis software. In structural analysis in Ansys, boundary conditions are to be defined in order to determine the stress and deflection.

After modelling the wishbones in Pro-E modelling software, these models were imported into Ansys Analysis Software. Various boundary conditions and load cases were applied for determining the maximum stress and maximum deflection for wishbone.

TABLE.III
INPUT PARAMETERS

Vertical load	9600N
Spring force	1800N

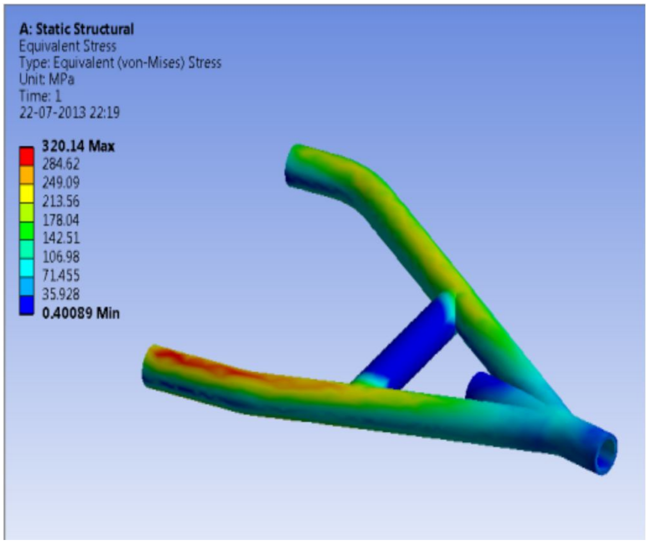

Fig.8 Analysis of lower wishbone in Ansys

Volume 5 Issue II, February 2017
ISSN: 2321-9653

TABLE.IV
RESULTS OF ANALYSIS OF WISHBONE

Parameters	Values
Maximum stress (MPa)	320.14
Maximum deflection (mm)	6.013
Allowable stress (MPa)	345.83

Since, Maximum stress induced in wishbone is less compared to allowable stress, hence the wishbone is safe.

B. Simulation of Suspension System

Lotus Engineering Software has been developed by automotive engineers, using them on many powertrain and vehicle projects at Lotus over the past 15 years. It offers simulation tools which enable the user to generate models very quickly, using a mixture of embedded design criteria and well-structured interface functionality.

C. Suspension Geometry in Lotus

Lotus simulation software has been used to simulate the suspension geometry of double wishbone suspension system. Various co-ordinates of the entire system are given as input and the virtual model is built. It looks like as shown

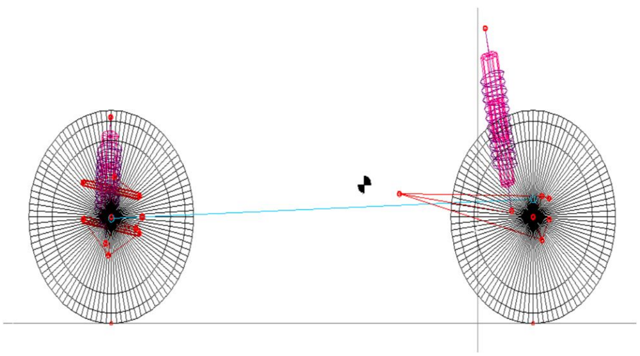

Fig.9 Suspension Geometry in Lotus

D. Camber Change in Bump

Camber change in bump has been simulated using Lotus simulation software. The camber change in bump looks like shown

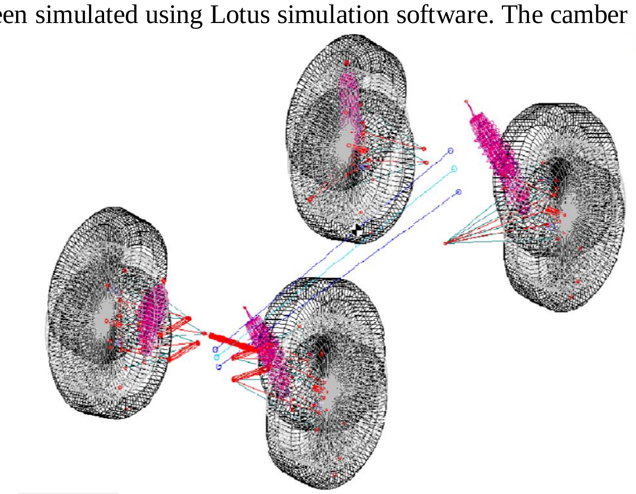

Fig.10 Camber Change in Bump

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Plot of Camber Angle Vs Roll Angle

From the below graph of Camber Angle vs. Roll Angle, it is clear that, as the camber of the tire varies in bump and droop then roll angle also varies. The camber angle varies from -20 to +20 with roll angle

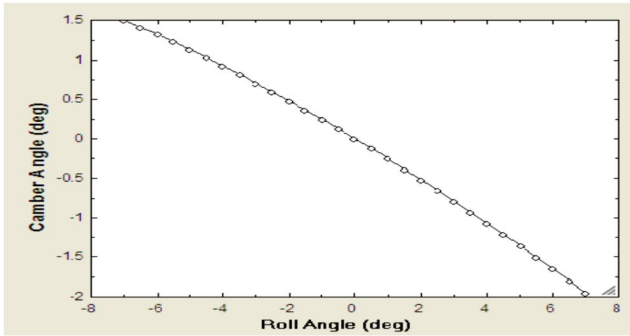

Fig.11 Camber Angle vs Roll Angle

VI. DESIGN CALCULATIONS

Deceleration :=(V2-u2)/2X5=-95.74

V=76kmph = 21.11 m/s

Turning Radius = 3.7 m.

Assuming worst case (Braking during cornering)

Total weight on each front wheel= (0.4X1274)/2

=254.8N

Due to the leverage, effect of the suspension system;

Force acting on each front spring is=254.8N

Required Travel = 4 inches =101.06mm

Rebound = 1.70 inches

For the rear;

Static weight on rear wheel = 765 N

Assume the dynamic force to be= 2 X static weight

= 2X765N

=1530N

Target wheel travel = 5 inches

Spring deflection = 4 inches

Required spring rate= 18.51 N/mm

The frequency obtained = 1.68 Hz

Similarly the rear normal frequency= 2.3 Hz

VII. CONCLUSIONS

We have designed the double wishbone suspension system and then simulated it in the LOTUS software. This was followed by analysis of the system in the ANSYS. The stipulated objectives namely providing greater suspension travel, reducing the unsprung mass of the vehicle, maximizing the performance of the suspension system of the vehicle and better handling of vehicle while cornering; have been achieved.

VIII. ACKNOWLEDGEMENT

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