Design & Development of Double Wishbone Suspension System for Solar Operated Vehicle

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Abstract- *in this paper our work was to study the static and dynamic parameter of the suspension system of a solar car by determining and analyzing the dynamics of the vehicle. Suspension is a necessary system for solar cars because it protects the frame and other on-board components from large jolts encountered along road for increased efficiency, most solar cars use a suspension that is stiffer than normal. For this project, the solar car has two front wheels and one rear wheel. The front wheels provide turning, so the front suspension needs 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 an A-frames, one above the other, mounted to the top and bottom of the wheel hub. A separate spring until then sits between either the hub itself or one of the wishbones and the body to control the wheel movement. . Lastly, we use an H- arm on rear suspension.*

Keywords- solar car Suspension system, Wishbone, H-Arm.

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 unstrung mass at each wheel assembly. In general, the larger the ratio of sprung weight to unstrung 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 unstrung weight ratio can also impact vehicle control. Double Wishbone Suspension System consists of two lateral control arms (upper arm and lower arm) usually of unequal length along with a coil over spring and shock absorber. Double wishbone Suspension system It is popular as front suspension mostly used in rear wheel drive vehicles. Design of the geometry of double wishbone suspension system along with design of spring plays a very important role in maintaining the stability of the vehicle. The upper arm is usually shorter to induce negative camber as the suspension jounces (rises), and often this arrangement is titled an Short Long Arms suspension (SLA). When the vehicle is in a turn, body roll results in positive camber gain on the lightly loaded inside wheel, while the heavily loaded outer wheel gains negative camber. The Four bar link mechanism formed by the unequal arm lengths causes a change in the camber of the vehicle as it rolls, which helps to keep the contact patch square on the ground, increasing the ultimate cornering capacity of the vehicle. It also reduces the wear of the outer edge of the tire.

II. SELECTION OF SUITABLE SUSPENSION SYSTEM

The selection of the suspension system which will best satisfy the requirements of a solar car was carried out. Out of the many available suspension systems in the market, the Double Wishbone Suspension System was selected for the solar car. This selection was done based on the following basic parameters:

1. Load bearing capacity 2. Flexibility
3. Cost 4. Technical aspects: Camber, Stiffness, Rolling
5. Availability of parts and component

III. BASIC COMPONENT OF DOUBLE WISH BONE AND H-ARM SUSPENSION SYSTEM

3.1 Spring: The spring is the core of nearly all suspension systems. It's the component that absorbs shock forces while maintaining correct riding height. The increased effect of shock impairs the vehicle's handling the amount of deflection exhibited under a specific load. A mounting plate welded to the lower arm serve as a lower spring seat. The upper seat is bolted to the strut piston rod. A bearing or rubber bushing in the upper mount permits the spring and strut to turn with the motion of the wheel as it steered.

Fig. spring

3.2 Shock Absorber: Shock absorber damp or control motion in a vehicle. If unrestrained, spring continue expanding and contracting after a blow until all energy is absorbed. Shock absorber can be mounted vertically or at an angle. Angle mounting of shock absorbers improves vehicle stability and dampens accelerating and breaking torque. Because the lower control arm and ball joint are retained. The control arm serves as the lower locator of the suspension.

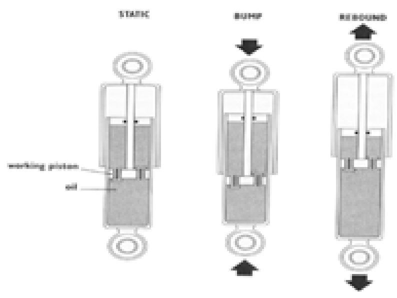

Fig. shock absorber

3.3 Double Wish Bone Suspension: The double (or "upper and lower A-arm") suspension is an independent suspension design using two parallel wishbone-shaped arms to locate the wheel. Each wishbone or arm has two mounting points to the chassis and one joint at the knuckle. The shock absorber and coil spring mount to the wishbones to control vertical movement. Double wishbone designs allow the engineer to carefully control the motion of the wheel throughout suspension travel, controlling such parameters as camber angle, caster angle, toe pattern, and roll center height, scrub radius, scuff and more.(2)

Fig.Double wishbone suspension

3.4 H-Arm: H-arm suspension are widely used for the rear suspension of the vehicle since they no need to be steered, they cannot be used for a front suspension They do not have any toe angle, kingpin axis due to the design of the knuckle. They have less degree of rotation. They are connected to the knuckle via nut and bolt. (3)

3.5 Ball Joint: A ball joint connects the steering knuckle to the control arm, allowing it to pivot on the control arm during steering. Ball joint also permit up and down movement of the control arm as the suspension reacts to road conditions. (4)

IV. DESIGN APPROACH

4.1Design of Wish Bone Arms: Design of arms is the preliminary step to design the suspension system. Initially, the material may selected, Based on the properties of the material, the allowable stress is calculated using sheer stress theory of failure. The designed arms are modeled using solid works 2013 software and then analyzed using finite element analysis software (ansys 18.0) to find the maximum stress and maximum deflection in the arms. Material Selection of arms is the very important and starting point of any design and fabrication point of view. The strength of the material should be well enough to withstand all the loads acting on it in steady motion. The material selection also depends on number of factors such as carbon content, material properties, availability and the most important parameter is the cost. Initially, three materials may consider based on their availability in the market- AISI 1018, AISI 1040 and AISI 4130. We are chosen AISI 1018 or the wishbones or lower control arm.

The main criteria were to have better material strength and lower weight along with optimum cost of the material. (5)

4.1 Calculations:

There are three stages to calculate or design the shock absorber:

1. First stage is calculating the total weight of vehicle with driver:
Our vehicle weight with driver is=300kg.
We are dividing 60% of weight on rear wheel and 40% of vehicle weight on front wheel.
2. Second stage is considering dynamic load:
We are taking standard value of load according to weight.
1kg=9.8N
For our vehicle weight (300kg=2940N)
As our 60% weight is on rear wheel, therefore on rear wheel 180kg weight is acting.
For single shock absorber 90kg weight is acting, (therefore 90kg=882N).
3. Third stage is spring design for shock absorber:
Compression of spring (δ) $=8\ WC^3n/G\ d$
Where,
W= load acting on wheel (882N).
C= spring index (assume 5).
n= number of active turns (assume 14).
G= modulus of rigidity of steel ($78600 N/mm^2$).
d= diameter of spring.
According to the load standard value of deflection (δ) (25mm=1000N)
Therefore 882N=22.02mm
$22.02=8\times882\times5^3\times14/78600\times d$
d= 7mm
Mean diameter of coil (D) = c × d
D=35mm
Total number of coil (n_1) =16
Height (h) =205mm
Outer diameter of spring coil (D_o) = D + d
$D_o=35+7$
$D_o=45mm$
Solid length (L_s) = $n_1 \times d$
$L_s=16\times7$
$L_s=112mm$
Free length (L_f) $=L_s + \delta + (0.15\times L_s)$
$L_f=112+22.02+ (0.15\times112)$
$L_f=150.85mm$

Wahl's shear stress factor $(K_w) = (4C - 1/4C-4)+(0.615/C)$

$K_w= (4\times5-1/4\times5-4) + (0.615/\times5)$

$K_w= 1.3105$

Shear stress $(\tau) = K_w\times (8W \times C / \pi d)^2$

$\tau= 1.3105 \times (8\times882\times5/ \pi 7)^2$

$\tau= 300.34N/mm^2$

Stiffness $(K) = W/\delta$

$K=882/22.02$

$K=40N$

Pitch of coil $(P) = Lf/n_1 -1$

$P=150.85/16-1$

$P=10.05mm$

V. CONCLUSION

Hence from above Calculations it can be concluded that double wish bone suspension system are convenient for our Solar Operated Vehicle.

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