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DESIGN OF SUSPENSION SYSTEM FOR A LIGHT WEIGHT ELECTRIC VEHICLE

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ABSTRACT

In future, when the petroleum reserves is exhausted, we will have one major source left with that is electric power, which could be taken from sun or any of renewable energy source. We proposed a suspension system design for a vehicle which runs on the electric power. Since it is a low budget vehicle which finds suitability in country side and also potentially heavy city rush vehicles. This possesses high efficiency and further to which for raising the efficiency we reduced the weight of the tyre by proposing a suspension with thin tyres. Also, on this newer type of suspension system will be having a reduced overall the hub weight without compromising all other stresses induced. For a light weight electric vehicle, it is necessary to reduce the thickness of the tyre because more the thickness, more power must be given to run the vehicle. But the biggest problem is that if the tyre thickness is reduced then, the hub can't be installed so we have to use the bigger tyre. So if we installed a suspension system in which the hub can be reduced and whole suspension system can work properly then our efficiency of a light weight electric vehicle will be increased.

KEYWORDS:U-Plate, T-Slot, Deflection, Wahl's Correction Factor.

INTRODUCTION

We are working on a new type of suspension system which will be reducing the hub weight. For a light weight electric vehicle, it is necessary to reduce the thickness of the tyre because more the thickness, more power should be given to run the vehicle. But the biggest problem is that if the tyre thickness is reduced then, the hub can't be installed so we have to use the bigger tyre.

So if we installed a suspension system in which the hub can be reduced and whole suspension system can work properly then our efficiency of a light weight electric vehicle will be increased. In future, when our petroleum taking cars will be exhausted then we have one major source that is electric power. Electric power can be taken from sun or any source but the vehicle will run only on electric power.

If the source is battery power then the efficiency of the vehicle should be good for better performance. So for increasing the overall effect of the vehicle it is necessary to reduce the weight of the vehicle.

So we designed a U-Arm which will play a very important role such that it will work as a wishbone or plate and a hub.

We designed our arm to reduce the weight of the hub drastically because we wanted to give the front suspension and front wheel drive with steering.

And with the help of this U-Arm we have achieved a proper way to steer and attach the suspension by reducing the weight.

DESIGN OF SUSPENSION SYSTEM

There are main four parts in this system

1. U-Plate/Arm
2. T-Slot
3. Spring with Damper
4. Shaft
5. Frame
6. Wheel

1. U-Plate/Arm
U-plate/Arm is the link used for the suspension and steering purposes for a light weight electric vehicle. Since we were trying to reduce the weight of the whole hub and wheel assembly therefore we took a thin tire but the mounting of hub was very difficult. So we have designed a U-Plate which works as a perfect hub and steering mechanism without rupture of the the suspension assembly. The U-Plate has a path made inside it for the motion of the T-Slot assembly. This path inside the U-Plate has been given so that a proper steering assembly could be provided. The material for the U-Plate is alluminium because of its good strength and low weight.

2. T-Slot
The T-Slot is the assembly which runs in the path made inside the U-plate/Arm. The purpose of this T-Slot is to provide the steering action inside the U-Plate and help in vertical motion in the suspension system. There are roller bearings on both the ends of the upper part and these bearings roll on the path guided by the U-Plate/Arm.

3. Spring with Damper
We have designed the spring for a vehicle which will be having the total weight of 850 kg including a driver and a passanger. So the springs used in the experiment is a bike suspension with the slight difference from the actual calculations. A damper is used with the spring for absorbing the shocks transmitted by the spring.

4. Shaft
This system is mounted on the shaft so the shaft has to be strong enough to withhold the pressure of the unsprung mass. The shaft used is carbon steel, that is $^{40}C_8$.

5. Frame
The frame used is of mild steel and has proper members for the proper strength. The U-Plate is hinged on the frame, similarly spring with damper are also mounted with the frame.

6. Wheel
Since our main moto was to design a proper suspension system for a light weight electric vehicles, so thin tires are used which are tempered for increasing the strength.

Design calculations for spring 1
R: Suspension Ratio
K: Spring Stiffness
k_w: Wheel Rate
m_s: Proportion of un-sprung mass
δ_s: Static displacement
F: Axial spring force
T: Torque
C: Spring index
d: Wire diameter
D: Coil diameter.
δ: Deflection
δ_{max}: Maximum deflection
L_f: Free length
P: Pitch

We have taken C =5,
Wahl's Correction Factor,
$K_s = \{4C-1/(4C-4)\} + \{0.615/C\}$

$K_s = 1.3105$

$\tau = (8WD \times K_s)/\pi d^3$
$400 = (8 \times 1471.5 \times 5 \times 1.3105)/\pi d^3$
Wire diameter, d = 7.8mm

$\delta=(8WC^3n)/Gd$
$\delta=(8\times1471.5\times5^3\times15)/(80\times10^3\times8)$
Deflectin, $\delta=34.48mm$

$\delta_{max} = (W_{max}\times d)/W$
$\delta_{max} = (7848\times34.48)/1471.5$
Maximum deflection, $\delta_{max} = 183.8mm$

n' = n+1
n' = 15+2 = 17

$L_f = n'd + \delta_{max} + 0.15 \times \delta_{max}$
$L_f = 17 \times 8 + 183.8 + 0.15 \times 183.8$
$L_f = 347.7mm$

Pitch = $L_f/(n'-1)$
= 347.7/15
Pitch = 23.158mm

Drafting of U-Plate/Arm
The maximum angle for steering is 41°.

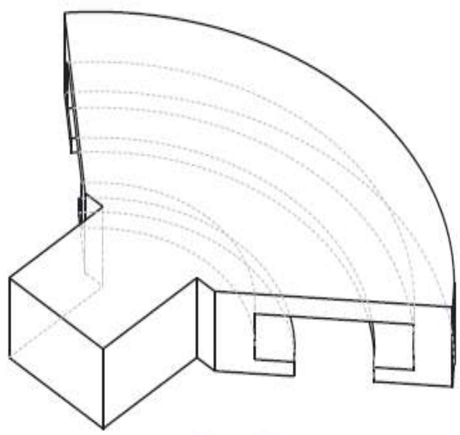

Fig.1 U-Plate/Arm

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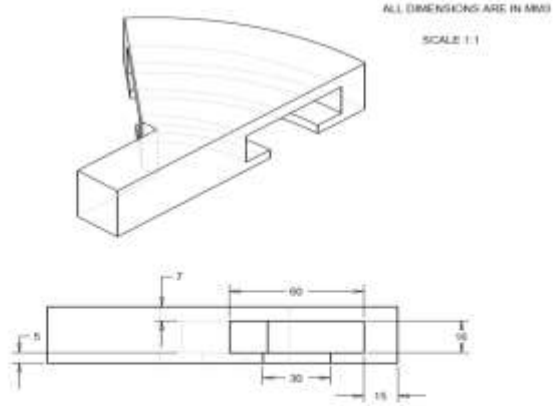

Fig.2 Side View U-Plate/Arm

The arcs of the path are 120°, 105°, 75°, 60° and the length of the T-Slot path inside the U-Plate/Arm is 60mm. The vertical height of the U-Plate/Arm is 28mm and for T-Slot is 16mm.

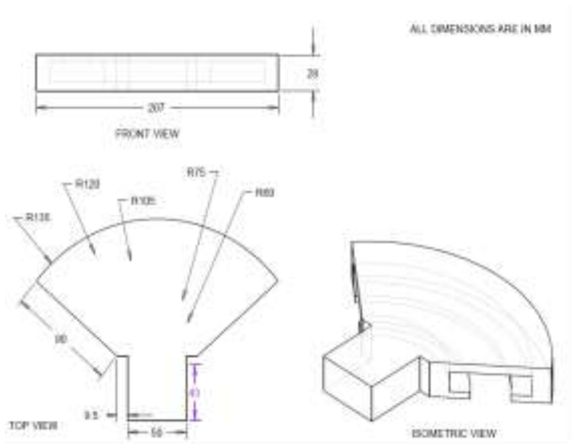

Fig.3 U-Plate/Arm

Drafting of T-Slot

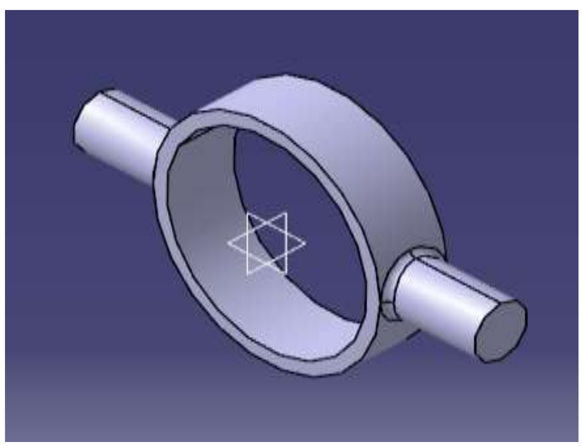

Fig.4 T-Slot Upper Part

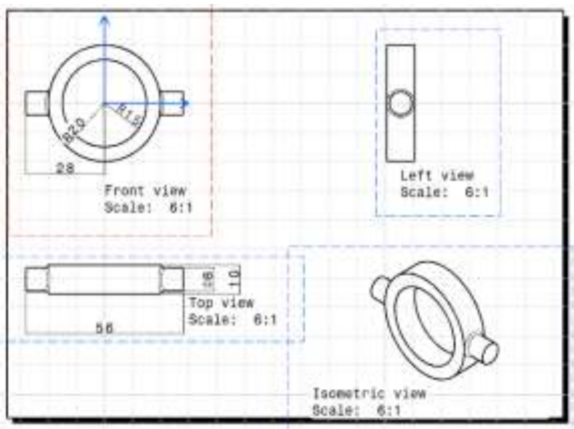

Fig.5 Drafting of T-Slot

Basic Experimental Setup of Suspension system

The basic components in this system are shown in set up diagram and the deflection in the spring due to te loading comditions is shown in the line diagram.

Fig.6 Experimental set up

The experiment of this project was done on 24 April, 2015 at 1:00 p.m. and readings were taken at different loads which is as shown in table 1 below**:**

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S.no.	Load Applied	Deflection
1	50	11.49
2	55	12.64
3	60	13.79
4	65	14.94
5	70	16.09
6	75	17.24
7	80	18.39
8	85	19.54
9	90	20.69
10	95	21.84
11	100	22.99
12	170	39.08

Table.1: Experimental Readings

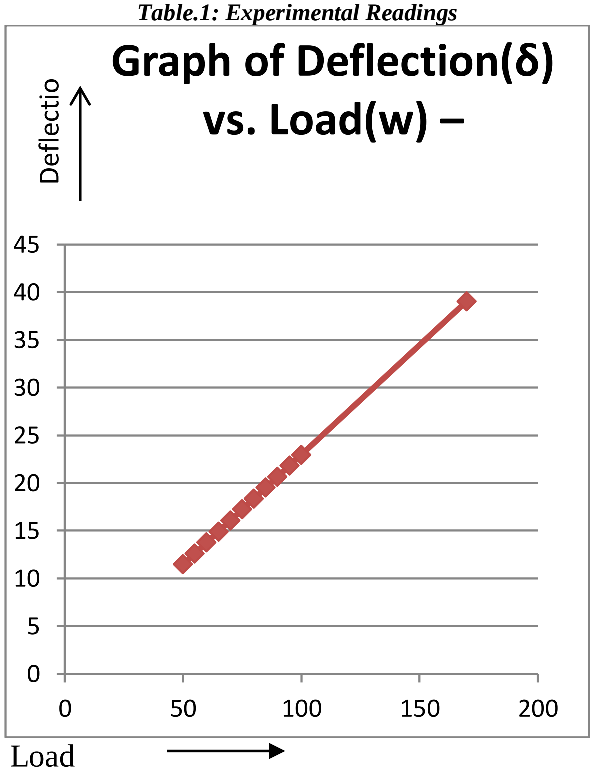

Chart.1:Deflection v/s Load

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Analysis of U-Plate/Arm

The factor of safety of U-Plate/Arm is 1.8.

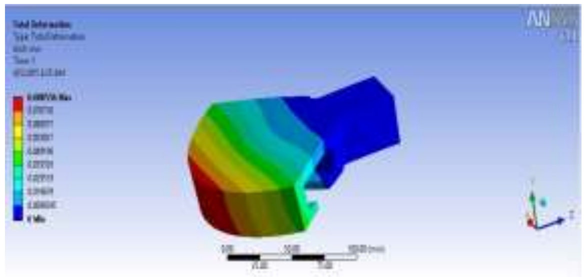

Fig. 7 Total Deformation of U-Plate

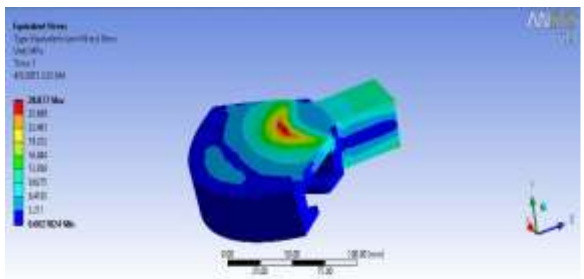

Fig. 8 Equivalent Stress of U-Plate

Comparision with conventional Hub

We compared the conventional hub with the U-Plate and while comparision the biggest achievement is that the we can take any size of the tire and the plate or arm will not be disturbed and we do not have to install the hub on the conventional position for the very thin tires to reduce complexity.

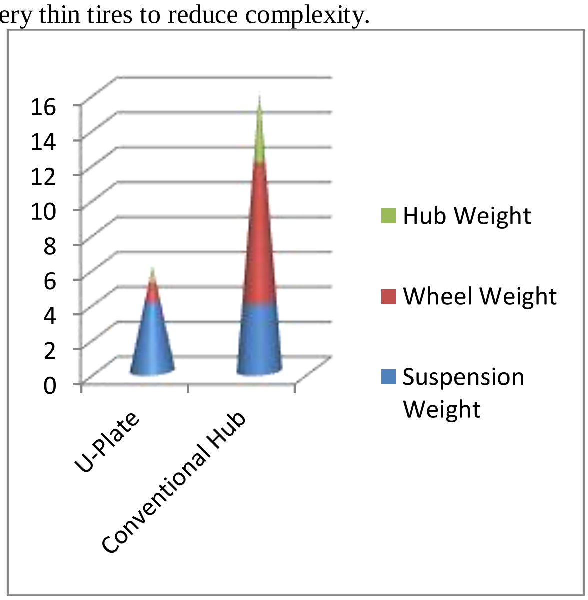

Chart.2: Comparision of weight for U-Plate/Arm with Conventional Hub

CONCLUSION

If we observe then the petroleum and coal will be finished in few years and after that only renewable resources will be there like solar energy, wind energy, etc. But as we know, the efficiency of these resources is very less due to which the nature constraints us to increase the efficiency. So we have designed the suspension system for the future when the roads will be extremely smooth and the suspension will come to only few bumps.
The suspension system is made for those electric vehicles which will run for the city purposes and country side. The speed at which we are expecting the suspension to work properly is 60km/hr and when the road is not smooth then the speed should be constrained to 30km/hr.
The suspension is expected to work properly for 4 persons and can withstand the weight of 5 persons easily. The main aim of this suspension system is to reduce the weight of the whole suspension system so that the weight of the whole vehicle could be reduced.
We have some disadvantages in this type of suspension system but we have designed our suspension system for the coming future where weight will matter a lot and roads will be much better than today.
And we hope that one day this type of electric vehicle will make a great industry all over the world which will give the comfort of a car and light weighted, easy handling and maintenance cost as a bike.

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