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Design and Development of Suspension for Solar Powered E-Bike

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Abstract - *India is rapidly becoming most pollutant nation in the world. We are dependent on conventional form of energy to drive the vehicle which uses petrol and diesel as a fuel. To deal with the problems created by fossil fuels, we need to look at the non-conventional sources of energy, mainly solar energy. According to the report there are 37 million motorcycles running on Indian roads. In the major cities, 72% pollution is created only by vehicles and no. of vehicles are increasing day by day. Solar e-bikes are electrical bikes with integrated photovoltaic (PV) solar cells on their wheels or other parts of e-bikes skeleton, which can charge their batteries when parked and during trips. The basic principle of solar powered portable bike is to utilize energy which is stored in a battery during and after charging it from a solar panel. The chargeable batteries are used to control and to drive the motor which acts here as an engine and moves the vehicle. There are various types of suspension are available in market but for optimizing the better and efficient cushioning effect. It's a need of today to do improvement and advancement in suspension system. A suspension system is a mechanical device which is used to smooth out or damped shock, impulse and dissipates kinetic energy. In vehicles, the problem happens while driving on bumping road condition so the rider feels uncomforted. Hence the design of spring in shock absorber is very important. In this project work, we are going to do some modifications in the existing solar powered e-bike. Mainly, we are focusing on the design of independent suspension system for supportive wheels at the rear end of the bike.*

Key Words: Non convectional, Suspension, E-Bike, Integrated PV cells, Better optimisation

1. INTRODUCTION

According to Dutch National Energy outlook 2016, 92% of energy is obtained by burning fossil fuels and projections for 2020 reduces only to 82%. About 37% of this consumption is represented by oil consumption mostly for transport sector and projection increase the participation of this fossil fuel to 38.5% by 2020. Electrical generation represents about 1% of all national consumption. Decreasing the consumption of fuels on the transport sector directly combats greenhouse emission (GHG) emissions.

Solar e-bikes are electrical bikes with integrated photovoltaic (PV) solar cells on their wheels or other parts of e-bikes skeleton, which can charge their batteries when parked and during trips.

The basic principle of solar powered portable bike is to use energy that's stored during a battery during and after charging it from a solar array. The charged batteries are wont to drive the motor which serves here as an engine and moves the vehicle.

There are various types of suspension are available in market but for optimizing the better and efficient cushioning effect. It's a need of today to do improvement and advancement in suspension system.

A suspension may be a robot which is employed to smooth or damp shock, impulse and dissipate K.E. In vehicles, the matter happens while driving on bumping road condition therefore the rider feels uncomforted. Hence the planning of spring in shock is extremely important.

2. LITERATURE REVIEW

Raviraj N. Rathod, et al. designed the spring using 3D modeling software CATIA. Static analysis is done on the spring by different materials as oil tempered spring steel and beryllium copper. The analysis is done by considering load of bike weight, load of single person and load of two persons. In this particular analysis, maximum shear stress and total deformation is calculated by using ANSYS software and the comparison is made on two materials. It was observed that the stresses developed in oil tempered spring steel is more than the beryllium copper, hence the beryllium copper is safe material for the maximum loading as compared to oil tempered spring steel.[1]

Setty Triveni, et al. studied the mono suspension system for three different types of two wheelers. To meet the above objective, first the existing springs of Honda CB Unicorn & Yamaha FZ springs were selected and tested for its strength by conducting the compression test. Later its 3D models of all three springs were created using SOLIDWORKS and then by importing it into the ANSYS software, evaluation of the stresses, strains and its load carrying capacity was done for static conditions.[2]

S. S. Khode, et. al. discussed various types of suspension systems vis. Dependent and Independent Suspension system in which he explained the wishbone type of independent system in detail.[3]

Shubham Kadu, et al. designed magnetic suspension system and compared it with a passive hydraulic suspension system in which they mentioned the problem of toxic pollution of

hydraulic oil in case of hydraulic suspension system which is totally eliminated in magnetic suspension system. Also, it provides better cushioning effect, increased comfort as compare with hydraulic suspension system.[4]

3. WORKING

The method used in the solar power bike is to convert renewable solar energy into mechanical work. The parts used in the solar electrical energy are solar panel, battery, DC motor, bike wheel. Solar panel is used to convert the solar energy into electrical energy. The solar panel situated at the top of the vehicle, where actual collecting of sun rays takes place. The solar energy from sun rays is transmitted to power maker through charge controller. Then this solar energy gets stored in solar batteries. The battery is an electrical device that converts energy of light directly into electricity by photovoltaic effect, which is a physical and chemical phenomenon, which can be used to run the vehicle through motor and motor controller. Solar panels of photoelectric cells are a device which has electrical characteristics, vary when exposed to light. They are the building blocks of photovoltaic modules.

When the solar rays are falls on semiconductor, a negative charged electron and positively charged holes are created. The electrical junction of solar cell separates these electron and hole from one another (Depletion layer). When electron hole pair is form near the junction then an electric field forces the holes to P side and electron to N side resulting a voltage difference between two regions and current flows which stored in battery, utilized to drive the vehicle. Recently a new type of photovoltaic cell has been developed which are more efficient than conventional type and capable of generating electric power from sunlight. The sufficient electromotive force built up to causes the electron to move through the electrical lead and an electrical current through lead wire. Also for the better stability of bike carrying solar panels at the top, on uneven road surface, we are providing two supportive wheels with independent suspension at rear end. For achieving this objective, we have designed the helical compression spring suspension.

Fig -1: Chassis

4. DESIGN AND ANALYSIS

Notations Used: **-**

1. D = Mean Diameter (mm)
2. Do = Outer coil diameter (mm)
3. Di = Inner coil Diameter (mm)
4. l = Deflection in spring (mm)
5. T' = Shear stress (MPa)
6. P = Load on helical compression spring of single suspension of supportive wheel structure (n)
7. N_t = Total number coils
8. N = Number of active coils
9. p= Pitch (mm)

For designing the suspension with helical compression spring, we have to consider various forces acting on the suspension.

As per design requirements, we have to consider total weight or load to be sustained by suspension.

Weight of Bike (W_b): 130 Kg

Weight of supportive structure (W_s): 5Kg

Total Weight of solar panels & their Supportive structure (W_p): 15 Kg

Weight of One person (W_m): 80 Kg

Hence,

Total Weight (W) = $W_b+W_s+W_p+W_m$

=130+5+15+80

=230 Kg

Hence,

Total load acting on rear Suspensions (L)= 65% of total load [Re]

=0.65*230*9.81 N

=1466.595 N

Load acting on one suspension spring (L_1) = L/2= 1466.595/2= 733.29 N

Load on Supportive Suspension Spring:

Let assume that load acting on rear supportive suspension spring (F) is 40% of load acting on rear suspension.

Therefore, F=0.4*1466.595 N= 586.368 N

In Dynamic condition, load on supportive suspension is

F1= 2*F= 2*586.368= 1172.736 N

So, load acting on one suspension spring (P) is,

P= F1/2= 1172.736/2= 586.368 N

Material:

The material used for helical compression spring is steel alloy. We have selected oil tempered spring steel which has 0.85 to 0.95% carbon (cold drawn steel wire) with following material properties.

1.Ultimate tensile strength (Sut) = 1138 N/mm^2.
2.Modulus of rigidity (G) = 78600 N/mm^2.

Therefore, Permissible shear stress (T') = 0.5*Sut= 0.5*1138= 569 N/mm^2. [V. B. Bhandari] Assuming spring index (C) to be 7.
C = D/d = 7

Wahl's shock stress factor, K = ((4C-1)/ (4C-4)) + (0.615/C)
K = ((4*7-1)/ (4*7-4)) + (0.615/7) = 1.2128

Now we have,

T' = K*8*P*C/ (3.14*d^2
569 = 1.2128*8*586.638*7/ (3.14*d^2)
d^2 = 22.28
d = 4.72mm ~= 5mm

Now, D = d*C = 5*7 = 35mm
D = (Do+Di) /2
2D = Do+Di = 2*35 = 70 Do + (Do-2d) = 70
Do + (Do-2*5) = 70
Do = 40 mm. Di = 30mm.

Deflection (l) = 8*P*D3*N/ (G*d4) Assuming deflection, l = 45mm,

45 = (8*586.638*353*N)/ (78600*54)
N = 10.98 ~= 11 ... (Number of active coils) Assuming square and ground ends,

Total number of coils, Nt = N+2 = 11+2 = 13.

Solid length = Ls = Nt*d
= 13*5 = 65 mm.

The axial gap between two turns when maximum load is applied is 1 mm. (V. B. Bhandari). Axial Gap = (Nt-1) *1 = (13-1) *1 = 12mm

Free length (Lf) = Ls + Deflection + Axial Gap
Lf = 65 + 45 + 12 = 122mm.

Pitch of spring = p = Lf/ (Nt-1) = 122/ (13-1) = 10.16 ~ 10mm Stiffness = Force (F)/Deflection (l)
= 733.29/45
= 45 N/mm.

Table -1: Components with Specifications

Sr. No.	component	specification
1	Solar Panel	(100W) *2
2	Batteries	(12V 7A) *4
3	Charge Controller	(48V) *1 (12V) *1
4	DC Hub Motor	750W
5	Fabricating Materials	Bearings, Rectangular pipes, Metal Sheet, Wheels, Fabric body.
6	Accessories and attachments	Indicating lights, Horn, Charging Ports, Shock Absorber, and Wire looms.

5. FUTURE SCOPE

- There is need for increase in efficiency of solar panels since now it is nearly 21.8% only.
- Future research could be directed at examining the willingness to pay and user satisfaction of solar bikes for leisure trips and for commuting with variations in battery power.
- Solar vehicles have been developing since the last ten years and are powered by energy from the sun. Although there are not a practical or economic form or a solution of transportation at present days, but in the future, they may play a part in reducing our reliance on burning fossil fuels such as petrol and diesel.
- As far as expanding technology & innovation is concerned, various companies have done a massive art work of engineering & design to make the best models possible.

- As our nation comes under tropic of Capricorn and tropic of cancer, so solar energy available is in abundant form and also the government of India take initiative to quarter pled the solar energy utilization by 450 GW said in UN climate summit by PMO nearly 21.8% only.
- Another future scope for the increasing efficiency of solar powered e-bike is nothing but providing alternators for the vehicle which converts the mechanical energy into electrical energy. An alternator is a maintenance-free unit. In some automobiles, it can last for up to 10-15 years without any repairs and maintenance work. If an alternator fails, the car may still run for a short interval of time on battery generated power. However, the engine can start as soon as the battery charge is depleted. Replacing an alternator with a new OEM part is expensive, but there are alternatives. The most common symptom of a problem with vehicle's charging system is a battery-shaped warning light (in the photo) or the "CHARGE" icon that comes on while driving. The charging system warning light doesn't point or give indication directly to a failed alternator, although problems of alternator are very common.
- Also, an alternator can be used to charge one of the four batteries while the bike is running. For this, an alternator is to be assembled on the two supportive wheels of the bike. When bike is running, then the two supportive wheels runs freely. So, their kinetic energy can be converted into electrical energy using alternators on them. Thus, this electrical energy can be used to charge the battery.

6. CONCLUSIONS

- Solar powered e-bike is a project to make eco-friendly, zero pollution vehicle option for IC engine motorcycle. As this field of automobiles will be explored, the problems will get solved. It can be used to cover short distances and at the same time keep the environment pollution free.
- Future trials with solar e-bikes could be directed at public e-bike sharing schemes, especially at city centers, offering tourist and visitors a choice for sustainable mobility, reducing the need to charge shared e-bikes at docking stations.
- The use of solar powered vehicle is the best way to reduce environmental pollution which is caused by the present-day automobile emissions.
- By using Mac Pherson strut type independent suspension, it is possible to achieve better stability of the bike on uneven road surfaces.
- Since this system uses only one shock absorber at each wheel, it reduces the cost and weight of the bike.
- There is tremendous future research can be done in solar-powered e-bike such as providing alternator, make suitable for e-bike charging electrically etc.

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