International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

Regenerative Suspension System

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Abstract: *In India capacity of power consumption is increased because industrialization and standard of human life is incrcreased. Now a days vehicle became a basic need of human hence the production of vehicles as well as demand of vehicles are increasing. Hence number of vehicles on road are increased. Therefore accidents are increasing. One of the best way to minimize the accidents is to install the speed breakers in front of school, hospital, temple, railway crossing etc. Due to speed breaker rider maintain minimum speed and chances of accidents are reduced. Speed breaker oppose the vehicle and impact force is created in suspension system. By using impact force power is generated with the help of dynamo and alternator. The generated power is used to charge the battery. About 100-400 watts power is generated with the help of middle size vehicles like car, taxies etc.*

Key words: **Speed breakers, Impact Energy , Regenerative suspension system, Alternator, Dynamo and Battery**

1. INTRODUCTION

The number of vehicles are travelled on a road. The road may be rough or smooth. On rough road more vibrations are created as compare to smooth road. These vibrations are not used for any purpose and vibrations are wasted. Vibrations are commonly wasted in forms of thermal energy.. By using regenerative suspension system 100-400 watts average power is generated with the help of middle size vehicles. Middle-size passenger vehicle needs 180 to 200 watts power for various processes like fuel ignition and injection processes. Also the middle size vehicles requires 250 to 260 watts power for lighting system like head light, front light, main lamp etc.

The total need of power of middle size vehicles for various requirement is about 180 to 400 watts. By using regenerative suspension system it is possible that to charge the battery of vehicle. Therefore load on the vehicle engine is reduced and the requirement of fuel is reduced at certain level. Thus by using regenerative suspension system charging of battery as well as fuel consumption is reduced.[5]

2. LITERATURE SURVEY

Larry Weng ,Geoff Walker et.al[1] have researched on energy storage system for regenerative dynamometers. In this paper, various types of dynamometers have been researched. One of those is regenerative dynamometer. In this mechanical energy is converted into electrical energy for charging the battery.

Zhang Jin-qiu, PengZhi-zhao et.al[2] studied on energy conversion system in suspension system. The regenerative suspension systems have attracted much attention in recent years for the improvement of vibrating attenuating performance and reduction of energy dissipation.

Jun Yin ,Xinbo Chen et.al[3] have researched on how to design and analyze regenerative suspension system. From this paper we come to know that how to design the kinematics of this system. To achieve better suspension performance. The regenerative suspension system should be controlled in consider of the kinematics and dynamics of the system. The advantage of regenerative suspension system is demonstrated by comparison with suspension performance of passive suspension system. MohdAzman Abdullah , JazliFirdausJamil et.al[4] have studied and developed a device to harvest vibrational energy . Based on the frequency and amplitude of potential vibrations a device is designed and developed. This device is further assembled in a passenger vehicle.[4]

3. OBJECTIVES

1. To generate the reciprocating motion as a prime input.

2. To convert reciprocating motion into rotary motion by rack and pinion.

3. To magnify the rotary motion using chain drive.

4. To store the kinetic energy using flywheel.

5. To transfer the energy to dynamo and to generate electricity.

6. To light up the indicator lamps attached to system as final output.

7. To conserve the vibrational energy which is being dissipated as heat.

4. DESIGN CALCULATION

The various steps for designing are as follows:

4.1.Nomenclature:

m = Mass of the flywheel k = Radius of gyration

I = Mass moment of inertia P_d=Diameter pitch m=Module

A = Addendum

B = Deddendum

Pc = Circular Pitch

ρ = Density of concrete

K1= Load factor

K2= Factor for distance regulation

K3=Factor for center distance of sprocket

K4=Factor for position of sprocket

K5=Lubrication factor

K6=Rating factor

T1 = Tension in tight side

T2 = Tension in slack side

Dact =Actual diameter of shaft Tmax= Maximum torque on shaft

4.2.Calculation:

Let the force put by human hand on rack = 30 kg.[9]

30x10 =300 N

In one minute rack will go up & down 30 times . Now pinion has 24 number of teeth so in 1 minute pinion Rpm will be 15 because only 12 teeth will come in contact at a time only with rack.

Now,

Gear-1, teeth = 44 and Rpm = 15

Gear-2, teeth = 18

Gear teeth ratio = 18:44

=1:2.4

Speed of gear-2 = 2.4x15

= 36 Rpm

Rpm of flywheel is 85 Rpm.

Diameter of flywheel = 350mm = 0.350 m

Width of flywheel = 80mm =0.080 m

∴ Volume of flywheel = $\pi \times r^2 \times b$

= 0.007696 m^3.

Flywheel is filled with concrete inside.

ρ = 2400 kg/m^3.

∴ Mass of flywheel = 0.007696 x 2400 = 18.47 kg

The mean kinetic energy of the flywheel, E =1/2 .I .ω^2

=1/2m.k^2.ω^2

= 0.6293 N-mm

Velocity ratio = 50 : 350

= 1 : 7

Speed of dynamo pulley = 85 x 7 = 595 Rpm. Purchase 500 Rpm standard dynamo from the market, which produce 10 watts power at full speed.

Torque transmitted by shaft,

$T = \pi/16 \times \tau \times d^3$

Select permissible shear stress (τ) from design data book (V.B. Bhandari)

τ = 70 N/mm^2

Thus, 9750 = π /16 x d^3 x 70 d=8.91mm

Taking factor of safety = 1.8

Dact = 8.9 x 1.8 = 16 mm

Select diameter of shaft = 20 mm.

For 20mm shaft diameter take standard bearing. Spherical ball or deep groove ball bearing

= 20mm

Spur gear terminology,

Take the gear of teeth, T = 24 D = 65mm b= 25mm.

Calculate spur gear terminology and check whether it can bear load.

Pd = T/D = 24/65 = 0.37 mm. m = D/T = 65/24 = 2.70mm.

Pc = πD/T = π x 65/24 = 8.50 mm.

A = 1/Pd= 1/0.37 = 2.70mm.

B = 1.157/Pd = 1.157/0.37 = 3.13 mm.

Root diameter = T-2/Pd = 22/0.37 = 59.45 mm.

Base circle = D x Cos(Pd x A) = 65 x cos(0.37x2.70) = 64.99mm.

Pc = 3.1416/Pd = 8.49mm.

Thickness = 3.1416D/2N = 1.57/Pd = 4.24mm.

By using the Lewis equation find the maximum load tooth can bear.

Lewis equation

Wt = σw x b x Pc x y

The permissible working stress (σw) in Lewis equation depends upon the gear material and may be obtained by Barth formulae.

σw = σo x Cv

σo is allowable static stress at elastic limit of the material. From design data book(V. B. Bhandari)

σo = 455mpa

Cv = 4.5/4.5+v = 4.5/4.5+ 3.40 = 0.57

V = πDN/60 = π x 0.065 x 1000/60 = 3.40 m/s

σw = σo x Cv

σw = 455 x 0.57 = 259.35

Y is known as Lewis form factor or tooth form factor.

Y = 0.154 – 0.912/T ---------- (for 20 degree full depth involute system.)

Y = 0.154 – 0.912/24 = 0.116.

Wt = σw x b x Pc x y

Wt = 259.35 x 25 x 8.49 x 0.116

= 6385 N =651 kg.

Putting 30 kg load on gear so design of our gear is safe.

4.3.Design of chain &sprocket:

Transmission Ratio = Z2 / Z1 = 44/18 = 2.44

Select number of teeth on pinion sprocket as 18 teeth.

Z1 = 18 teeth

4.4.Selection of pitch of sprocket:

The pitch is decided on the basis of Rpm of sprocket.

Rpm of pinion sprocket is variable in normal condition it is = 36 rpm

For this Rpm value select pitch of sprocket as

15mm from table. P = 15mm

4.5.Calculation of minimum center distance between sprockets:

Transmission ratio= Z2 / Z1 = 44/18 = 2.44 which is less than 5

Minimum center distance = C + (80 to 150 mm) Where C = (Dc1 + Dc2)/2

C = 120 mm

Minimum center distance = 120 + (80 to 150 mm)

= 280 mm

4.6.Calculation of values of constants

K1 = 1.25

K2 = 1.25

K3 =0.8

K4 = 1

K5 = 1.5

K6 = 1.0

4.7.Calculation of value of factor of safety :

For pitch = 15 & speed of rotation of small sprocket = 36 rpm

Factor of safety = 8.55

Calculation of value of allowable bearing stress : For pitch = 15 and speed of rotation of small sprocket = 36 rpm

Allowable bearing stress = 2.87 kg / cm^2

= 2.87 × 981 / 100 =28 N /mm^2

For horizontal position coefficient of sag K = 6

$T1/T2 = e^{\mu\theta}$

$T1/T2 = e^{0.35 \times 2.971}$

T1 = 2.80T2

T = (T1 – T2) X R

9750 = (2.80 T2 – T2) X 85

T2 = 63.72 N

T1 = 2.80 X 63.72

T1 = 178.43 N

So tension in tight side = 178.43 N Stress = force / area

Stress induced = 861/ (3.14 × 4^2) = 17.22 N /mm^2

As induced stress is less than allowable stress = 28 N /mm^2

Design of sprocket is safe. T_{max}=9750N-mm

6. CONSTRUCTION AND WORKING:

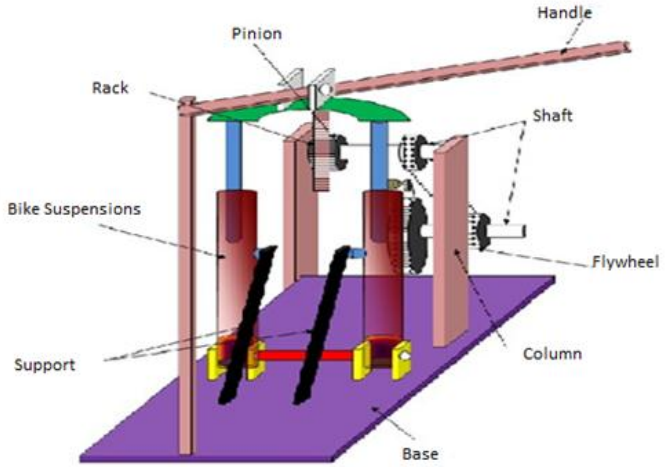

Fig. 1 Regenerative system

6.1. Construction:

1. Frame made up of the M.S. angle plate on which the whole arrangement is to be mounted.

2. Firstly altered shock absorber on which chain is welded is fitted on the horizontal angle plate with the help of nut and bolt.

3. Shock absorber carries the handle for giving the bumps and chain which is welded on it.

4. Gear box and alternator is fitted on vertical angle plate, input shaft of the gear box carries freewheel with the help of hub.

5. Teeth of the freewheel should be engaged in the chain on the shock absorber.

6.2. Working:

1. Energy available at the shock absorber is totally wasted. By using this energy we can charge battery which can be further used for running different appliances in the vehicle. It helps to reduce load on the engine.

2.Reciprocating motion of shock absorber is converted into rotary motion by using freewheel and chain arrangement.

3. Freewheel gives unidirectional rotation motion but rpm is very low rpm is increased with the help of gear box.

4. Gear box is capable of convert low rpm of freewheel to the synchronization speed of the alternator.

5. Alternator converts the rotary motion to AC output which is further used for charging the battery by converting into DC.

7. TESTING

Power produced by alternator is in the form of alternating current. For checking that shock absorber regenerator is generating current or not, we do the following tests which ensure that project runs successful

7.1.Checking for waveforms of current produced:

The output connection of the alternator is connected with oscilloscope in series.

The oscilloscope is useful because it allows electrical signals; especially time varying ones, to be observed. The signals may be slow moving or rapid.

Other features allow the signals to be physically moved about the screen. All of this makes it easier for the signal to be measured.

Fig.2 Sinusoidal wave generated and its amplification

Fig.3 Voltage and current readings

7.2.Testing for power generated:

Voltage and current is measured by using multi meter and power is calculated as follows;

V = 29.06V, I= 1.244 A;

Power = V× I

Power = 36.15VA =36.15 Watt

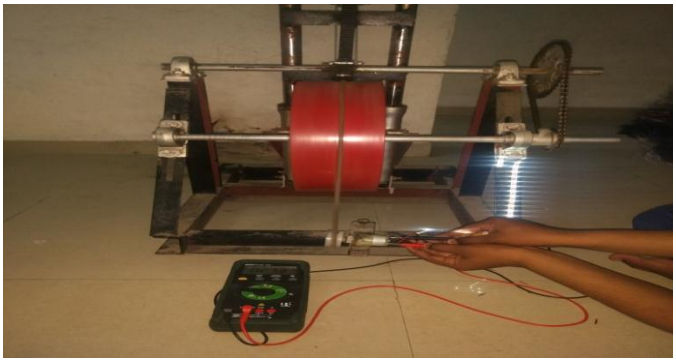

Fig.4 Testing Setup

8. CONCLUSION

The vibration energy of vehicle suspension system is wasted in the form of heat energy. By using regenerative system the wasted energy is converted into the useful energy like electrical energy and some amount fuel consumption is reduced. All types regenerative suspension are commonly electromagnetic suspension. From the appearance of full performance including oscillation guide capacity, regenerative efficiency and application reliability. By using advanced technology regenerative system can became important in vehicle manufacturing industry.

By using regenerative system electrical energy is produced. When vehicle come through a rough road that time more energy is created as compare to smooth road through alternator. Battery is connected to alternator and charges the battery.

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