Design, Fabrication and Testing of power generation Using vehicle movement by flywheel mechanism

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***Abstract*— To construct an unit which is capable of producing electricity using kinetic energy of vehicles passing over the platform which is mounted on a spring in place of speed breaker with the help of freewheel-flywheel mechanism arrangement. As the requirement of electricity is increasing day by day, we have to develop an alternate conventional source of energy to tackle the problem of energy crisis and reduce the dependency on power plants to some extent. Also such units do not require large space and cost of the unit is also comparative low. It can be employed in speed breakers where traffic intensity is very high such as Malls, Toll plazas, Multiplexes, etc. The energy obtained from it can be stored in batteries and then transmitted. This unit requires vehicle to pass over the platform. As the vehicle passes over it, it presses the spring and as result it moves downward which in turn rotates the shaft with help of sprocket and which connected to freewheel with chain drive. Freewheel and flywheel mounted on same shaft so the due to rotation energy is stored in flywheel and which is attached to dynamo which in turn generates electricity which is stored in battery.**

***Keywords*— Flywheel Mechanism, Energy, Power Generation, Eco-friendly**

INTRODUCTION

Electricity is required every point in our daily and now a days increased growth in population has resulted in reduction of conventional sources of energy. The availability and consumption of electricity is regarded as the index of national standard of living in present day civilization. Energy is important taking into account all sectors of country's economy .energy crisis is mainly due to two reasons, first the population of the world has increased rapidly, and second, the standard of living of human beings has increased. The share of global electricity demand of developing countries, jumps from 27% in 2000 to 43%in 2030.according to International energy agency the world will need almost 40% more energy in2030 than in2018. The availability of regular conventional fossil fuels are the main sources for power generation, but there is danger of sources getting exhausted eventually by the next few decades. Hence it becomes necessary that we depend on non-conventional energy sources for power generation.The increasing traffic and number of speed breakers these days emphasize on conditions to manufacture an innovative device which can use the energy of vehicles that is wasted on speed breakers to some profitable work. We can capture this kinetic energy at the speed breaker so that it can serve our purpose of electricity generation. An electromechanical unit is fixed under the speed breaker which is explained in the paper. This unit converts reciprocating motion into rotary motion. The rotational power (i.e. mechanical energy) is converted into the electrical energy by using gear arrangement and a generator which generates electricity. And this generated electricity can be used in various applications.

However, there are doubts in our society on the practical implementation of traffic energy harvester. This is the main reason of the low implementation of traffic energy harvester devices across the world. Among many traffic energy harvester devices that have been proposed, this project emphasizes on the speed breaker as the mechanism to harvest the traffic energy. In order to implement the speed breaker as a power generation unit, impact study on this new mechanism is important. It is important to prove that it is has the potential to be developed in large scale, and prove its practicability and cost effectiveness in comparison to conventional speed breaker in order to clear the doubts on its effectiveness as a power generation unit. Thus, this project is to investigate the impacts of traffic energy harnessing system on speed breakers to determine its positive and negative impacts on our society. Through this project, the possible impacts on the power generation speed breaker are being researched. Based on these impacts, simulations on speed breaker mechanism are being conducted to show the effects of these impacts on real life situation.

1. ASSEMBLY DETAILS

1.1 FLYWHEEL:

A flywheel is a mechanical device specifically designed to efficiently store rotationalenergy. Flywheels resist changes in rotational speed by their momentofinertia. The amount of energy stored in a flywheel is proportional to the square of its rotationalspeed. The way to change a flywheel's stored energy is by increasing or decreasing its rotational speed by applying a torque aligned with its axis of symmetry,

Fig1.1.Rim Flywheel

1.2 BELT & PULLEY ASSEMBLY:

A rope and pulley system—that is, a block and tackle - is characterized by the use of a single continuous rope to transmit a tension force around one or more pulleys to lift or move a load—the rope may be a light line or a strong cable. This system is included in the list of simple machines identified by Renaissance scientists. If the rope and pulley system does not dissipate or store energy, then its mechanical advantage is the number of parts of the rope that act on the load.

Fig1.2. Pulley

1.3 FREEWHEEL

Freewheel is used to transmit power in one direction only. During downward motion pinion is rotated in one direction but during upward motion of rack, pinion is freed due to which no motion is transmitted

Fig1.3.Freewheel

1.4. DYNAMO:

It is a device, which converts mechanical energy into electrical energy. The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current through "Faraday's Law of Electromagnetic Induction". A dynamo machine consists of a stationary structure, called stator, which provides a constant magnetic field, and a set of rotating winding called the armature which turns within that field.

Fig1..4 Dynamo

2. CALCULATIONS

2.1 FLYWHEEL:

Types of Flywheel:

Arm type and Rim type

1. Arm type flywheel (2 – 5-meterdiameter) (max size of flywheel is 5.3 M)
2. Rim type (0.4-1.8-meterdiameter)

Diameter has chosen according to space requirement as 0.6 m

Consider, it is rotating from 400 RPM to 410 RPM.

Speed fluctuation $CS = (N\,2 - N1)/N$

N= average speed in RPM = (410+400)/2 = 405 RPM

Cs = 10/405 = 0.025

From V.B..Bhandari, Page No. 25.2, Table no. 25.2,

Coefficient of speed fluctuation (Cs) or it can be taken as 0.03

Diameter = 600 mm (10'') = 60 cm

Suppose let we take Length of hub = width of rim

Width of hub for fly wheel W = D/ 4 = 15cm

Height of hub for fly wheel H= D/6 = 10cm

Length = 15cm

Material =mild steel

Density of Mild Steel = 8050 Kg/m3

We know that,

Density = Mass /Volume

V= volume (A*L) = π/4 *d2*L = 0.0424m3

$\varrho = \frac{m}{V}$

8050 =m/ 0.0424

m = 341.32Kg

Weight of flywheel = 341.32 Kg W= 3413.2 N

(Inertia) I = 0.5 mr^2

= 0.5 * 341.32 * 0.3^2

= 15.36 kgm^2

E = 0.5 I ω^2

Where, W = 2*π*N/60 = 2*π*410/60 = 42.94 rad/sec

E =0.5*15.36 *$(42.94)^2$

= 14160.72 Joules

Toque = mass moments of inertia * rotational acceleration rate.

T = I *a

25.39 =15.36 * a

a =1.653 rad/sec^2

As the power transmitting to the chain & sprocket is 1.09KW

We know that, P = 2*π*N*T /60

1.09*10^3 = 2*π*410*T / 60

T = 25.39Nm

2.2 CHAIN & SPROCKET:

Let us consider Speed of chain = 410 RPM

From page no. 14.7, From table no. 14.8

For the speed of 410 Rpm we will select the chain no. 06B

Maximum Power = 1.09 KW

Consider no. of teeth = 16,18

Used chain no.06B

For Z=18

Roller diameter, d1=6.35 mm

Width' b1=5.72 mm

Transverse pitch p_t=54.85 mm

z1= 18

z2= 44

Approximate centre distance,

a = 40*P ----------nominal

a = 40*9.525

a = 381 mm

No of links

L_n=2(a/p) + (z_1+z_2/2) + (z_2- z_1/2* π)^2 *(p/a)

= 2(381/9.525) + (18+44/2) + (44-18/2* π)^2* (9.525/381)

= 111.43 = 111

From table no 14.1

Pitch, P=9.525 mm

Width between inner plates, b1=5.72 mm

Roller diameter, d1=6.35 mm

Transverse pitch p_t=10.24 mm

Pitch circle diameter

$D_1=\frac{p}{\sin(180/z1)}$ $D_2=\frac{p}{\sin(180/z2)}$

$=\frac{9.525}{\sin(180/18)}$ $=\frac{9.525}{\sin(180/44)}$

D_1 = 54.85 mm D_2 = 133.59mm

Roller seating radius (r_i)

r_{imax} = 0.505d_1 + 0.069* (d_1)$^{1/3}$

r_{imax} = 3.33mm

r_{imin} = 0.505 d_1 = 3.2mm

Tooth Flank Radius (r_e)

r_{emax} = 0.008(z^2+180) =16.928mm

r_{emin} = 0.12*d_1(z+2) = 15.24mm

Root Diameter (D_f)

D_f = D – 2* r_i = 88.47mm

Tooth height above pitch polygon (h_a)

h_{amax} = 0.625*p – 0.5*d_1 +0.8*p/z = 2.9513mm

h_{amin} = 0.5(p-d_1) = 1.5875mm

Tooth Width (b_f)

b_f = 0.93 *b_1 = 5.3196mm

Tooth Side Relief (b_a)

b_a = 0.1p to 0.15p = 1.1907mm

2.3 BELT & PULLEY:

From Page No. 13.12 We will select the Z type of V Belt.

From table no. 13.23, Minimum Diameter = 50 mm =D2

Maximum Diameter = 100mm = D1

Speed of Maximum Diameter = 410 RPM = N1

Speed of Minimum Diameter =N2

We Know that, N1/N2 = D2/D1

410/N2 = 50/100

N1 = 820 RPM

Consider, Centre Distance = C = 2*D = 200mm

α = Sin^{-1}(R1-R2/C) = Sin^{-1}(25/200) = 7.18

Length of Belt = L = π (R1 + R2) +2*α(R1 – R2) + 2*C*Cosα

L = π(25 + 50) +2*7.18(25)+2*200*Cos7.18

L = 991.48mm

θ = 180 – 2* α = 165.64

We know that T_1 = Tension on tight side

T_2 = Tension on slack side

T_1/ T_2 = e $^{(\mu\theta/\sin\beta)}$ = 3.8528

T1 = 3.8528 T2

We know that,

P = (T_1 - T_2)* V

Where V = π*D*N/60 = 2.15 m/s

1090 = (3.8528 T_2 - T_2) *2.15

T_2 = 177.71N

T_1 = 679.89N

2.4 SHAFT DESIGN:

Consider, Material of Shaft = M.S.

Yield Strength = 250 MPa

Shear Strength = 0.75*Yield Strength = 0.75*250 = 187.5MPa

From Page No. 9.7, For Angle of Twist = Θ

Permissible Angle of twist is 0.25 per meter length.

Let us assume length of Shaft = 550mm

G = 79300 N/mm2

We know that, According to Torsional Rigidity,

$D^4 = \frac{584*T*L}{G*\theta}$

$D^4 = \frac{584*25.39*1000*550}{79300*0.1375}$

D = 30 mm

2.5 SPRING DESIGN:

10 KN for 1 spring & spring index C=5

Consider, material of spring IS 4454 grade 2

Tall =0.45*Sut …..(Sut = 1500 N/mm2)

T=675N/mm2

Modulus of rigidity to material of steel G=80 Gpa

1. Wire diameter

Whal Stressfactor Kw =(4C-1/4C-4)+(0.615/C)

Kw=1.35

Shear stress include T=Kw[8*F*C/∏*d^2]

d^2 = 1.35[8*10000*5/∏*675]

d=15.65

Mean coil diameter D=C*d , 5*15.65 , D=78.25mm

No of Coils

Spring stiffness K=f max /δ max,

Assume δ max =50mm

K=200N/mm

Now, K=[Gd/8*C^3 *n]

n=6.26

For Square & Grounded side spring,Total no of coils n'=n+2

n'=8.26

spring length & pitch

solid length Ls =(n+2)*d

Ls=129.26mm

Free Length

Lf =Ls +δmax+(n'-1)*1

Lf=186.52

Lf=P*n+2*d

186.52=P*6.26+2*15.65

P=24.79mm

3. WORKING OF THE SYSTEMS

While moving the vehicle posses some kinetic energy and it has been wasted. This kinetic energy can be utilize to produce power by using special arrangement called Power Ramp. It is Electro-mechanical unit and utilizes power generation and its storage. Ramp is inclined plate likely to be speed breaker, Whenever the vehicle allowed to pass over the ramp it get pressed downwards then spring attached to Ramp get compressed. The sprocket which is attached to the ramp starts rotating and shaft connected to sprocket also rotates in same direction of sprocket. On that shaft, freewheel is install and get rotated. This freewheel connected to other shaft by using chain and sprocket arrangement. on second shaft no. of flywheel mounted which is used to store energy and get connected to dynamo using belt and pulley arrangement.

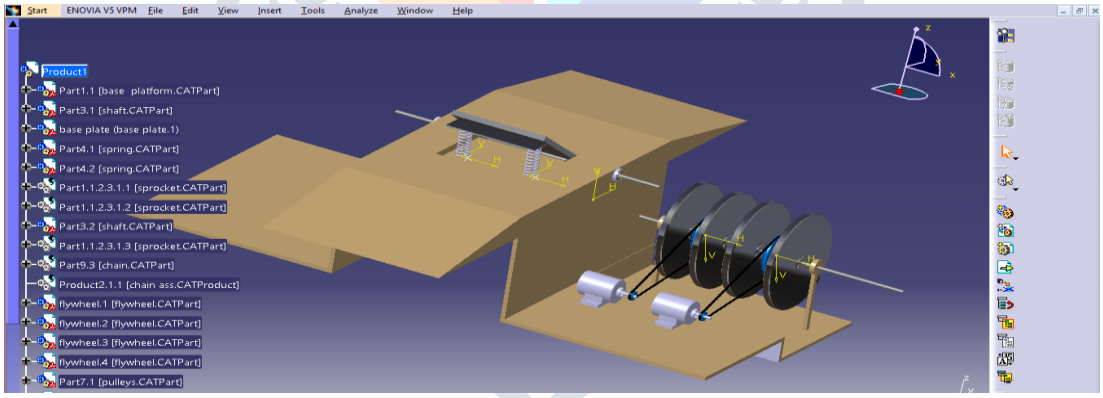

Fig1. Model in Catia

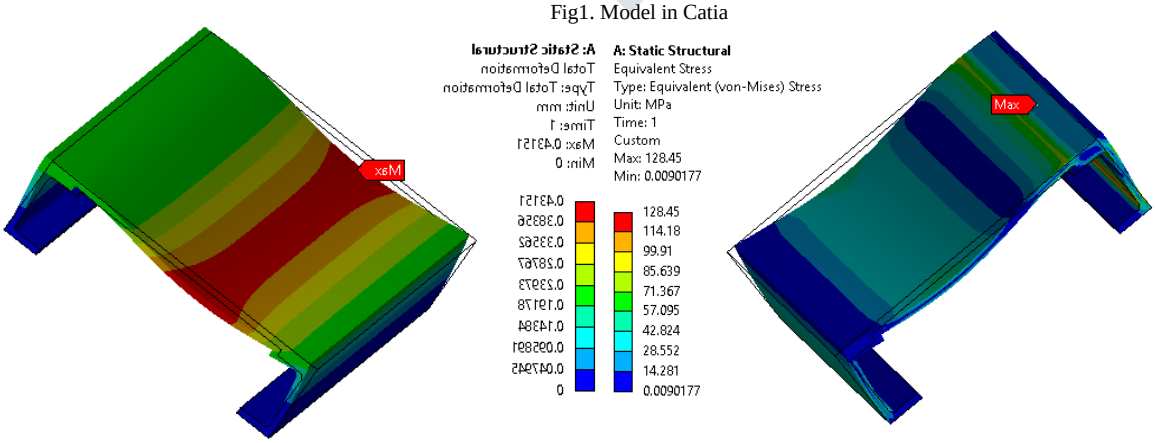

Fig2. Analysis of platform on Ansys

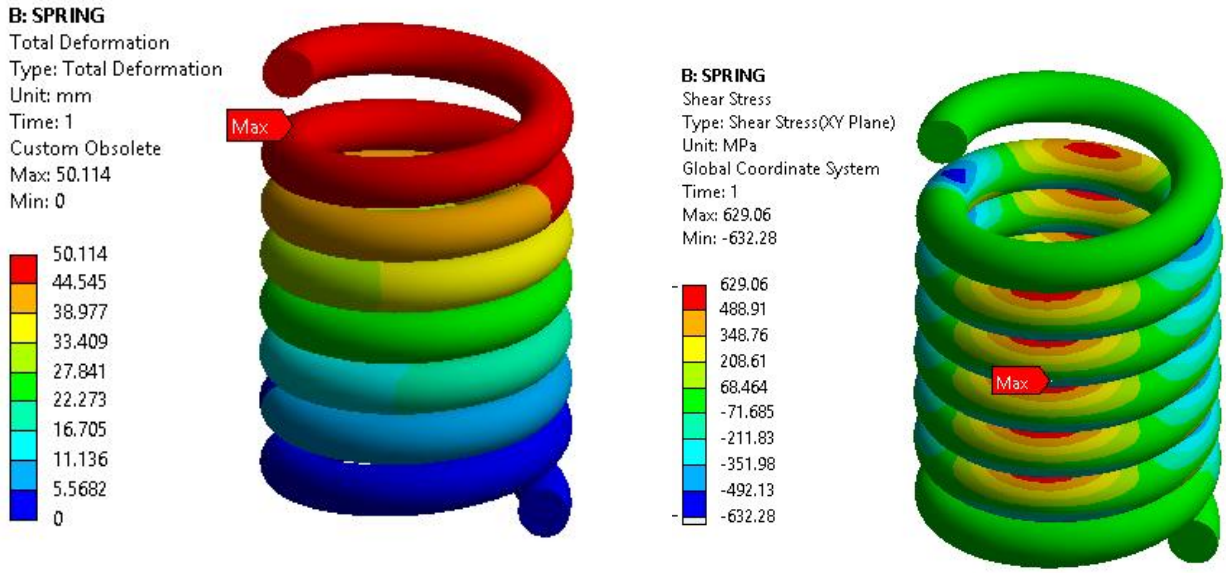

Fig2.Analysis of Springs in Ansys software

I. CONCLUSIONS

Electricity plays very important role in our life due to population explosion the current power generation has become insufficient to fulfill our requirement in this project we discovered technology to generate electricity from vehicle movement. In coming days this will helpful to the world since it will save lot of electricity of power plant that gets wasted in illuminating the streetlights

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