Foot Step Power Generation Using Rack And Pinion

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Abstract- *Nowadays energy and power are the one of the basic need in this modern world. Energy demand is increasing day by day. On the other hand, the many energy resources are getting exhausted and wasted. Proposal for utilization of waste energy of foot power with human locomotion is very relevant in populated countries like India where roads, railway stations, bus stands, temples, etc. are overcrowded and millions of people move around. This whole energy is wasted. If this energy made possible for utilization it will be a great invention. In this project we are converting non-conventional from just walking foot step into electrical energy. This project uses simple drive mechanism such as rack and pinion assembly. The control mechanism carries the rack & pinion; D.C generator, battery and LED strip to show output. We have discussed the various applications and further extension.*

Keywords- Footstep, Conventional Energy, Non-conventional Energy system.

I. INTRODUCTION

In this project the weight which acts on the foot step is used to generate electrical energy. When a person walks over the foot step, a force acts on the step. One can simply be amazed by knowing how much energy a person can have just by walking on the floor with normal speed. Whenever a person walks, manages to lose energy towards the floor by means excess weight to the floor. That energy may be used and converted into electrical energy. The Mechanical energy(weight)is converted into electrical energy using drive mechanism, in this case rack and pinion. Generated energy can be stored in batteries. Then the output of the battery is used to lighten the lamps in the room.

II. PROBLEM STATEMENT

Design and fabrication the model of foot step power generation. Also to fabricate the model of the same which would able to show the characteristics of the systems and working according to need.

III. OBJECTIVES

To design and develop the model of Stair case power generation.

Also fabricate the model which will work on the systems for required application step. One can simply be amazed by knowing how much energy a person can have just by walking on the floor with normal speed. Whenever a person walks, manages to lose energy towards the floor by means excess weight to the floor. That energy may be used and converted into electrical energy. The Mechanical energy(weight)is converted into electrical energy using drive mechanism, in this case rack and pinion. Generated energy can be stored in batteries. Then the output of the battery is used to lighten the lamps in the room.

IV. METHODOLOGY

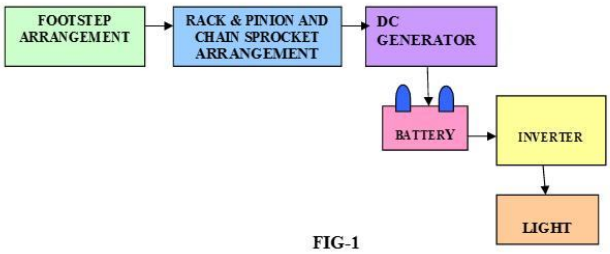


Fig-1: Methodology

V. LITERATURE REVIEW

"Power Generation in Automobile Suspension System" by C. Nithiyesh Kumar, K. Gowtham, M. Manikandan, P. Bharathkanna, T. Manoj Kumar

In this research paper author studied three methods of foot step power generation namely piezoelectric method, rack and pinion method and fuel piston method comparatively and found that the rack and pinion mechanism is more efficient with moderate cost of operation and maintenance.

"Generation of Electrical Energy from Foot Step Using Rack and Pinion Mechanism" by Md.Azhar, Zitender Rajpurohit, Abdul Saif, Nalla Abhinay, P.Sai Chandu

In this research paper authors used regulated 5V power, 500mA power supply. Bridge type full wave rectifier is used to rectify the ac output of secondary of 230/12V step down transformer. A rack and pinion is a type of linear actuator including a pair of gears which convert rotational motion into linear motion. The "pinion" engages teeth on the rack. In this paper, since the power generation using foot step get its energy requirements from Non-renewable source of energy. There is no need of power from external sources (mains) and there is less pollution in this source of energy. It is very useful to the places like all roads and as well as all kind of foot step which is used to generate the non-conventional energy like electricity.

"Electrical Power Generation Using Foot Step for Urban Area Energy Applications" by Joydev Ghosh, Amit Saha, Samir Basak, Supratim Sen.

In this research paper authors used 80 volts and 40 mA from one coil have been generated from a prototype model as first invention. The second invention provides 95 volts and 50 mA from one coil and this generated power can be used to light LED array and to run DC fan after rectifying the AC or can charge batteries. For high efficiency in the axel of the second gear, they fitted a strong magnet vertically, so that when the gear will rotate due to human body weight the magnet also rotate. The magnet is placed in a loop type copper coil. When the magnet start rotating according to the Faraday's law of electromagnetic induction, there will be induced emf in the coil.

"Power generation through step" by Vipin Kumar Yadav1, Vivek Kumar Yadav1, Rajat Kumar1, Ajay Yadav

In these research paper authors used equipments with following specification: Motor Voltage:10 volt Type: D.C. Generator, RPM:1000 rpm, Gear 1-Mild Steel,No. of teeth:59(big gear),No. of teeth:36(small gear),Type: Spur Gear, No. of gear used:2 Spring 1-Load bearing capacity:60-90 kg, Mild Steel,Total displacement:5 inch, Bearing 1-Type: Ball bearing, Bearing no.N35,Shaft 1-Diameter: 15 mm-Material: Mild steel author concluded that with these method energy conversion is simple efficient and pollution free.

"Power Generation Footstep" by Shiraz Afzal, Farrukh hafeez

This paper is all about generating electricity when people walk on the Floor if we are able to design a power generating floor that can produce 100W on just 12 steps, then for 120 steps we can produce 1000 Watt and if we install such type of 100 floors with this system then it can produce 1MegaWattAs a fact only 11% of renewable energy contributes to our primary energy. If this project is deployed, then not only we can overcome the energy crises problem but this also contributes to create a healthy global environmental change. In this project a gear system is attached with flywheel which causes to rotate the dynamo as the tile on the deck is pressed The power that is created is saved in the batteries in addition we will be able to monitor and control the amount of electricity generated

When an individual passes it push the tile on the ground surface which turn the shaft beneath the tile, turn is limited by clutch bearing which is underpinned by holders. Primary shaft is rotate approx. twice by a single tile push. The movement of the prevailing shaft turn the gearbox shaft which builds it 15 times (1:15) then its movement is smoothen by the help of fly wheel which temporary store the movement, which is convey to the DC generator (it generates 12V 40 amp at 1000 rpm).

"POWER GENERATION FROM STEPS" by Ramesh Raja R, Sherin Mathew

This research paper attempts to show how energy can be tapped and used at a commonly used floor steps. The usage of steps in every building is increasing day by day, since even every small building has some floors. A large amount of energy is wasted when we

are stepping on the floors by the dissipation of heat and friction, every time a man steps up using stairs. There is great possibility of tapping this energy and generating power by making every staircase as a power generation unit. The generated power can be stored by batteries, and it will be used for slighting the building.

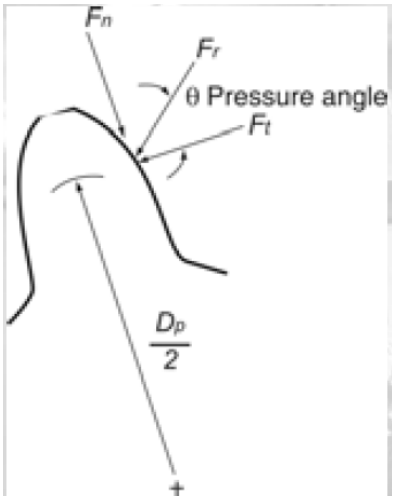
"Electricity Generation from Footsteps; A Regenerative Energy Resource" by Tom Jose V*, Binoy Boban*, Sijo M T*

In these research paper author manufactured a model made from stainless steel, recycled car tires and recycled aluminium, also includes a lamp embedded in the pavement that lights up every time a step is converted into energy (using only 5 percent of the generated energy). The average square of pavement produces about 2.1 watts of electricity. And according to author, any one square of pavement in a high-foot traffic area can see 50,000 steps a day. Based on this data, only five units of Pavegen pavement can be enough to keep the lights on at a bus stop all night.

3.1.1 Design of Rack & Pinion:

Pitch circle diameter of the gear is= 27.5 mm

Circumference of the gear is= pitch circle diameter =27.5



Nomenclature:

f_t = transmitted force

f_n = normal force

f_r = resultant force

θ = pressure angle

Pressure angle = 20^0

Rack and pinion calculation:

1. $f_n = f_t \tan\theta$……(1)

f_t = tangential force

f_t = 65 x 9.81 (Consider average weight of human=65 kg)

f_t = 637.65 N

Now,

$f_n = 637.65 \times \tan 20^0$....using equation (1)

f_n = 232.08 N

2. $f_r = \frac{f_t}{\cos\theta}$ ……(2)

$$f_r = \frac{637.65}{\cos 20}$$

f_r = 678.57 N

3. Power (P) = $\frac{\text{Work}}{\text{time}}$ ……(3)

$$P = \frac{\text{Force(ft)} \times \text{displacement}}{\text{time}}$$

$$P = \frac{637.65 \times 0.050}{1}$$

P= 31.88 Watt

Now,

$$P = \frac{2\pi NT}{60} \quad \ldots\ldots\ldots\ldots (4)$$

$$T = \frac{P \times 60}{2 \times N}$$

$$T = \frac{31.88 \times 60}{2 \times 3.142 \times 30}$$

T = 10.15 Nm

4. $T = f_t \times r$ ……..(5)

$$r = \frac{T}{f_t}$$

$$= \frac{10.15}{637.65}$$

r = 0.015

r = 15 mm

So D=2*r = 30 mm

5. Using Lewis form factor:

$$\sigma_t = \frac{f_t \times P_d}{y \times b} \quad \ldots\ldots\ldots\ldots\ldots(6)$$

Let,

y=Lewis form factor

b=face width of tooth

P_d = diametrical pitch

Then,

- $P_d = \frac{T}{D}$ ……..(7)

$$= \frac{18}{30}$$

P_d = 0.6 mm^{-1}

Substituting values in equation (6)

$$= \frac{637.65 \times 0.6}{30 \times 0.308}$$

σ_t = 41.405 N/mm^2

6. $\sigma_{allow} = \frac{S_{ut}}{fos}$ ……..(8)

$$= \frac{210}{2}$$

σ_{allow}= 105 N/mm^2

So $\sigma_t < < \sigma_{allow}$

So design is safe.

$m = \frac{D}{T}$ ….(9)

$= \frac{30}{18}$

m= 1.66

Then the module of pinion = 1.66

Also The module of rack = 1.66

Pinion dimension:

Outer Dia. = $d_0 = 2m + D$ …….(10)

= 2 x 1.66 + 30

d_0 = 33.32 mm

7. RRoot dia. (d_r) = D – (2m + 2C) where (C=root clearance)… …..(11)

= 30 – (2 x 1.66 + 2 x 0.25)

d_r = 26.18 mm

Addendum,

Ad = m ……..(12)

A_d = 1.66 mm

Dedendum,

D_d = m + C where (C=root clearance)… …….(13)

D_d = 1.66 + 0.25

D_d = 1.91 = 2 mm

8. LLinear displacement of rack for one rotation of piston,

L = πm x T ……(14)

= π x 1.66 x 18

= 94.44

L = 100 mm

Therefore,

Maximum length of rack is 100 mm.

Width of rack is 10 mm.

3.2 BASIC DESIGN OF MS PLATE

By using bending equation,

$\frac{M}{I} = \frac{\sigma}{Y}$ ……(1)

Where M=Bending Moment

I=Moment of inertia of area of cross section

σ = Bending Stress

$I = \frac{bd^3}{12}$ ……..(2)

$= \frac{300 \times 4^3}{12}$

I=1600mm^4

Therefore,

$\frac{637.65*150}{1600} = \frac{\sigma}{2}$ …….using equation no (1)

σ_b=119.559N/mm

$\sigma_b << \sigma_{allow}$

1. i.e, $\sigma_{allow} = \frac{210}{1}$ = 210

So design is safe.

3.3 SPRING

Specification : (standard values are considered here from net)

δ=75mm

Material=steel wire

Ultimate tensile strength=1090 N/mm^2

Modulus of rigidity=81370 N/mm^2

Permissible shear stress for spring wire should be taken as 50% of ultimate tensile strength.

We are finding the following values:

1. Wire diameter.(d)
2. Mean coil diameter.(D)
3. Number of active coil.(N)
4. Total number of coils.
5. Free length of spring.
6. Pitch of the coil.

P=638 N…….(assume 65kg)

δ=75 mm

C=6…….. (Spring index)

Sut=1090 N/mm^2

G=81370 N/mm^2

T=0.5 Sut

1. Wire diameter:

The permissible shear stress is;

T=0.5*Sut

=0.5*1090

T=545 N/mm^2

- $K = \frac{4c-1}{4c+4} + \frac{0.615}{c}$

$$=\frac{4*6-1}{4*6+4}+\frac{0.615}{6}$$

K=1.2525

- $T=k*\frac{8*P*c}{\pi*d^2}$

$$545=1.2525*\frac{8*637.65*6}{\pi*d^2}$$

d= 4.73mm = 5mm

Where;

d=wire diameter

Di=inside diameter

Do=outside diameter

D=mean coil diameter

2. Mean coil diameter:

D=c*d

=6*5

D=30 mm

Number of active coil:

$$\delta=\frac{8*P*D^3*N}{G*d^4}$$

$$50=\frac{8*638*30^3*N}{81370*5^4}$$

N=18

3. Total number of turns:

It is assumed that the spring to spur and gear ends. The number of inactive coils is 2.

N_1= N+2 =18+2 =20

4. Free length of spring:

The actual deflection of spring is;

$$\delta=\frac{8*P*D^3*N}{G*d^4}$$

$$\delta=\frac{8*638*30^3*18}{81370*5^4}$$

□ =48.78 mm

Solid length of spring.

It is assumed that here will be gap of between consecutive coils which spring is subjected to max force

Total number of coils is 18.

- Axial gap (N1) =N-1= (18-1)*1=17 mm
- Free length=solid length +axial gap +δ (Solid length=N1*d=20*5=100)

=100+17+49

Free length=166 mm

5. Pitch of coil:

$$p=\frac{\text{free length}}{N1-1}$$

$$=\frac{166}{18-1}$$

p=9.76 mm

Because the outer diameter of base pipe is 20mm.

3.4 SPUR GEAR

$$\text{Power} = \frac{\text{Force} * \text{Displacement}}{\text{Time}} \quad \ldots.(1)$$

Force (F) = m*g

Consider weight of person is 65 kg.

$$P=\frac{(65*9.81)*(0.050)}{1}$$

P= 31.88Nm/Sec

Power= 31.88Nm/sec

on pinion is 12 and 20^0 Full depth involute.

Speed of motor =100 rpm.

Material of gear is cast iron FG200.

Therefore, S_{ut} =200N/mm^2

- Beam Strength (S_b) :

$S_b=m*b*\sigma_b*Y$ ……. (2)

$S_b=m*10m*(200/3)*0.272$

$S_b=181.315m^2$ N

$$P_{eff}=\frac{C_s*f_t}{C_v} \quad \ldots\ldots.. (3)$$

$$V=\frac{\pi*d_p*n_p}{60*10^3}$$

$$=\frac{3.14*m*12*100}{(60*10^3)}$$

V=0.0628*m m/sec

$$C_v=\frac{3}{3+V}$$

$$=\frac{3}{3+0.0628m}$$

F_t= P/V

F_t = 31.88/ (0.0628m)

F_t = 507.64/m

Now, from equation (3)

$$P_{eff}=\frac{C_s*f_t}{C_v}=\frac{1.5*(507.64/m)}{(6/(6+0.0628m))}$$

$$= \frac{126.91*(6+0.0628m)}{m}$$

Now, we know that

$S_b = FOS * P_{eff}$

$$181.315*m^2 = \frac{2*126.91*(6+0.0628m)}{m}$$

Therefore

m = 2.5mm

Now,

b =10*2.5

b =25 mm

Now, $d_p = m* Z_p$

=2.5*12

d_p = 30mm

$d_g = m*z_g$

$d_g = 2.5*24$

d_g =60mm

$h_a = 1*m$

h_a=2.5mm

$h_f = 1.25*m$

h_f =15mm

$a = (d_p + d_g)/2$

$a = (30+60)/2$

a = 45mm

- Wear Strength (S_w)

$S_w = b*dp*Q*K$ (5)

$$= \frac{25*30*0.21*2*12}{(12+24)} * (BHN/100)^2$$

$S_w = 105* (BHN/100)^2$

Now,

$$P_{eff} = \frac{253.82*(3+0.0628m)}{m}$$

$$= \frac{253.82*3+0.0628*2.5}{2.5}$$

P_{eff} = 320.52N

$S_w = Fos*P_{eff}$

$S_w = 2*320.52$

S_w =641.04 N

From equation (6)

$S_w = 641.04 = 105* (BHN/100)^2$

Therefore,

BHN=247.08

3.7 SHAFT:

$Z_p=12$ $Z_g=24$

$$M_t = \frac{60*10^6*31.88*10^{-3}}{2*3.14*100}$$

= 3044.316 N mm

F_t (Tangential force) = 638 N

F_r (Radial force) =232.08 N

Resultant Force = $(F_t^2 + F_r^2)^{1/2}$

= 678.6 N

$-R_{BV}*80+638*57.5=0$

R_{BV}=458.5626 N

R_{AV}=179.4375 N

$R_{AH}+R_{BH}=232$

$-R_{BH}*80+232*57.5$

R_{BH}=166.75 N

R_{AH}=65.25 N

$R_A=(65.25^2+179.4375^2)^{1/2}$

R_A=190.93 N

R_B=487.94 N

Moment at point C= $M_c=R_A*57.5$=10979 N. mm Torque=10.15 N mm

$T_e=(M^2+T^2)^{1/2}$

T_e=14951.95 N mm

Tou = 0.75*(0.18*Sut) Sut=200

=0.75*(0.18*200)

=27 N/mm^2

Tou = 0.75*0.3 Syt Syt =276

=62 N/mm^2

We have to take small between two values

Therefore, tou = 27 N/mm^2

$$Tou = \frac{16\ T_e}{3.142*d^3}$$

d =14mm

VII. WORKING

The complete diagram of the power generation using foot step is given below. The pushing power is converted into electrical energy by proper driving arrangement. The rack & pinion, spring arrangement is fixed at the upper plate and lower plate. The spring is used to return the plate in same position by releasing the load. The gear wheel is coupled to the smaller motor shaft. The generator is used here, is permanent magnet D.C generator. This arrangement is fitted in FOOT STEPs; the complete arrangement is kept inside the floor level except the pushing arrangement. Basic Components:

It consists of the following main parts:

1. MS plate
2. MS Pipes
3. Rack and pinion
4. DC motor
5. FRAME
6. LED lights Etc

ADVANTAGES

1. Power is generated simply by walking on the step.
2. Power also generated by running or exercising on the step and implementing this mechanism on treadmills.
3. No need input fuel for power generation.
4. This is a Non-conventional system.
5. Battery is used to store the generated power else we can use directly this generated power for conventional purposes.

APPLICATIONS

1. This can be implemented on railway stations, bus stops, air ports to generate electric power by human physical activity.
2. Also can be implemented in parking lots, electric escalators.
3. This mechanism can be implemented on gymming instruments like cardio machine for power generation and the power generation rate is high.
4. We can use this mechanism in automobile suspension system.
5. In rural areas etc.High Initial Cost

VIII. CONCLUSION

In concluding the words of our project, since the power generation using foot step gets its energy requirements from the non-renewable sources of energy. There is no need of power from the mains and there is less pollution in this source of energy. It is very useful to the places like all roads and as well as all kind of stair case which is used to generate the non-conventional energy like electricity. It is able to extend this project by using same arrangement and construct in the footsteps/speed breakers so as to increase the rate of power production rate.

REFERENCES

[1] “Power Generation in Automobile Suspension System” by C.Nithiyesh, Kumar,K.Gowtham, M.Manikandan, P.Bharathkanna, T.Manoj Kumar

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