Footstep Power Generation

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Abstract

Energy crisis is a major concern in today's world. As the demand of energy is increasing day by day, so the ultimate solution to deal with these sorts of problems is just to implement the renewable sources of energy. The objective of footstep power generation project is to abstract renewable energy. If this project is installed in highly dense areas such as railway stations, clubs, parks etc. then maximum amount of energy can be abstracted from it. By simply walking on footpath, electricity is generated. Also we are adding piezoelectric crystal on the platform of the footstep to increase power output. This project consists rack and pinion assembly as a driving mechanism. In this project, force energy is converted into electrical energy. The control mechanism consists of the rack & pinion, D.C generator, battery and inverter control. We have discussed the various applications and further extension also. So this project is implemented to all foot step, the power generation is very high.
Keywords- Piezo-Electric, DC Generator, Rack, Pinion, springs, Gear

I. INTRODUCTION

This process involves number of simple setup that is installed under the walking platform. When people walk on this platform their body weight is utilized to rotate pinion through rack. Pinion is connected to dynamo which ultimately produce electricity. And while the power producing platform is over crowded with moving population, energy is produced at larger levels. Greater movement of people will generate more energy. This work will be great invention if energy wasted through walking is utilized properly. Generally, great amount of such renewable energy is available at highly dense places.

Mechanical energy is converted into electrical energy with the help of rack and pinion assembly. When a person claims the stair case, a force has been acted on the step which has been placed at a certain angle of inclination. When force is applied, rack which is connected to step moves down and rotates the pinion. This rotational speed has been increased using Chain and sprocket drive.

II. CONSTRUCTION

When a person climbs or get down a step, he pushes a step down, thus producing impact force or thrust force. This impact pressure energy can be utilized to operate the DC motor through bi-directional rack and pinion arrangement and piezoelectric transducer. The impact force applied by the human generates vibrational energy which is utilized for to-fro motion of rack. It then converts this linear motion into circular motion of pinion, which rotates the shaft connected to it. DC motor attached to the other side of shaft converts this mechanical energy into electrical energy.

Simultaneously, 12 Piezo-electric transducers connected in series and 2 such series in parallel are installed on the top of MS plate converts vibrational energy into electrical energy. This energy is further stored in the battery.

III. CALCULATION

A. Spring Calculation

Specification:
(standard values are considered here from net)
δ=190-11=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

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=63…..(assume 65kg)
δ=75 mm
C=6.
G=81370 N/mm^2
T=0.5 Sut

1) Wire Diameter:

The permissible shear stress is;
ɩ = 0.5×Sut
Sut=1090 N/mm^2
= 0.5×1090
ɩ = 545 N/mm^2

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

$= \frac{4\times6-1}{4\times6+4} + \frac{0.615}{6}$

k=1.2525

$T= k \times\frac{9\times P\times c}{\pi\times d^2}$

$545=1.2525\times\frac{8\times638\times6}{\pi\times d^2}$

d =4.546=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

3) Number of Active Coil:

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

$50=\frac{8\times638\times30^3\times N}{81370\times5^4}$

N=18

4) Total Number of Turns:

It is assumed that the spring to spur and gear end. The number of inactive coils is 2.
N_1=N+2=18+2=20

5) Free Length of Spring:

The actual deflection of spring is:

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

$\delta = \frac{8\times638\times30^3\times18}{81370\times5^4}$

δ = 48.78 mm

6) Solid Length of Spring:

It is assumed that here will be gap of between Consecutive coils which spring is subjected to Maximum force.
Total number of coils is 18.
Axial gap($N1_1$) = 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

7) Pitch of Coil:

$P = \frac{freelength}{N1-1}$

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

P = 9.76 mm

B. Rack and Pinion

Nomenclature:

f_t = transmitted force

f_n= normal force

f_r = resultant force

θ = pressure angle

Pressure angle = 20^0

1) Fr = Ft tan θ…….(1)

f_t = tangential force (weight of human = 65kg)

f_t = 65 x 9.81

f_t= 637.65 N

f = 637.65 x tan20.........using equation (1)

f_r = 232.02 N

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

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

F_n= 678.57 N

3) Power

$P = \frac{Work}{time}$…….(3)

$P = \frac{Forcexdisplacement}{time}$

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

P = 31.88 watt

4) Power

$P = \frac{2\pi NT}{60}$ …….(4)

$T = \frac{Px\ 60}{2\pi xN}$

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

T = 9.3 N.m.

5) T = f_t x r ……(5)

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

$= \frac{9.3}{637.65}$

r = 0.015

r = 15 mm So D = 30 mm

6) Using Lewis form factor:

$\sigma_t = \frac{f_t x P_d}{y.b}$…...(6)

Let,

P_d = diametrical pitch

$P_d = \frac{T}{D}$ …….(7)

$= \frac{18}{30}$

= 0.6 mm^{-1}

Then,

$\sigma_t = \frac{f_t x P_d}{y.b}$ …using equation(6)

$= \frac{588.6 \text{ X } 0.6}{30 \text{ X } 0.308}$

σ_t = 38.22 N/mm^2

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

$= \frac{210}{2}$

σ_{allow}= 105N/mm^2

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

So design is safe.

8) 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

9) Pinion Dimension:

Outer Dia. = d_0=2m + D ….. (10)

= 2 x 1.66 + 30

d_0 = 33.32 mm

10) Root Dia.(d_r) = D-(2m+2C) ……(11)

= 30 – (2 x 1.66 + 2 x 0.25)

d_r = 26.18 mm

11) Addendum,

Ad = m …… (12)

A_d = 1.66

12) Dedendum,

D_d = m + c …… (13)

D_d= 1.66 + 0.25

D_d = 1.91 = 2 mm

13) Linear displacement of rack for one rotation of piston,

L = (πm) x T …….(14)

= π x 1.66 x 18

= 94.44

L = 100 mm

Maximum length of rack is 100 mm.

Width of rack is 10

1) Frame Calculation

b = 300 mm

d = 22 mm

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

For $I = \frac{bd^3}{12}$

$= \frac{300 \times 22^3}{12}$

I = 266200 mm^4

Therefore,

Using equation no.1

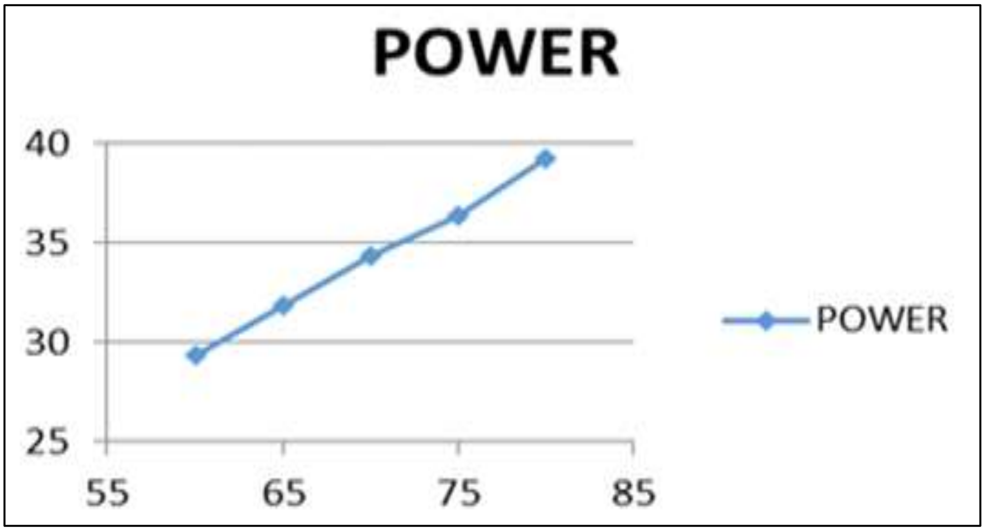
$= \frac{\sigma}{11} \frac{14715 \times 300}{266200}$

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

$\sigma_b = 182.41 N/mm^2$

So, design is safe.

IV. MAXIMUM ENERGY INDICATION GRAPH (POWER VS HUMAN WEIGHT)



V. COST ESTIMATION

Money is important factor in any project. While installing any project, its cost has to be estimated. If cost of project is less, then ultimately its cost of electricity generation is reduced. Operation cost of footstep power generation system is nearly equal to zero. Life of this system is approximately equal to 10^6 load cycles (for 65 Kg work load). Only operational and maintenance is associated with this system. Cost of electricity generated per unit watt is very low.

C. Per Unit Cost Estimation

Minimum average life of components

= 10 lakh cycles. (From Ansys)

Power generated in each cycle = 30…..(from calculations)

Efficiency of the Model = 50%

Total cost of model = Rs.6250

Therefore,

Steps required to generate 1MW Power: $= \frac{1\times10^6}{\text{each step power generation}\times\text{effiency}}$

$= \frac{1\times10^6}{30\times0.5}$

= 66,666.67 steps

2) Power Generated by Each Model

$= \frac{\text{Number of cycles before failure}}{\text{cycles required for 1MW power generaation}}$

$= \frac{1\times10^6}{66666.67}$

= 15MW

Cost required per unit kilo-Watt $= \frac{6250}{15\times1000}$

= 0.41667 Rs/KW

D. Cost Estimation Table

Table 1: cost estimation table

SR NO.	*COMPONENT*	*DETAILS*	*COST IN RS.*
1.	*Base plate and upper plate*	*Mild steel -300×300 mm (300×2)*	*1000*
2.	*Fixed Cylindrical pipes*	*MS pipes, 30mmdia.-100mm length (100×4)*	*400*
3.	*Moving pipes*	*MS pipes,20 mm dia. 100 mm length (100×4)*	*400*
4.	*Springs*	*Alloy Steel Wire(100×4)*	*400*
5.	*Stair frame*	*MS l angle frame*	*1000*

6.	*Rack and pinion*	*Cast iron, module 1.5*	*1100*
7.	*DC motor*	*12 volt,60 rpm*	*250*
8.	*Fabrication*	*Cutting, welding etc.*	*600*
9.	*Assembly*	*Mounting, fixing motor shaft with pinion. Adjusting rack and pinion etc. and final welding*	*500*

VI. CONCLUSION

Footstep power generation system produces electricity by utilizing energy which is wasted through walking. Mechanism like rack and pinion and piezo-electric material are integrated to produce desired output. Cost of electricity generation solely depends upon the initial cost, maintenance cost and life of system. Maximum advantage of this system can be taken if installed in highly dense area.

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