Multi Domain Energy Generation

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Abstract— The growing demand of power for a variety of human activities cannot be answered without continuous efforts of exploring better options and application for sustainable energy sources. Today power has become one of the major needs of human life however, one of the fear of the generation is whether the current energy sources continue to generate the required amount which has a progressive trend across generation. Hence, dreaming future days with insufficient or no electricity makes the generation future very difficult or impossible. Therefore, such conditions call an integrated research approach on power generation and it is our responsibility to work and come up with a possible means of sustainable and green energy production for satisfying our day to day progressive energy requirements and make the planet earth a better place to live in. The rapid industrialization, growing technology and expansions have demanded very high power of electricity that is increasing day by day and thereby the world is facing energy crisis due to limited power resources. The electricity generation greatly depends on conventional sources, which are limited in amount and some are harmful for the environment. Therefore, it is critical to explore an environmental friendly and sustainable energy source. In order to reduce the greenhouse gas emission, the renewable energy sources are now widely utilized for electricity generation. Among different renewable energy production technologies, solar and wind technologies are widely used for large- scale electricity generation. Though still a small percentage of renewable resources are exerted for electricity generation, the researchers are trying to improve technologies so that the green electricity can be economically feasible, environmental friendly and sustainable in the electricity production industry.

Keywords: Multi Domain, Energy Generation

I. Multi Domain Energy Generation

A. Introduction

The day-to-day increasing population and decreasing quantity trend of conventional sources for power generation, provides a need to think on other energy resources. States are working toward the development of non-conventional sources for power generation. Due to the reasons that conventional sources of power are releasing live risking by-products which are causing huge problems to humans and all living things on the planet earth. They are getting scarcer due to continuous exploitation of high amount. Energy harvesting is related to developing a mechanism for driving energy from different sources and energy of today's world is mainly generated from conventional energy sources which mostly are decreasing day by day. Moreover, these conventional energy sources cause pollution and are responsible for global warming. To solve these problems, researchers are trying frequently to explore new energy sources which are clean, environment friendly, sustainable, and promising in order to meet the future electricity demand of the generation. And it is also essential to focus more on renewable (unconventional) energy sources for electricity generation and it is also paramount to think more specific to the utilization of kinetic energy which is helpful to reducing dependence on conventional sources of electricity generation.

Non-conventional energy system is very essential at this time to our nation. Modern technology requires a vast amount of power in the form of electricity for its different operations. A transducer can be anything which converts one form of energy to another. Piezoelectric material is one kind of transducers. We squeeze this material or we apply force or pressure on this material to converts it into electric voltage and this voltage is function of the force or pressure applied to it. The material which behaves in such a way is also known as piezoelectric sensor.

B. Piezoelectric Arrangement

Piezo generation is a new approach to generate electrical energy from the sensing cum converting equipment called piezo sensor or piezo buzzer. It mainly works on a principle of piezoelectric effect which is creating pressure energy crystaline material viz., quartz crystal to generate electricity. Piezoelectric effect is discovered in 1880 by Jacques and Pierre Curie during studies into the effect of pressure on generation of electrical charge by crystals (such a quartz).

1) Piezoelectric Effect:

Piezoelectricity is defined as change in electric polarization with change in applied stress Direct piezoelectric effect). The piezo material exhibits both "Direct piezoelectric effect" as well as 'converse piezoelectric effect'. Direct piezoelectric effect is the production of electricity when thecrystals are mechanically stressed and the converse piezoelectric effect is the stress or strain in the crystal when an electric potential is applied. The most common crystals used are lead zirconate Titanate crystals.

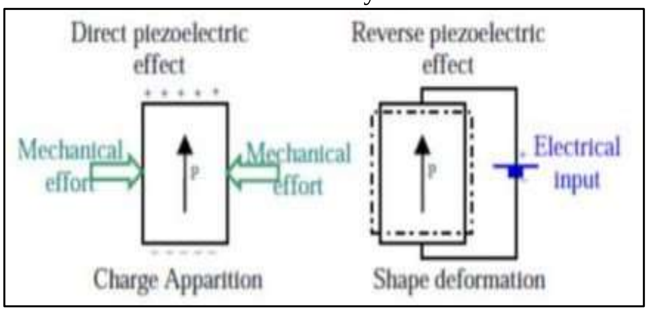


Fig. 1.1 Piezoelectric Mechanism

2) How It Works?

In a piezoelectric crystal, the positive and negative electrical charges are separated, but symmetrically distributed. This makes crystal electrically neutral. Each of these sides form an electric dipole and dipoles near each other tend to be aligned in regions called "Weiss domains". The domains are usually randomly oriented, but can be aligned during poling, a process by which a strong electric field is applied across the material, usually at elevated temperatures. When a mechanical stress is applied, this symmetry is disturbed and the charge asymmetry generates across the material. In converse piezoelectric effect, application of an electrical field creates mechanical deformation in the crystal.

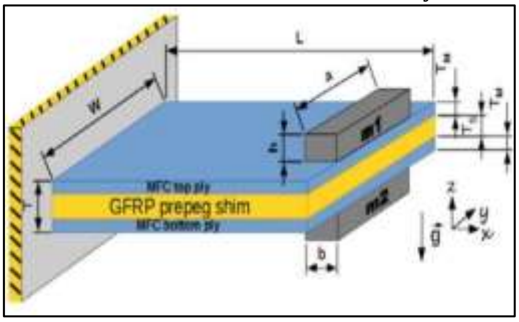


Fig 1.2 Piezoelectric cantilever model

The most common application of piezo crystals to generate a potential is the electric cigarette lighter. Pressing the button of lighter causes a spring loaded hammer to hit a piezoelectric crystal producing a sufficiently high voltage that electric current flows across a small spark gap, thus heating and igniting the gas. Some substances like quartz can generate potential differences of thousands of volts through direct piezoelectric effect.

Flexible piezoelectric materials are attractive for power harvesting applications because of their ability to withstand large amount of strain. Larger strain provides more mechanical energy available for conversion into electrical energy. A second method of increasing the amount of energy harvested from piezoelectric is to utilize more efficient coupling mode.

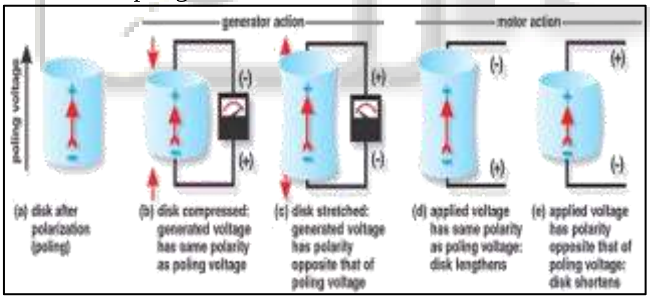
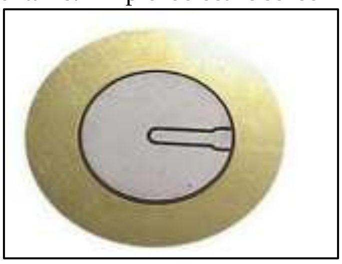


Fig. 1.3: Working Mechanism of Simple Piezo Transducer.

3) Piezoelectric Sensors:

- Product type: Piezoelectric sensor or piezoelectric transducer
- Color: copper and silver
- Dimension: 40 mm
- Weight: 2 g
- Sheet material: bronze
- Package contains: 1 x piezoelectric sensor



4) Types of Piezo- Sensors:

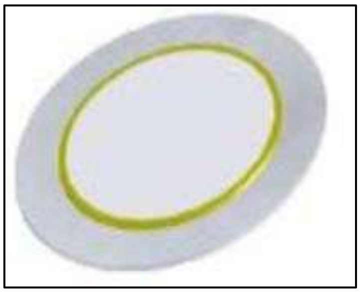


Fig. 1.4 (a): two terminal circle type

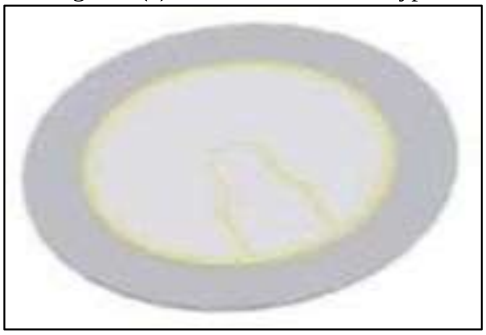


Fig. 1.4 (b): Three terminal circle with brim feedback

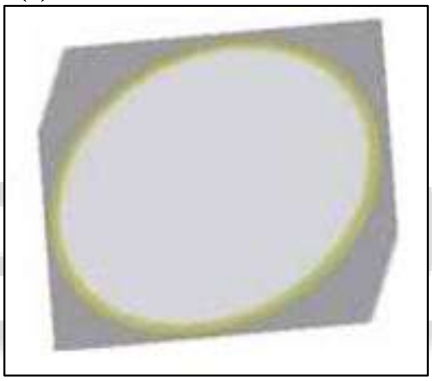


Fig.1.4 (c) Two terminal square Type

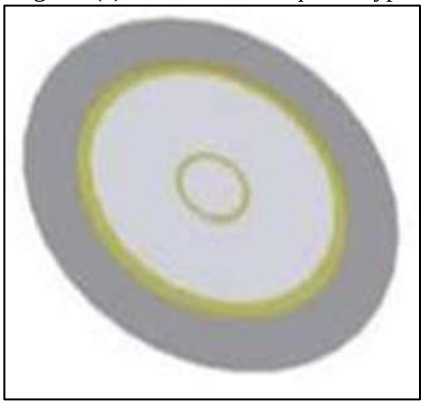


Fig. 1.4 (d): three terminal circle with centre feedback

C. Rack And Pinion Arrangement:

In this project, we have also presented the design of power generation using suspension system based on available piezoelectric sensors and Rack and Pinion Mechanism. The suspension systems are used in vehicle to support weight of vehicle body and to isolate the vehicle chassis from road disturbances. The dampers are designed to dissipate vibration energy into heat so as to reduce the vibration transmitted from road excitation. It is feasible to harvest this vibration energy from the vehicle suspension system to improve the efficiency of the vehicle. The suspension system used for the regeneration of vibration energy is called regenerative suspension system.

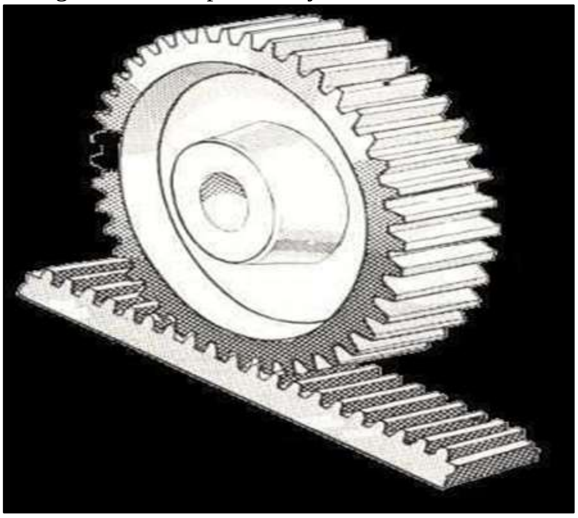


Fig. 1.5: Rack and pinion

1) *Pinion Gear:*

Fig. 1.5 (a): Pinion Gear

Module: 1
Number of Teeth: 21
Bore Diameter: 6mm
P.C.D: 21
OD: 23

2) *Rack Gear:*

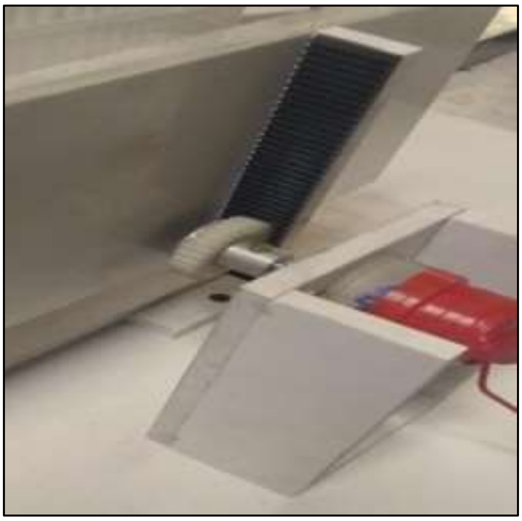


Fig. 1.5 (b): Rack Gear

Module: 1
Number of Teeth: 42 Length: 127mm

3) *Working:*

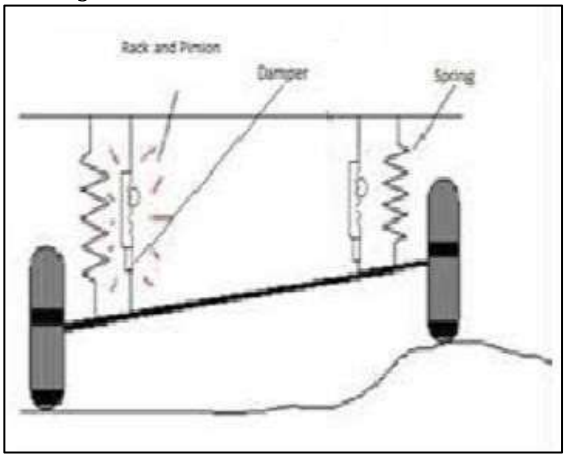


Fig.1.6: Working system

Vertical movement of rack in actual operation is happened due to suspension movement. This movement of rack results in vertical movement of rack attached to the suspension frame. This rack drives the pinion meshing with it. On the pinion shaft 2nd gear is mounted which rotates with same RPM as of the pinion speed. This 2nd gear drives the 3rd gear having bigger dia. Of 98 mm mounted on 2nd shaft. On this 2nd shaft V-groove pulley is mounted. Another pulley is mounted on alternator which is driven by belt drive. As alternator shaft rotates it cuts the magnetic flux and EMF is generated at the output. This EMF generated is used to glow the LED lamp, or we can measure the output voltage and current by using DMM for analysis propose.

One of the promising options is by using piezoelectric material or PZT. PZT can be used as a mechanism to transfer ambient vibrations into electrical energy. This energy can be stored and used to power up electrical and electronics devices. With the recent advancement in micro scale devices, PZT power generation can provide a conventional alternative to traditional power sources used to operate certain types of sensors/actuators, telemetry, and MEMS devices.

Piezoelectric materials act as a transducers and pressure exerted by the moving parts transformed into electric current. We propose a design plan that converts the mechanical energy in bikes to electrical energy much more efficiently than it has been done before.The electricity generated will then be used to recharge the battery of bike for further use and functioning of the bike.

D. Battery System:

Lithium-ion batteries (Li-Ion). This technology is considered as the most promising for the near future by a majority of literary sources. This is why in most of the reports the Lithium-ion technology is the only one studied in detail among others. It has high energy density, because lithium possesses both the highest electrochemical potential and a low equivalent mass. It has high efficiency and a long lifespan and its potential to improve is considered as very high. However it is expensive. it presents safety issues (overcharging can cause fires and destruction) and the energy density is still insufficient to satisfy the needs of the market. In addition, material availability concerns have been raised.

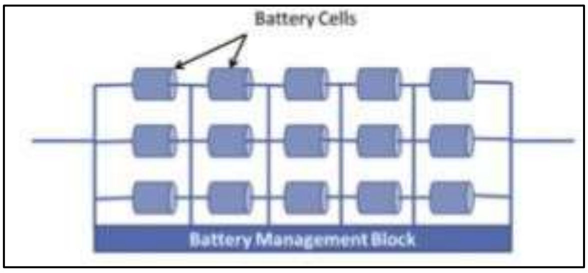


Fig. 1.7: Battery management block

There is a large variety of Lithium-ion chemistries, with diff erent characteristics and degrees of maturity.

12 Volt DC battery:
Output voltage: 12V
Output Current: up to 1.3 amp
Working Time: 1hr at max 1.3 amp load

Fig.1.7 (a): Battery

The lead acid battery is made up of plates, lead, and lead oxide (various other elements are used to change density, hardness, porosity, etc.), with a 35% sulfuric acid and 65% water solution. This solution is called electrolyte, which causes a chemical reaction that produces electrons. When you test a battery with a hydrometer, you are measuring the amount of sulfuric acid in the electrolyte. If your reading is low, that means the chemistry that makes electrons is lacking. So where did the sulfur go? It's resting on the battery plates so that when you recharge the battery, the sulfur returns to the electrolyte.

1) Battery Management System:

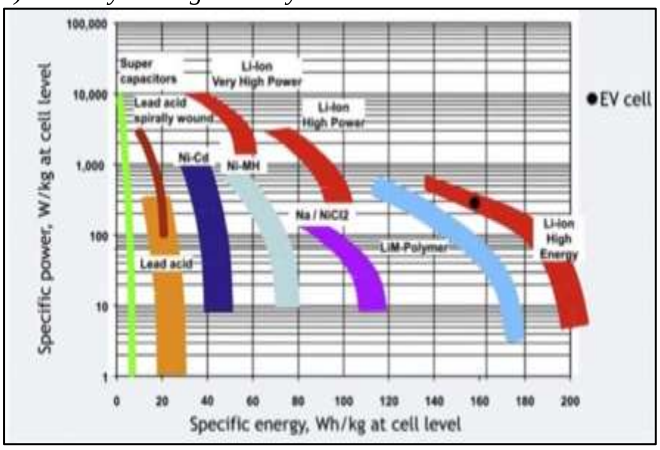
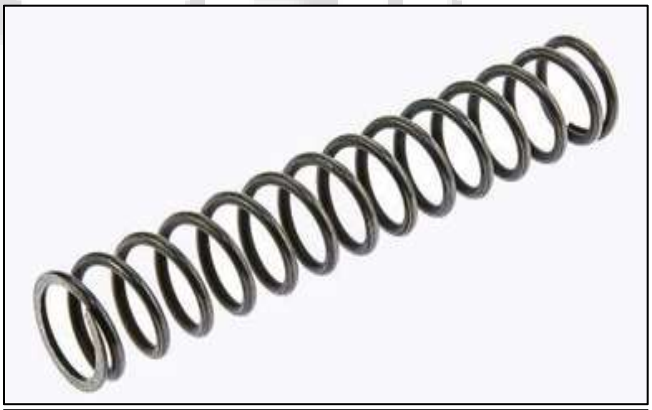


Fig. 1.8: Specific energy and power of the main battery technology

Battery management systems (BMS) have two main roles: the first one is to monitor the battery to determine information such as its State of Charge, State of Health (the ability of the battery to deliver its specified output) and Remaining Useful Life. These parameters are crucial for users as well as to optimize the charge and discharge processes and must be communicated to on-board systems (safety system, communication with the driver, engine management). Diff erent modelling methods have been proposed in the literature. The second role is to operate the battery in a safe, efficient and non-damaging way. As can be seen, battery blocks are composed of cells arranged in parallel and series to meet the needs of the engine. As those cell characteristics can differ slightly, it is necessary to balance the charge between each cell to prevent damage and improve the lifetime of the stack. Passive balancing methods have been used, during charge, using dissipation through resistors, but it is not an efficient solution. Second generation batteries will probably rely on active cell balancing, one method being presented in. It involves voltage and current monitoring in each cell, and temperature monitoring in multiple points to ensure that none of the cell is functioning outside its operational conditions. The benefits off ered are a longer calendar and cycle life, increased safety and a higher power capability for a relatively small cost increase. It is particularly important for Lithium-ion technologies since, despite their promises, they can be damaged and present a risk of fire or explosion if they are managed incorrectly, and their high cost makes even more crucial an increase in their cycle and calendar lives.

E. Springs:



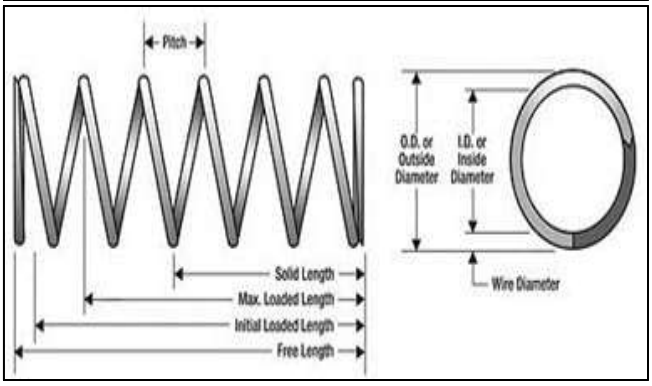


Fig. 1.9: Spring Spring ID: 12mm
Spring OD: 14mm Length: 80mm Pitch: 8mm

Wire dia: 1mm

The most widely used type of spring, compression springs are designed to oppose compression and return to its uncompressed length when the applied force is removed. The potential applications for compression springs are limited only by the imagination.

Compression springs are devices made up of helically formed coils with pitch in between used to push back on an applied force or load in order to return to its original position when the force or load is released. They are the most commonly used type of spring as well as the most economical. There are many types of compression springs used to fulfill certain functions for many applications, devices, and/or mechanisms.

You may find several compression spring types in the mechanism of a firearm as well as other types of springs like torsion or extension springs depending on the type of firearm. You might also find them in devices or mechanisms that operate through buttons and such; the spring will be located behind the button to make sure the button returns to its original position after being released. You will also find compression springs in the automotive industry used for the suspension of your automobile. As you've seen noted above, there are many compression spring uses but the list doesn't stop there, you may find these springs almost anywhere. From a ballpoint pen or a notebook to a pogo stick or a medical device.

The different types of compression springs are magazine compression springs, conical compression springs, barrel compression springs (convex and concave), and you might also find torsional compression springs which fulfill two functions by exerting a vertical force as well as a rotational force.

1) Tension Spring:

Tension springs are tightly wound coils that are designed to operate with tension. The spring stretches to a specific length as the load/force is applied to it.

Fig 1.9 (a) Tension Spring

In an unloaded position, the loops of the spring are touching, with either a loop or hook attached at one end, and it is when this attachment is directed with force that the spring stretches. When these components are pulled apart, usually from either side, the spring tries to hold itself together, causing the springing action, until the force is stopped and it can return to its original form.

The tension springs we manufacture have dimensions of 0.1mm to 26mm and can be created using the hot or cold coiling processes, with both steel and stainless steel. The end types we provide vary from coiled loops or hooks, to screw in fixture attachments. Popular choices include the half hook, extended hook and screw plug.

The initial tension applied to the tension springs can be controlled using the cold coiled process, in which the wire is formed into a spring shape using a computer controlled coiling machine, whilst unheated. Cold coiling gives the tension springs added flexibility which can be more easily achieved than the hot coiling production process.

F. DC Motor:

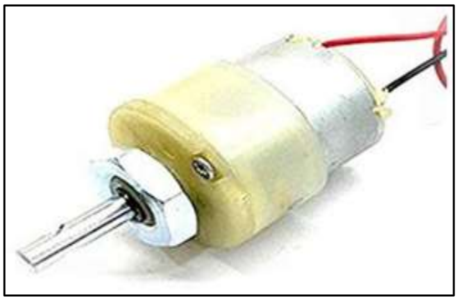


Fig. 1.10: DC Motor

- Voltage: 12V DC supply
- Current: 2amp
- 6mm shaft diameter with internal hole
- 12 V DC motors with Gearbox
- Weight: 125grm

G. Generator:

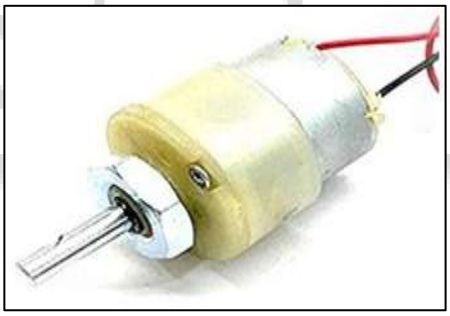


Fig.1.11 Generator

Output Voltage: up to 12V DC
RPM: 100rpm
Output Current: up to 2amp
6mm shaft diameter with internal hole
Weight: 125grm

II. SAMPLE CALCULATIONS:

A. Model Calculations:

Electrical Calculation When a vehicle is running at a speed of 20 to 30 km/hr we observe 6 to 9 volts with the help of multi meter. Voltage Generated (V) = 9 volt, Current Generated (I) = 3.2 amp

As Electrical Power (P) = V x I = 9 x 3.2 = 28.8 Watts

- TO CALCULATE CHARGING TIME FOR 6 VOLT BATTERY :

Charging time = battery current (Ah) / current generated (A)
= 4.5 (Ah) /3.2(A)
= 1.40 hr.
But it was noted that during charging 40% get loss
= 4.5 x 40 /100

= 1.8 Ah
Charging time
= 4.5 +1.8 /3.2
=1.9 hr.

– TO CALCULATE CHARGING TIME FOR 12 VOLT BATTERY

Consider that the suspension system is mounted on both side of the front suspension. Total voltage produced by this suspension system in 18 volt, 64A. Therefore time required to charge a 12 volt, 33 Ah battery is,
Charging Time = Battery current (Ah) / currentgenerated (A)
= 33 (Ah)/ 6.4 (A) =5.15 hr.
But it was noted that 40% loss during battery charging
= 33 x 40/100
= 13.2 (Ah)
Charging time = 33 + 13.2 /6.4
= 7.21 hr.

B. Design Calculations:

Weight of vehicle = 202030 N Radius of wheel= 51 cm
Total torque = Engine rating*gear ratio*SLR
= 1220*12*4.5
= 65880 N-m
Since, 100% efficiency is not possible so, assuming 80% efficiency
Total torque = 0.8*65880
= 52704 N-M
Tractive force = T/R
= 52704/0.51
Tractive force for each wheel = 103341.17/4
= 25.83KN
Displacement of plate = 0.125 M
Speed of vehicle/plate = 60 Km/hr = 16.67m/sec
Assume:
Time required to move the plate for 0.125 m is 1 sec.
Pinion complete 1 rotation in 1 sec. N = 60 rpm

1) Design of rack and pinion

Material for pinion = C45	..... (1.12 PSG) Pi = 3228.75 watt
Sut = 700 N/mm2	Since ,100 % power cannot
Syt = 380 N/mm2	transmitted so assuming 80% efficiency.
Assume no. of teeth on pinion at 20° pressure angle = 20 Pi = 0.8*3228.75	
Zp = 20	= 2583 watt
σb = sut/3	

= 700/3
= 233.33 N/mm2
yp = 0.484-(2.87/-zp) = 0.487- (2.87/20)
= 0.3405 b = 10 m

a) Beam strength calculations
Fb = σb*b*m*yp
= 233.33*10m*m*0.3405
= 794.48m^2 N

b) Effective load:
V (pitch line velocity) V = (π*20*m*60)/60
= 0.06283 m/s
Ft = p/v
Now, Pi = input power
= force*displacement
= 25.83*103*0.12
Now, Ft = P/V
= 2583/0.0628*m
= 41110.93/m
Newton Effective Force = Ka*Km*Ft/K Now, Kv=3/3+v
= 3/3+0.0628*m
Service factor Ka = 2 ; Load distribution factor = 1
Feff (Effective Force)
=2*1*41110.93*(3+0.0628m)/3*m
Considering factor of safety (Nf) = 2 (For case hardened) ....PSG 8.19, Table No. 20
Fb = Nf* Feff
794.48*m^2 = 2*27407.28*(3+0.0628m)/m m^3-4.33m-206.98 = 0
Therefore, m = 6.15
By taking next step for module, module = 8 mm.

c) Dimensions of pinion :
Diameter of pinion = m*Zp
= 8*20
= 160 mm.
Addendum (ha) = 1*m
= 1*8
= 8 mm.
Deddendum (hf) = 1.25*m
= 1.25*8
= 10 mm.

d) Design of rack:-
Module (m) = 8mm.
Pitch = π*m
= π* 8
= 25mm.
Total length of rack = 625 mm.
Number of teeth = 625/25
= 25

2) Design of shaft :

Centre distance between gear (a) = m*(Zp+Zr)/2
=8*(20+25)/2
=80mm.
Internal diameter of gear (d) = 0.3*a
= 0.3*180
= 55 mm
On strength basis :- = d/4.

Material for shaft = C45	PSG 1.10(a

Sut = 700 N/mm^2 Syt = 380 N/mm^2 BHN = 229
Input power (Pi) = 2583 watt Speed (N) =60rpm
Radial force (Fr) = Ft*tan□ =25.83*10^3*tan(20)
But gears have hole of 55 mm. So, Diameter of shaft = 55mm. For tolerance, Choose IT7 grade.
IT7=10i
i = 0.45(D)^(1/3)+0.001D
i = 0.45(55)^(1/3)+0.001(55)
i = 1.76um
= 1.76*10^(-3)mm 16i =16*1.76*10^ (-3)

16 IT7=Tolerance =0.028 =0.028mm

3) Design of key :

Material same as shaft. Assume rectangular key of, t = thickness = d/6 W)

(a) Considering shear failure of key, T =
(w*L*Fs)*(d/2)(10^3)*5655.76
= (55/4)*L1*350*(55/2) L1
= 42.75mm~=50mm

(b) Considering crushing failure of key,
σc = 4t/dhl σc = syt/Nf
σc = σt =700 N/mm^2. Fr=9401.35 N
Fs=350 N/mm^2 σt =700 N/mm^2
Kb=2……combine shock and fatigue factor for bending
Kt=2…..combine shock and fatigue factor for Torsion.
P= 2Πnt / 60=2π*60*T/60 T=411.09 N.m… Torque.
Bending moment , M=f*L/4
M=9401.35*1.2/4 M=405 N.m
Equivalent Torque , Teq = √[(Kt*T)^2+(Kb*M)^2]
Teq = √[1*411.09)^2+(2*2820.405)^2] Teq = 5655.76 Nm
Teq = (π/16*d^3*fs max) Fmax = Fs … permissible
10^3*5655.76 = (π/16)*d^3*350
d = 43.49 mm
L = 700*55*55/6
= 4*5655.76*1063/l
L = 64.135 mm ≈ 65 mm

4) Selection of Bearing:-

Ln =25000 hours,
Continues operation
…...PSG 4.3
Now,
……………
Fr = 9401.35 N Fa = 0 .
So, Pe = [XVFr + YFa]*Ka
where,
X=1 equivalent load bearing
………………….PSG 4.4
Ka = 2[machine with moderate shake impact]
Pe = z*1 *9401.35 *2
= 18802.7N.

5) Spring design :

Load =25.83 * 10^3 N
We have to use two springs. Load on each spring = 25830 / 2
=12915 N
Mostly, material used for helical compression spring carbon steel (Oil hardened and tempered condition.)
Material Selection :-
…...…….PSG 1.10
C65 is selected
C (%) =0.65
Mn (%)= 0.75
Tensile Strength = 1380 N / mm2
Yield Stress = 430 N/mm2 .
d=7mm
Spring index [c] = 5.4
C= D/d
5.4*7 =D
D=37.8 mm
d = 7 mm is not applicable
So, d = 7*4 = 28 mm
C = D/d = D/28
D = 151 mm
deflection of spring = 125 mm
total length of spring = 250 mm
i) Solid length = (Ls) = n’ d
= (125/28) = n’
n’ = 4.46 = 5 turns
Total no. of coils = 5
ii) free length (Lf) = 250 mm
Lf = Ls+ δmax+ 0.15 δmax
250 = 125 + 1.15 δmax
δmax = 108.69
iii). spring stiffness (K) : K = F/δ
= 12915/125
= 103.32 N/mm
iv) Inactive coils & active coils :
For square and ground end n’ = n+2
5-2 = n
n = 3 turns (active)
2 (inactive coils) Design calculations :
d = dia. Of spring wire
= 28 mm
D = mean dia. Of spring
= 151 mm
n = no. Of active coils
= 3 turns
n’ = total no. Of coils
= 5 turns
δ = axial deflection due to load
= 125 mm
fs = 0.75(0.18*sut)
Or = 0.75 (0.3*sut) select
smaller of two values
Hence, 186 N/mm^2 and 96.75 N/mm^2 fs = shear stress
= 96.75 N/mm^2
G = modulus of rigidity of material
= 77*10^3 N/mm^2 C = spring stiffness
= 5.4
P = (pitch)
= Lf/(n’- 1)
= 250/(5 – 1)
P = 62.5 mm
(A) Torque produce in wire:
T = (w*D)/2
= (12915*151) /2 125
D = 225.40 mm
T = 975082.5 N-mm
Now, corrected.(1)spr
D/d
We also know,
C = 225.40/28
T = (π/16)*d3*fs C = 8.05 (2)
From eqn. (1) & (2)
Fs = (8wD/ πd^3)
= 8*12915*151 /(π*28^3)
Fs1 = 226.22 N/mm^2
(B) Direct Stress Fs2 due to load Fs2 = W/(π/4)d^2
= 12915/(π/4)*28^2
=20.97 N/mm^2
Total Resultant Stress [Shear] Fs=[(4C-1)/(4C-4)]+0.615/C
=1.284
Total stress formulae Fs=k*(8WD)/πd^3

=1.284*8*12915*151/(π*28^3)
=290.47 N/mm^2
[2] Deflection of helical spring

D		= 37.50 mm

But we required deflection of 125 mm, so
ing index ,
C =Corrected total stress in spring ,
K = (4C-1)/(4C-4)+0.615/C K = 1.18
Fs = K*(8WD/πd^3)
= 1.18*8*12915*225.40/(π*28^3) Fs = 398.47 N/mm^2

C. Material Cost

1) Raw Material Cost

The total raw material cost as per the individual materials and their corresponding rates per kg is as follows,
Total raw material cost = Rs.2000

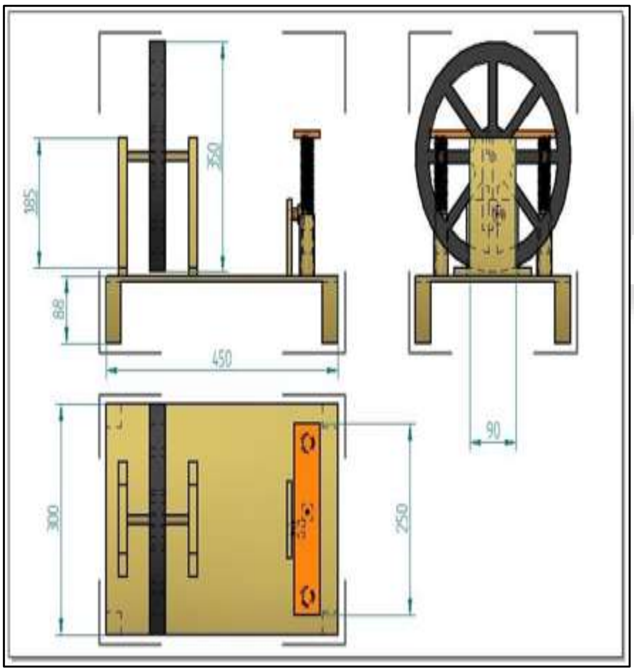
2) Miscellneous Cost

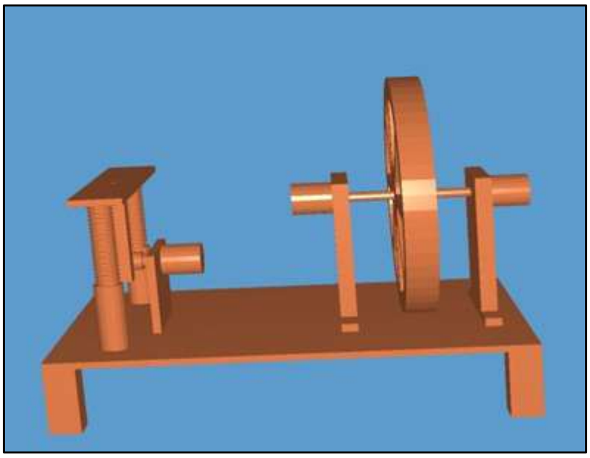
Overhead + Handling charges = 1000

3) Total Cost

TOTAL COST = Raw Material Cost +Machine Cost + Cost of Purchased Parts + Miscellaneous Cost
Hence the total cost of machine = Rs.5950

III. PROJECT DRAWING





IV. CONCLUSION

- In this work information regarding production of electricity by the application of piezoelectric sensors and rack and pinion arrangement is studied.
- Vibrational energy treated as waste form of energy until yet. Since electrical energy produced by other sources is non-renewable hence the electrical energy is saved efficiently and effectively.
- This mechanism can thus reduce the need to recharge the electric vehicle battery again and again.
- As the vehicle self powered it ultimately reduces the use of electricity and also saves the cost for the same.

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