

Floating Oscillator based Electric Generator using Mechanical Energy Harvesting

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Abstract - Industries are the major source for the development of the country. The dramatic increase in population causes the requirement of industries to meet out their basic needs. This increase in industrial civilization causes demand for power to function. For this we need large amount of power generation from different kinds of sources but conventional sources are causing unbalance in the environment by pollution and global warming. To overcome the power demand and production of power in eco-friendly manner, speed breakers are the most efficient sources for the power generation. Since the vehicles count increasing day by day, a large number of vehicles stand in queue at the tollbooth. So, we can utilize the potential energy of vehicles by using speed breakers at regular interval in tollbooth.

Moreover, the linear oscillations are of TO and FRO motion, for making the shaft to rotate in one direction the ratchet and pawl setup is used which is responsible for vehicle and for larger power requirement use of large size magnets with strong magnetic field is advisable. The materials used are made up of nylon which is well suited for medium weight vehicles. But for heavy weight vehicles, it is better to use high strength materials for rack and pinion gears. This paper represents the use of floating magnetic oscillation to produce electrical energy by converting potential energy of the vehicle into kinetic energy and then into electrical energy.

Key Words: Floating magnetic oscillator, renewable sources, speed breaker power generation, Neodymium and ferrite magnet.

Table 1. Statistics of Indian Roadways

Indian roadways	5603293 km
Number of speed breakers(approx.)	>500000
Average power generated by speed breaker with Floating oscillator	3000W/day
Total power generated in India/day	1500 MW

1. INTRODUCTION

Roadways are the largest and frequently used means of transportation in terrestrial. A large amount of potential energy is wasted at the speed breakers every time when the vehicles pass over it. So, the potential energy of the vehicles can be utilized to generate electricity at the speed breakers. The roller and rack-pinion mechanism use only mechanical parts so the efficiency is lower by frictional losses.

To overcome the frictional losses and gain additional energy and for efficient energy conversion, use of permanent magnet in addition to spring is very much efficient. By using the permanent magnet, we can utilize both kinetic energy of spring and magnetic energy of magnets for electricity production.

In this method, the free-floating magnet between the magnets are responsible for making linear oscillations which is given to the rack and pinion gear which is responsible for converting two-way linear motion into one-way rotation motion. Springs which are impacted by the potential energy of the vehicle are used to transfer the potential energy of the vehicle to the magnetic oscillations. Since the moving parts are of magnetic domain the losses due to friction between the mechanical stationary parts are very much reduced in this method.

2. BLOCK DIAGRAM OF PROPOSED SYSTEM

The figure.1 specify the block diagram of proposed method. In this, the speed breaker arrangement is connected to the floating magnetic oscillator arrangement through which the spring and gear mechanism is connected to it. The pinion gear is connected to ratchet through pawl which is attached to it. Through this gear mechanism, 12V DC generator is connected which is responsible for converting given mechanical energy into electrical energy.

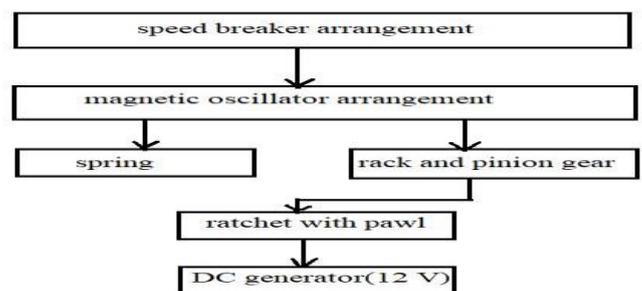


Figure.1 Block diagram of Proposed Method

3. ANALYSIS AND DESIGN

3.1 MAGNET

L_m - Length of the magnet = 0.4 inch

A-pole area in inch square = 3.14-inch square

B_r - Residual magnetic flux in kilogauss

For N42 grade magnet, $B_r=13.2$ kilogauss

Force due to magnet with contact with a piece of steel in lb

$$F = 0.58 * B_r^2 * L_m * \sqrt{A}$$

$$F = 0.58 * (13.2 * 13.2) * 0.4 * \sqrt{3.14}$$

$$F = 71.649 \text{ lb} = 32.5 \text{ Kg}$$

Force in terms of Newton

F = Mass * Acceleration due to gravity

$$F = 32.5 * 9.81$$

$$F = 318.819 \text{ N}$$

Force exerted by one magnet to another magnet in Newton (F)

$$F = 318.819 \text{ N}$$

Net force acting on the floating magnet = F – force due to weight of the floating magnetic segment + force due to the applied load

$$= 318.819 - (2 * 9.81) + 981$$

$$= 1280.199 \text{ N}$$

Net force acting on floating magnet = 1280.199 N.

3.2 HELICAL SPRING

d – diameter of the spring wire = 8 mm.

D – mean coil diameter of the spring = 75 mm.

N – number of active turns of spring = 7 turns.

W – applied load = 981 N.

G – modulus of rigidity of wire material = 80 GPa.

Axial deflection produced when load applied

$$\delta = \frac{8 * W * D^3 * N}{G * d^4} = \frac{8 * 981 * (75^3) * 7}{80 * 8^4}$$

$$\delta = 70.728 \text{ mm}$$

L_f – free length of the spring = 250 mm.

L_s – solid length of the spring.

$$L_s = L_f - \delta - 0.15 \delta$$

$$L_s = 250 - 70.728 - (0.15 * 70.728)$$

$$L_s = 168.668 \text{ mm.}$$

Stiffness of the spring

$$K = \frac{W}{\delta} = \frac{981}{70.728}$$

$$= 13.87 \text{ N/mm.}$$

3.3 RACK AND GEAR

PINION GEAR

T_1 - Number of teeth = 96 teeth

D_1 – Diameter of pinion gear = 120 mm

$$\text{Module} = \frac{D_1}{T_1} = \frac{120}{96} = 1.25$$

DRIVEN GEAR

T_2 – Number of teeth = 12 teeth

D_2 – Diameter of driven gear = 15 mm

$$\text{Module} = \frac{D_2}{T_2} = \frac{15}{12} = 1.25$$

RACK

Length of the rack = $\pi * D_1 = \pi * 120$

Length of the rack = 376.99 mm.

3.4 SPEED CALCULATION

N_1 – Speed of the pinion gear in RPM.

N_2 – Speed of the driven gear in RPM.

$$\frac{N_1}{N_2} = \frac{T_2}{T_1} = \frac{12}{96} = 0.125$$

$$N_2 = \frac{20}{0.125} = 160 \text{ RPM. (} N_1 = 20 \text{ RPM).}$$

3.5 TORQUE CALCULATION

Torque = force * perpendicular distance (radius of driven gear)

$$\text{Torque} = 981 * 60 \text{ mm}$$

$$T = 58.86 \text{ Nm.}$$

3.6 POWER OUTPUT

$$\text{Power produced} = \frac{2 * \pi * N * T}{60} \text{ Watt}$$

$$P = \frac{2 * \pi * 160 * 58.86}{60}$$

$$P = 986.209 \text{ Watt.}$$

4. CONSTRUCTION

The combination of three upper fixed magnets and lower fixed magnets and floating magnets are called moving arrangement. The upper part of the moving arrangement is connected to the handle for applying force and lower part of it is connected to springs. The upper and lower magnets and floating magnets used here are neodymium magnets with magnetic grade N42. The floating magnets are ring shaped neodymium magnet suspended axially with stainless steel

rod on its axial hole. The three floating magnets are attached with wooden rod horizontally through which the rack and pinion mechanism is connected. Initially the floating magnets are made to repel with lower fixed magnets which make them floating. These floating magnets are made to be fixed in desired position by stands connected to the sidewalls at the time of moving arrangement moves downwards. The pinion gear and ratchet are connected with shaft which is fixed at sidewalls by ball bearings through which DC generator set is connected through shaft.

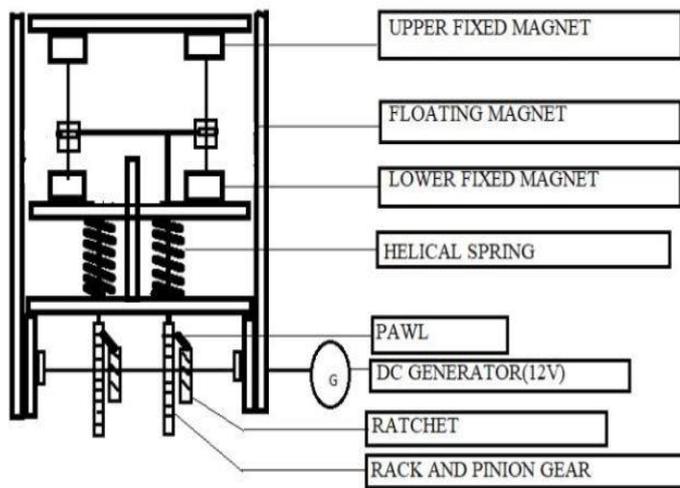


Figure 2. 2D construction details with three floating magnets

5. WORKING

When the vehicle passes over the speed breaker setup, the force is applied on the handle (Figure 3). The moving arrangement attached to the handle which also moves downwards causes the spring to compress while the floating magnet is kept stationary with the help of stands attached to sidewalls. Immediately after the vehicle passing, the spring expands with massive force which is impact on the floating magnet during the lower fixed magnets repel the floating magnet with massive force (Figure 4). At that time floating magnet make oscillations (TO and FRO motion) which given to the rack through which the pinion gear along with ratchet rotates (Figure 5). The ratchet which convert the two-way linear motion into one-way rotational motion of the DC generator set. After several oscillations the floating magnet comes to the initial position (Figure 6).

Overall the potential energy of the vehicle is first converted into kinetic energy of floating magnetic oscillation arrangement. Then the kinetic energy of magnetic oscillation and compression of springs are converted into mechanical energy by rack and pinion gear mechanism. Then the speed is multiplied by compound gear setup. Then the mechanical energy is converted into electrical energy by DC generator.

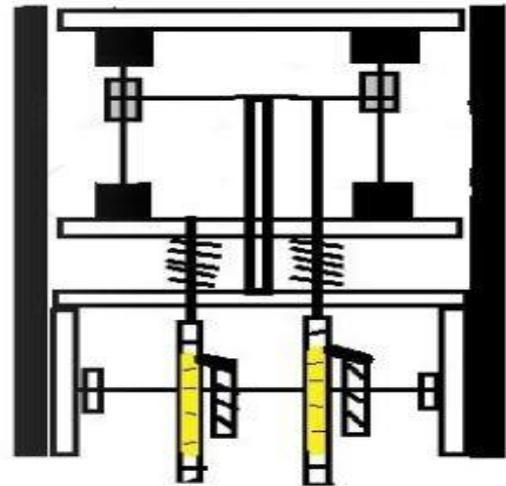


Figure 3. phase 1

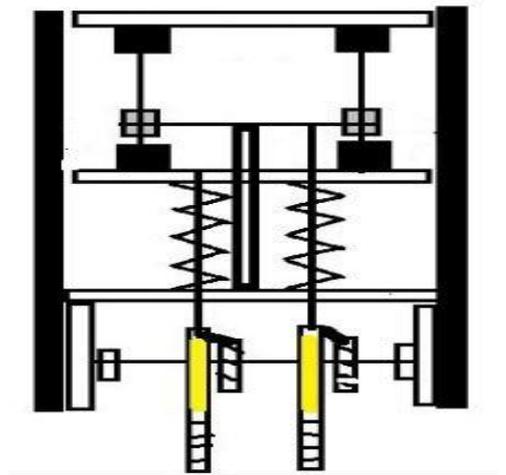


Figure 4. phase 2

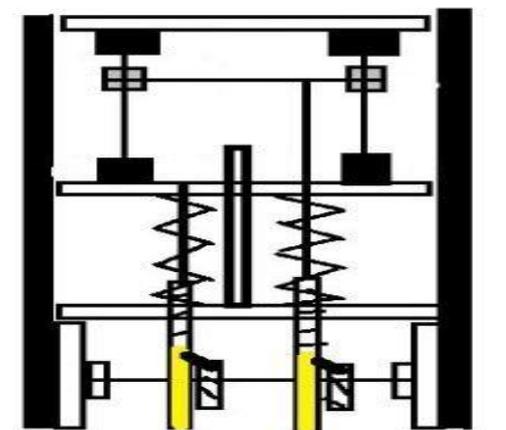


Figure 5. phase 3

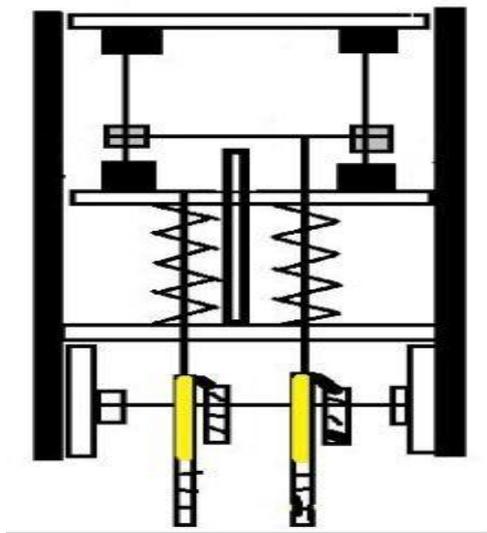


Figure 6. phase 4



Figure 7. Experimental setup

6. RESULT ANALYSIS

Table 2. Result Analysis

SI NO	LOAD (Kg)	OUTPUT POWER FOR ONE CROSSING(W)
1	50	55
2	100	121
3	150	210
4	200	250

Thus, these experiments conclude that, if load increases then the spring deflection is maximum for which the mechanical energy (rotation of pinion gear) is increased. Thus, the electrical energy increases as potential energy (weight of the vehicle) is increased. The electrical energy is also proportional to the speed of the vehicle through which it passes the experimental setup.

7. COMPARISON WITH PREVIOUS SPEED BREAKER MECHANISM

SI NO	PARAMETERS	RACK-PINION METHOD	FLOATING OSCILLATOR
1	Efficiency	Moderate	High
2	Shaft rotation	Low	High
3	Design	Moderate	Moderate
4	Weight impact	Spring	Spring
5	Cost	Moderate	Moderate
6	Maintenance	More required	Less required

8. CONCLUSION

Availability of sources (potential energy of the vehicle) is free of cost and enormous. Hence this project is very much useful to obtain power from ever available energy from the vehicles. Even though the cost of the Neodymium magnet is little higher, by considering its importance in the future electricity development, it is better to implement in roadways and gets benefited. The development of electric vehicles is rapidly increasing, so by implementing it we can provide the electric energy necessary for the electric vehicle by energy from the vehicle itself.

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