Design of Road Power Generator (RPG):an Alternate Energy Source for Sustainability

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***Abstract* -This paper presents the overall concept of Road Power Generator (RPG) that deals with the mechanism to generate electricity from the wasted kinetic energy of vehicles. It contains a flip-plate, gear mechanism, flywheel, and finally a generator is coupled at the end so that the rotational motion of the flywheel is used to rotate the shaft of the generator, thus producing electricity. RPG does not require any piezoelectric material. It is novel concept based on flip-plate mechanism. The project can be installed at highways where a huge number of vehicles pass daily, thus resulting in more amount of electricity generated. This generated electricity can be utilized for different types of applications and mainly for street lighting, on road battery charging units and many domestic applications like air conditioning, lighting, heating, etc.**

Keywords: Rack and pinion, Flip plate, Wasted energy, Flywheel

I. INTRODUCTION

Due to the advent and development in the field of renewable energy sources, the dependence on fossil fuels and conventional energy sources has been decreased drastically. This has led to higher penetration and use of Distributed Resources. The rapid increase in the demand for electricity and the recent change in the environmental conditions such as global warming led to a need for a new sources of energy. As we are aware of the factthat the number of vehicles are increasing day by day. Every time a vehicle passes over Speed Breaker, large amount of energy is wasted through friction. There is great possibility of generating power by tapping this energy. By just placing a unit like the “Power Generation Unit from Speed Breakers” or "Road Power Generator", a significant amount of energy can be tapped [1]. This generated electricity can be used for different purpose such as lighting of streetlights,battery charging and signal lights on road etc.

The proposed design offerspollution free power generation, would cause no obstruction in traffic, leading to low budget electricity production. It would occupy less floor area and its maintenance would be easy. The power generated by this technique can be used in street lights, road signals, lighting of the bus stops, lighting of the check post on the highways, etc.

II. WORKING PRINCIPLE OF RPG

A. Road Power Generator

Road Power Generation (RPG) is one of the most recent power generation concepts. By installing a flip plate on the road, this device converts the kinetic energy of the vehicles into electrical energy. Flip plate converts the stroke motion of the vehicles into the rotary motion by rack and pinion concept andthus the generation of electricity takes place. This paper also explains clearly, the working principle of the designed system, its practical implementation, and its advantages. Design of each component has been carried out using standard procedures, and the components have been fabricated and assembled.This mechanism shows the best source of energy that wecan get in day to day life. One might conclude that to be materially rich and prosperous, a human being needs to consume more and more energy.The utilization of wasted energy is an indication of the growth of a nation and environmental friendly approach.

B. General Working

Road Power Generation (RPG) is a system design to capture wasted kinetic energy from all vehicles. This device converts the kinetic energy of the vehicles into electrical energy [2]. This process is carried out byinstalling moving plate on the road. This plate captures very small movement from the road surface and it transfers this movement to the flywheel system. RPG includes the method of driving one flywheel to another, once it reached predetermining velocity. The RPG flywheel system has been developed to achieve large amount of moment of inertia in relatively small space.

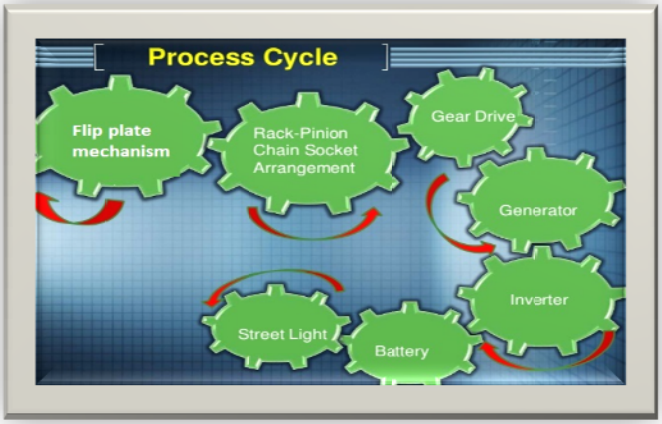

Fig. 1. Process of converting energy from the flip-plate mechanism to electricity

The captured energy is converted into electricity which is fed into power grid. In this paper the two flip plates are mounted on the road surface and these plates are followed by the rack and pinion arrangement. Pinion is mounted on the shaft which is attached to the frame via bearing. Frame is installed under the road. The flywheel with pulley is mounted on the shaft and second pulley is mounted on the D.C generator and these two pulleys are connected with the help of a belt. As wheel of the vehicle reaches upper most position of the plate, plates get slide through the wheel, simultaneously rack moving downward provides torque to pinion [3]. The pinion transmits this torque to shaft. Shaft is supported by two bearings attached on wall of frame. The shaft having pulley and flywheel arrangement on shaft through one-way bearing.

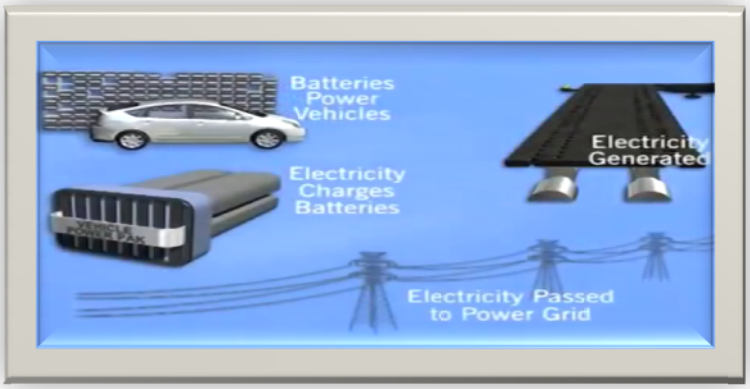

Fig. 2. Movement of car over the flip-plate mechanism

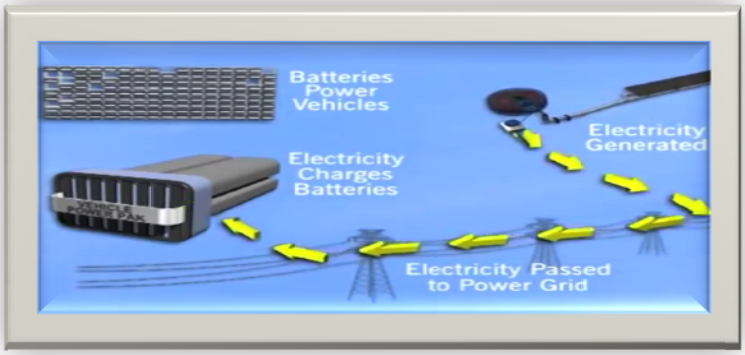

Fig. 3. Conversion of rotational energy in the flywheel to electrical energy to charge the batteries.

This arrangement enhances the rotation of flywheel for small motion of shaft. The bigger pulley has 2 belts coupled with smaller pulley mounted on the D.C. generator shaft. The d. c. Generator converts the rotation of smaller pulley into electricity.

III. SEQUENTIAL PROCESS IN RPG

1) Block Diagram : -

The general block diagram of RPG is as shown in figure 4. The flip plate is coupled to the belt and flywheel system, which in turn provides mechanical input to the DC generator. This energy is stored in batteries and can be used for lighting purposes, etc.

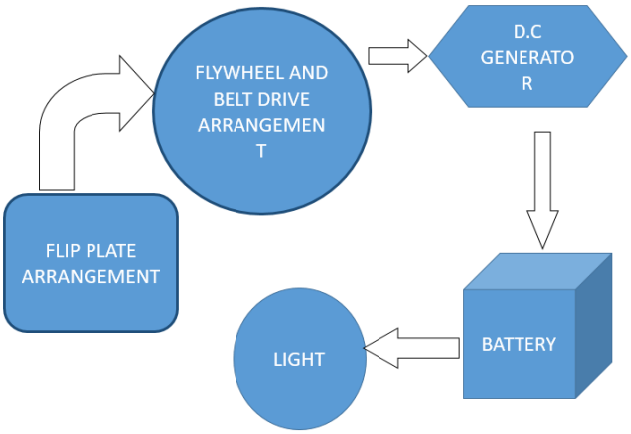

Fig. 4. Block Diagram for the RPG system

2) Flowchart : -

The flowchart for the same is described as follows: -

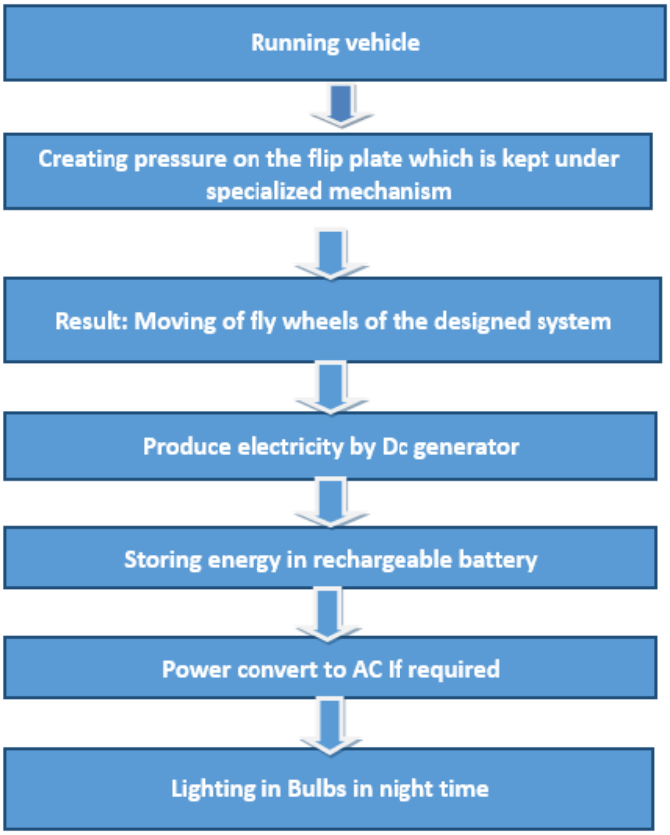

Fig. 5. Flowchart for working of RPG

IV. DESIGN OF RPG

1) *General Dimmensions*

Initially, a truck [6 x 4ft.] to be the vehicle passing assumed.

Also, considering single reduction drive axle with ratio [SLR] to be 4.5:1.

Let, transmission low gear ratio – 12:1.

So, for a truck, engine rating or capacity – 900 lb-ft [Max torque = 1220 Nm]

Weight of the truck – 44500 lb [20 tonn/4.5]

Radius of the wheel(R_w) – 11R22.5 = 20 inches = 50.8cm (51cm approx.)

Thus, Total torque(τ_w) = Engine rating x Gear Ratio x SLR

= 900 x 12 x 4.5

= 48600 lb-ft [Theoretically]

or = 1220 x 12 x 4.5

= 65880 Nm

But practically it is impossible to get 100% efficiency. So, efficiency considered is 80% -

= 0.8 x 48600

= 38880 lb-ft

or = 52704 Nm

Now, Tractive Force = τ_w / R_w

= 52704/0.51

= 103.341 kN

or= 76.235 x 10^3 lb

But, tractive force for a single wheel = 103.341/4

= 25.83 kN

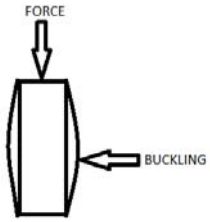

Fig. 6. Buckling in the member bars

Here, we take breadth(d) = 1.25depth(d)

Now, Buckling (σ_c) = $\frac{F_c}{Area} = \frac{F_c}{bd}$

Considering, factor of safety (f_{os}) = 2 (for steel)

$\frac{\sigma_c}{f_{os}} = \frac{25{\cdot}83*10\text{^}3}{b*d} = \frac{25{\cdot}83*10\text{^}3}{1.25d^2}$

$\sigma_c = \frac{25{\cdot}83*10\text{^}3}{1.25d^2}$ x 2

= 210 x 10^6(buckling stress for steel)

Thus, we get d = 14 mm

As, b = 1.25d = 18mm

Also, $\frac{\sigma_c}{f_{os}} = \frac{n\pi E}{SR\text{^}2}$

Where, Slenderness ratio (SR) = $\frac{l}{k}$

k = radius of gyration

n = column effective length factor, whose value depends on the conditions of end support of the column.

(n = 1, because the plate is hinged with the rod on both ends.)

Also, Radius of gyration (k') = $\sqrt{\frac{I}{Area}}$

Where, I = Moment of Inertia

$$k' = \sqrt{\frac{bd^3/12}{bd}}$$

$$k' = \sqrt{\frac{d^2}{12}}$$

k'= 4.04 mm

So, effective k = 2xk' = 8.08mm

Now, accordingly, $\frac{\sigma_c}{f_{0s}} = \frac{1*(\pi^2)*190*10^3}{SR\text{^}2}$

So, $\frac{l}{k}$= 133.638

And so, l = 1079.79 mm

= 107.97 cm (±5%)

B. *Power and Torque: -*

$T_P = F_T$ x r

Where, T_p = Torque exerted on pulley mechanism (12 kNm – assumed)

F_T = Tractive Force on the pulley.

r = radius of the pulley.

12 x 10^3 = 103 x 10^3 * (r)

r = 0.1165m = 12cm

We require final pulley having 12 cm radius and so according to the turns ratio of the second pulley = 2:1.

Thus, the radius of the second pulley = 24 cm.

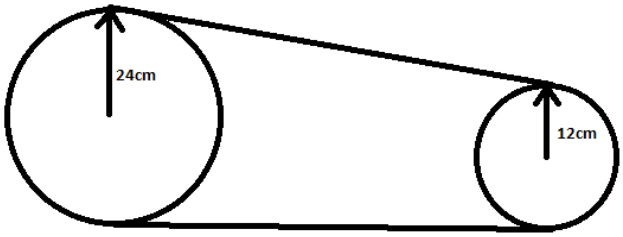

Fig. 7. Pulley Mechanism

V. CONCEPTUAL DESIGN AND PARTS OF RPG

A. *Male part of the flip-plate*

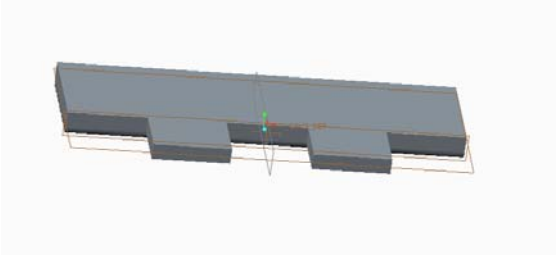

Fig. 8. Male part of the flip-plate

B. *Female part of the flip-plate*

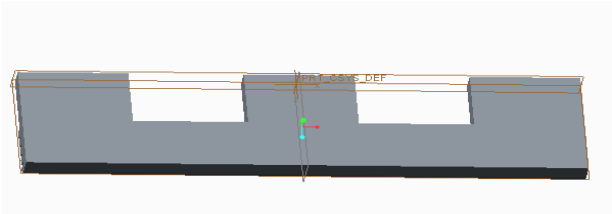

Fig. 9. Female part of the flip-plate

C. *Pinion*

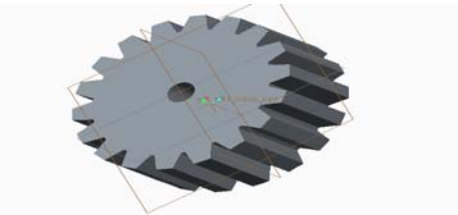

Fig. 10. Pinion used for the motion of the flywheel

D. *Shaft*

Fig. 11. Shaft used to transfer the energy to the flywheel

E. *Mini gear*

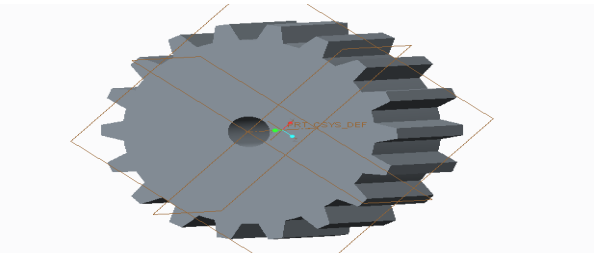

Fig. 12. Mini gear structure

F. *Sprocket*

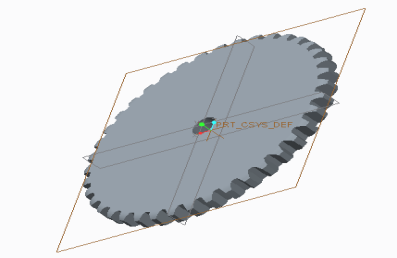

Fig. 13.Sprocket Structure

G. Flywheel

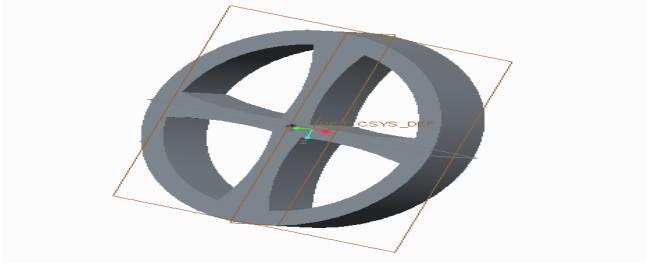

Fig. 14. Flywheel structure

H. Dynamometer

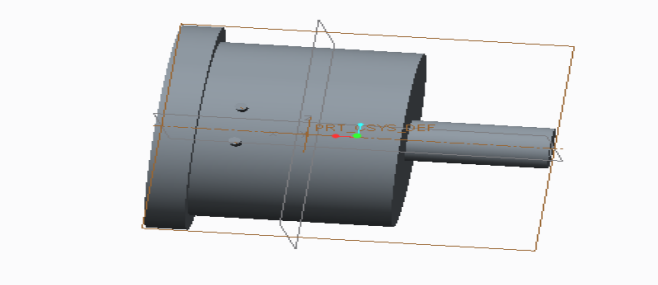

Fig. 15. Dynamometer for converting mechanical energy to electricity

I. Conceptual Layout

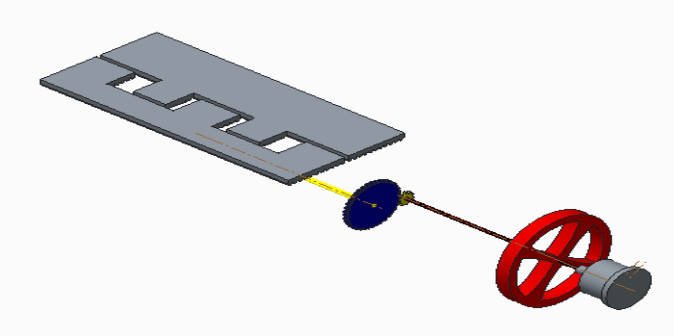

Fig. 16. Whole mechanism for RPG

VI. CONCLUSION

The demand for sustainable energy is increasing day by day. So, RPG proves to be a viable mechanism that can tap the wasted kinetic energy of the vehicle and in turn it can produce electrical energy. This generated energy can be used to light the street lights and also can be used to charge batteries for cars. The design of the same was carried out and the results proved that a compact RPG system can be used so as to get reasonably good amount of energy. Similarly, different constituent parts were designed and different results on the basis of design were obtained.

VII. REFERENCES

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Ashwin Chandwani was born in Vadodara, Gujarat, India on 11th March 1996. He is currently pursuing B.Tech in Electrical Engineering from Nirma University, Gujarat, India. His major fields of interest are renewable energy studies and power system compensation (active and passive). His current research focusses on application of Artificial Neural Network for efficient power quality conditioning system and Renewable Energy Extraction.

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