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# STUDY OF GENERATING POWER FROM SPEED BREAKERS USING RACK AND PINION MECHANISM

**Gurudath T V*, Hemanth Raju Sundar*, Bhagyalaxmi S Patil**, Pavan Kumar R****

**Department of Mechanical Engineering Kaunas University of Technology, Kaunas, Lithuania*

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**ABSTRACT -** Necessity is the mother of invention. The world has been growing very rapidly in terms of population; automobiles; energy requirements and more. This unchecked growth has resulted in a large demand for energy. Energy is the primary need for survival of all organisms in the universe. The deficit of energy has led to more emphasis on renewable forms. The traffic on the roads has doubled or even tripled over the recent years. But, this can be used to our advantage, by employing vehicular motion to generate useful power.

This study will give the idea of "power generation through speed breakers", inspired by various other existing designs. This concept is based on a fact that, lot of energy is generated when vehicle passes over a speed breaker. Energy generated can be tapped and Power can be produce using the speed breaker as power generating unit. The kinetic energy of the moving vehicles can be converted into mechanical energy of the shaft through rack and pinion mechanism. This mechanical energy will be converted to electrical energy using generator which will be saved with the use of a battery. A spring system is also used in conjunction to bring the system back to its original position. The energy saved during the day can be used at night for commercial use like lighting street lights, traffic signals and several such purposes. This paper deals with the study of Power generation through Rack and pinion mechanism at Speed Breakers.

**Key Words:** Conventional Energy, Rack and Pinion mechanism.

## INTRODUCTION:

Energy sources may broadly be classified into two major categories that are: conventional energy sources and renewable energy sources. Conventional energy sources have been utilized for power generation and industrialization for centuries. These energy sources are mainly dependent on fossil fuels namely: coal, oil and natural gas. Renewable energy sources are the ones that are inexhaustible, clean, pollution free, and environmental friendly. These energy sources include: hydro power (water energy), wind energy, geothermal energy, solar power and tidal energy. Energy exists in various forms, example mechanical, thermal, electrical etc., but has one thing in common. Energy is possessed of the ability to produce a dynamic, vital effect. With the use of suitable arrangements energy can be converted from one form to another. Among other forms of energy, electrical energy has the advantages such as easy transportable with minimum loss, economical in use, and easy conversion to other forms etc., Hence electrical energy is preferred over other forms of energy. In the last decade electricity generation has drastically switched gears from conventional to renewable with regard to the associated advantages. Nowadays renewable energy and energy recovery are considered the most efficient strategies to reduce the financial and environmental drawbacks of the excessive utilization of fossil fuel.

Energy crisis has become one of the biggest problems for any nation. At least 300 million of India's 1.25 billion people live without electricity. Another quarter-billion or so get only spotty power from India's decrepit grid, finding it available for as little as three or four hours a day. The lack of power affects rural and urban areas alike, limiting efforts to advance both living standards and the country's manufacturing sector.

Most of the investigations have been paying attention on solar energy, wind energy and wave energy. On the other hand, the operational mode of many of the utilized systems is not sufficiently optimized. This indicates strongly that high amounts of energy are still wasted and may be recovered. With the vast development of the technologies and understanding them, many other creative techniques of power generation have been emerged. The newly developed techniques are aimed at cost effectiveness. Thus they become more affordable to the countries like India, where installation cost and space occupancy are serious issues.

One such creative technique is power generation through speed breakers. The idea is to tap the potential energy that a vehicle would acquire when it is lifted over the speed breaker as it rolls over it. Speed bumps are systems that receive their kinematics from vehicles passing over them in which generated kinetic and potential energies are converted to electrical energy. The speed bumps systems translate vertically in which the mass of the moving vehicle experience vertical translation that results in potential and kinetic energy. Speed bumps constitute an excellent solution for energy recovery in countries that are poor in national energy resources. Hence, lighting streets during night time is a secondary to the local authorities since providing power

to streets lighting needs a considerable amount of power. The automotive industry in India is one of the largest in the world with an annual production of 23.37 million vehicles in FY 2014-15, following a growth of 8.68 per cent over the last year. The automobile industry accounts for 7.1 per cent of the country's gross domestic product (GDP). The Two Wheelers segment, with 81 per cent market share, is the leader of the Indian Automobile market, owing to a growing middle class and a young population. Moreover, the growing interest of companies in exploring the rural markets further aided the growth of the sector. The overall Passenger Vehicle (PV) segment has 13 per cent market share. This boom has lent more credibility to the concept of using speed breakers to generate power. This paper is concerned with the study mechanism behind the power generation and the expected power output of such a system. Further, the paper also includes another innovative concept of installing this mechanism before the speed breakers in order to tap more energy, and to reduce the speed of the vehicles to a larger extent.

**SCOPE OF THE PAPER:**

In the present scenario power becomes the major need for human life .The availability and its per capita consumptions are regarded as the index of national standard of living in the present day civilization. Energy is an important input in all the sectors of any countries economy.

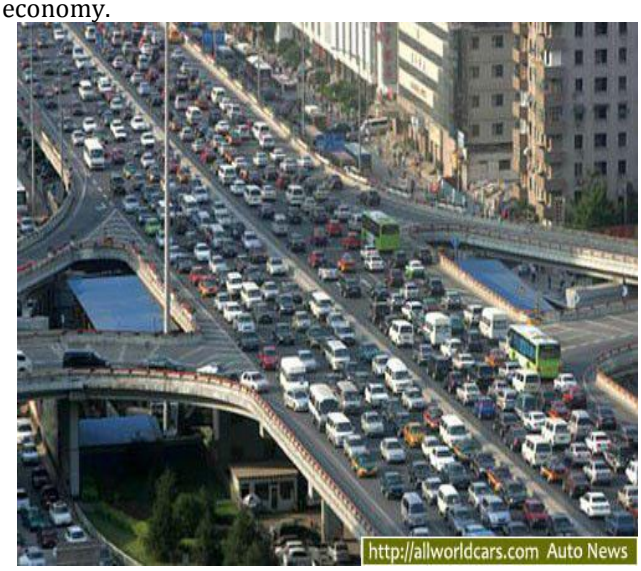


*Fig 1. Traffic in Major cities*

There are many problems faced by the power sector and these need to be addressed. The current power infrastructure in India is not capable of providing sufficient and reliable power supply. Some 400 million people have zero access to electricity since the grid does not reach their areas. Another problem is unstable power supply. There are frequency fluctuations caused by load generation imbalances in the system and this keeps happening because consumer load keeps changing. Frequency is the most crucial parameter in the operation of AC systems. The rated frequency in India is 50.0 Hz. While the frequency should ideally be close to the rated frequency all the time, it has been a serious problem in India. Poor power quality control has knock-on effects on equipment operation, including large-scale generation capacity. Rural areas in India are electrified non-uniformly, with richer states being able to provide a majority of the villages with power while poorer states still struggling to do so. The Rural Electrification Corporation Limited was formed to specifically address the issue of providing electricity in all the villages across the country. Poverty, lack of resources, lack of political will, poor planning, and electricity theft are some of the major causes which has left many villages in India without electricity, while urban areas have enjoyed growth in electricity consumption and capacity. Hence more research and development and commercialization of technologies are needed in this field. India, unlike the top developed countries has very poor roads. Talking about a particular road itself includes a number of speed breakers. By just placing a unit like the "Power Generation Unit from Speed Breakers", so much of energy can be tapped. This energy can be used for the lights on the either sides of the roads and thus much power that is consumed by these lights can be utilized to send power to rural areas.

**LITERARY SURVEY**

Paper by Aswathaman.V – "PRODUCE ELECTRICITY BY THE USE OF

SPEED BREAKERS" [1] in Journal of Engineering Research and Studies attempts to show how energy can be tapped and used at a commonly used system- the road speed breakers.

The number of vehicles passing over the speed breaker in roads is increasing day by day. A large amount of energy is wasted at the speed breakers through the dissipation of heat and also through friction, every time a vehicle passes over it. There is great possibility of tapping this energy and generating power by making the speed-breaker as a power generation unit. The generated power can be used for the lamps, near the speed breakers. The utilization of energy is an indication of the growth of a nation. For example, the per capita energy consumption in USA is 9000 KWh (Kilo Watt hour).

In another paper by Shakun Srivastava et al [2], explains that, the rotor is directly connected to the prime mover and rotates as the prime mover turns. The rotor contains a magnet that, when turned, produces a moving or rotating magnetic field. The rotor is surrounded by a stationary casing called the stator, which contains the

wound copper coils or windings. When the moving magnetic field passes by these windings, electricity is produced in them. By controlling the speed at which the rotor is turned, a steady flow of electricity is produced in the windings. These windings are connected to the electricity network via transmission lines. IIT Guwahati has evaluated the machine and recommended it to the Assam ministry of power for large scale funding. IIT design department says it is a „very viable proposition" to harness thousands of megawatts of electricity untapped across the country every day. A vehicle weighing 1,000 kg going up a height of 10 cm on such a rumble strip produces approximately 0.98 kilowatt power. So one such speed-breaker on a busy highway, where about 100vehicles pass every minute, about one kilo watt of electricity can be produced every single minute. The figure will be huge at the end of the day. A storage module like an inverter will have to be fitted to each such rumble strip to store this electricity.

A publication in Elsevier by Mohamad Ramadan et al [3], revealed that powers of roughly 26.2 to 44.7 W can be generated from the speed-breaker system when masses of 65 kg and 80 kg are applied. Hence, a consequence average of 0.37 W/kg forms a promising sign for the performance of such systems in real applications. Extrapolations to a real physical system indicate that a minimum average power of 0.56 kW can be generated for every passing vehicle. In other words installing a speed bump power generator on road will provide a power that may be utilized to lighten city streets, boulevards, and supply low-voltage powers to cameras or speed-sensors.

**MECHANICAL COMPONENTS INVOVLED IN THE SYSTEM**

In the design of the project, two types of gear wheels are used. They are spur gear wheels and sprocket gear wheels. The gear specifications are as follow Minimum number of teeth needed to avoid interference is selected for the gear pair and thus calculated speed. Maximum load is assumed. Material is selected on the basis of Lewis form factor. Tangential tooth load, tooth width and the value of the module is calculated for weaker element. Several components used to design the mechanical system are listed below.

(ALL THE EQUATIONS AND TABLES ARE USED FROM DESIGN DATA HAND BOOK BY K.LINGAIAH)

a) **Spur Gears:** Two pairs of Spur Gears are used as shown in Fig2. Their specifications are mentioned below in *Table 1*

*Fig2: Spur Gears*

*Table 1: Specifications of SpurGear*

| | |
|---|---|
| Spur gears | 2 |
| Number of Teeth | 35 and 18 |
| Addendum diameter | 74.22mm and 43.3mm |
| Module | 2.0mm |
| Face width at base | 4.16mm and 4.3mm |
| Pressure angle | 20full depth teeth |
| Material | Hardened steel |

b) **Sprocket Wheels:** Two regular sprocket wheels and a freewheeling sprocket wheel are used

1. Material – mild steel (tempered) and stainless steel
2. Addendum diameter –78mm and 182mm
3. Number of teeth – 16 and 44
4. Pitch – 12.7mm

**c) Freewheel:**

1. Material – mild steel (hardened)
2. Addendum diameter – 50mm
3. Number of teeth – 18
4. Freewheeling – one direction
5. Pitch – 14.6mm

d) **Flywheel:** The purpose of this component is to reduce the thrust force and Thereby reducing the fluctuations in the system. It is basically

made of cast iron which is a heaver metal to restrict the shaft in the perpendicular direction.

e) **Chain drive:** The chain drive is used between the freewheeling sprocket and the largest of the rest of the two sprockets.

1. Pitch –12.7mm
2. Roller diameter –7.95mm
3. Width – 7.85mm
4. Breaking load – 13,800 N

f) **Spring**: The rack when pressed down has to be reset for the next incoming pair of wheels or next incoming vehicle. Rack has to retrace its downward motion in upward direction. This is achieved by using springs under the rack. The springs are selected such that in downward motion most of the force due to weight of the vehicle has to be transferred to the pinion and the spring should deform easily. It does not pose any shock to the rack or the entire assembly because of its nature. As the weight on the rack is released the spring should reset the rack to its original position. The spring selected is of less stiffness with appreciable compressive strength to withstand the heavily loads possible. Material is selected for the spring for the given conditions. Factor of safety is suitably assumed. Stress factor is calculated by assuming spring index of 6. Outer and inner diameter of spring, active number of coils, and total number of coils are calculated.

1. Wire diameter – 3.36mm
2. Spring index –15.76
3. Mean coil diameter – 51.05mm
4. Number of active coils – 8

g) **Rack:** The conversion of the linear motion of the speed breaker to be converted into rotary motion for the generation of power. Mechanism of rack and pinion is used. The rack meshes with the sprocket and converts motion. To make the model cost effective and stronger, the usual rack and pinion mechanism is replaced by a chain tightly stranded to a wooden piece and a sprocket that meshes with the chain.

*h)* **Shaft***:* An aluminium shaft of 20mm diameter is used to mount the gears. The shaft is mounted on bearings to provide for resistance free rotation about its own axis. The loads acting on the shaft are that of the weights of the components mounted on the shaft, transmission loads and self-weight of the shaft.

i) **Bearings:** To support the rotation of the shaft in its seat in the wooden frame, single sleeve needle roller bearings is employed. They are a type of cylindrical roller bearings. The diameter of the shaft is reduced to that of the inner diameter of the bearing and thus providing a step in front of the bearing on the shaft to allow for locking of the movements along the axis of the shaft and also prevents any eccentricity possible in the rotation of the shaft. Each set of bearings bear the weight of the components mounted on the respective shaft and transmission loads.

## PRINCIPLE AND WORKING:

Electricity can be generated with the help of speed breaker by making gear arrangement and using electronic gadgets, thus a large amount of electricity can be generated. Rack-pinion mechanism is convenient to produce ample amount of energy with maximum efficiency with a very simple and effective design for generating electricity using a generator.

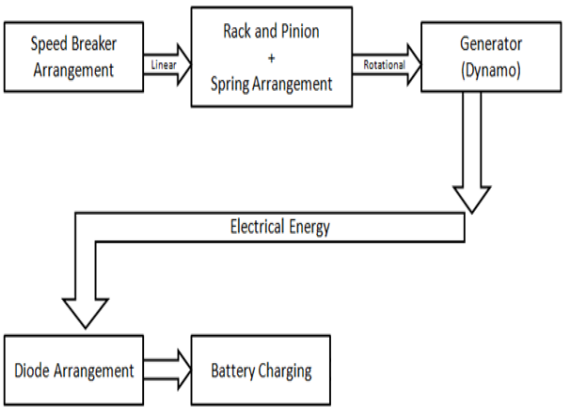


*Fig 3. Flowchart of the Energy generation mechanism*

The work is concerned with generation of electricity from speed breakers-like set up. The load will act upon the speed breaker & further the load will be transmitted to the rack and pinion arrangements, Fig.4. Here the reciprocating motion of the speed-breaker is converted into rotary motion using the rack and pinion arrangement. The axis of the pinion is coupled with the sprocket arrangement. The sprocket arrangement is made of two sprockets, Fig.5, one of larger size and the

other of smaller size. Both sprockets are connected by means of a chain or a belt and pulley arrangement which serves in the transmission of power from the larger sprocket to the smaller sprocket. As the power is transmitted from the larger sprocket to the smaller sprocket, the speed that is available at the larger sprocket is relatively multiplied at the rotation of the smaller sprocket

Also a flywheel is connected on the shaft of the smaller sprocket so as to get continuous rotation of the shaft and thus the generator. Thus, electricity is produced when pinion is rotates in clockwise direction.

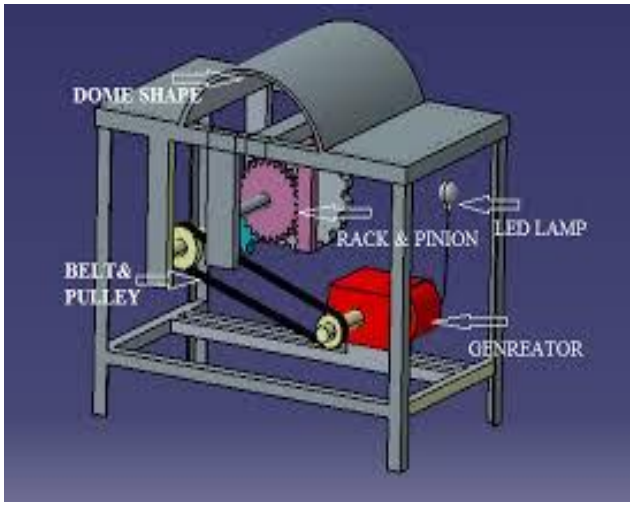


*Fig 4. Setup of Rack and Pinion Mechanism using Belt and Pulley Arrangement*

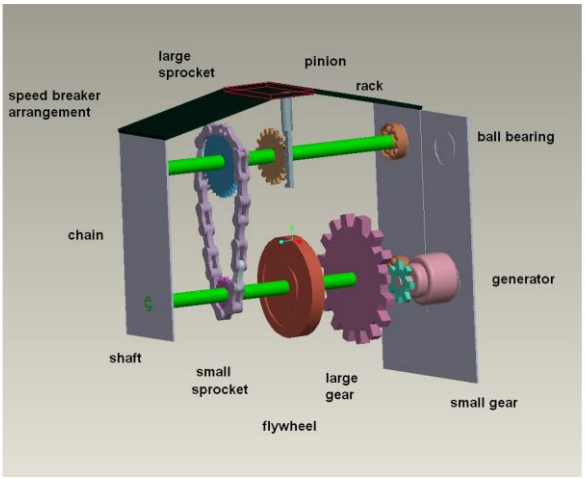


*Fig 5. Sprocket Arrangement*

**POWER CALCULATIONS:**

(ASSUMING VALUES FOR MASS OF THE VEHICLE AND HEIGHT OF THE SPEED BREAKER)

Consider, (Assumptions)

- The mass of a vehicle = 1000 Kg
- Height of speed brake = 10 cm

**Equations used:**

1. Work done = Force x Distance
2. Force = Mass x Acceleration due to gravity
3. Power = Work done / Time
4. Power = Voltage x Current

**Calculations:**

**STEP 1:** Force = Weight of the Body = 1000Kg x 9.81 = 9810 N

**STEP 2:** Distance travelled by body = Height of speed brake = 10 cm

**STEP 3:** Output power = Work done/Sec = (9810 x 0.1)/60 = 16.35 W

**STEP 4:** Power developed for 1 vehicle passing over the speed breaker arrangement for one minute is 16.35 W

**STEP 5:** Power developed for 60 minutes (1 hour) = 16.35x60 = 981W

**STEP 6:** Power developed for 24 hours = 981 x 24 = 23544 W = 23.544 KW

As the Mass of the vehicle increases the Output Power increases as they are directly proportional (from equations 1, 2, and 3). Thus, in turn both Current and Voltage both increase (from equation 4). A general plotting of this is as shown below in Fig 5, Fig 6, and Fig 7. [3]

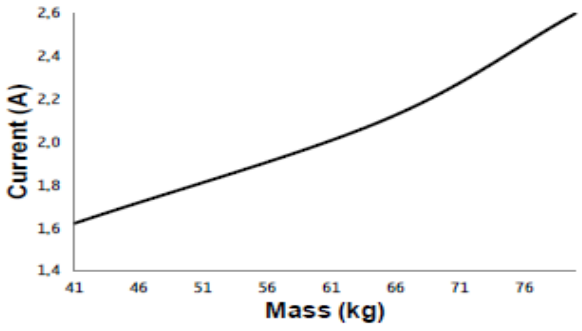


*Fig 6. Variation of the Current in function of Mass*

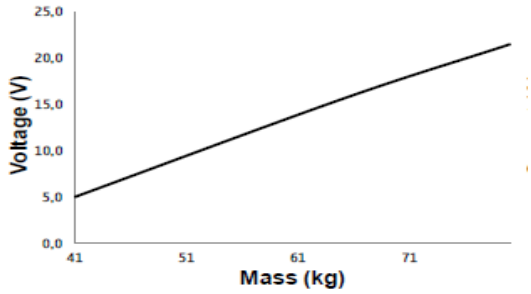


*Fig 7. Variation of the Voltage in function of Mass*

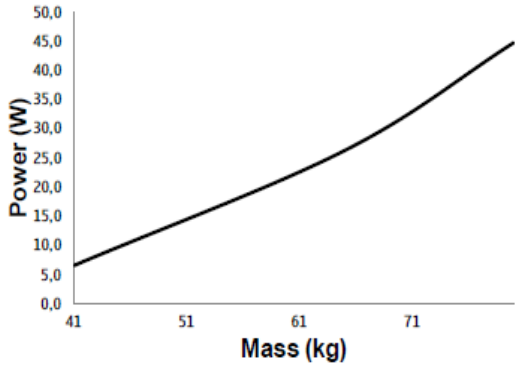


*Fig 8. Variation of the Power in function of Mass*

**FURTHER SCOPE OF IMPLEMENTATION OF RACK AND PINION SYSTEMS:**

The space available for such systems on the speed breakers is limited. An improvement can be made by implement such systems in rows before and after the speed breakers to tap as much energy as possible. The mechanism remains the same. All the energy generated by all the rows of systems could be used to charge batteries, which then can be harnessed for several purposes. This increases the overall efficiency and the power generated at each hump. A few possible schematic diagrams regarding such implementation are shown below.

**A GENERAL OVERVIEW OF THE PROPOSED SYSTEM:**

A top view of a possible arrangement of Rack and Pinion is shown in Fig 9,. Each section contains a flap over which the wheels of the vehicles pass. The mass of the vehicles pushes the flaps down. The open end of the flap is attached to a Rack-Pinion mechanism and spring housing with the help of a roller as shown in Fig 10. The spring material is made of less stiffness, and thus, will not resist the load of the vehicle. Fig 11, shows the internal cavity for power generating equipment's and the front view of the spring mechanism. A section is cut as shown in Fig 11, to prevent the flap from going below the surface of the road.

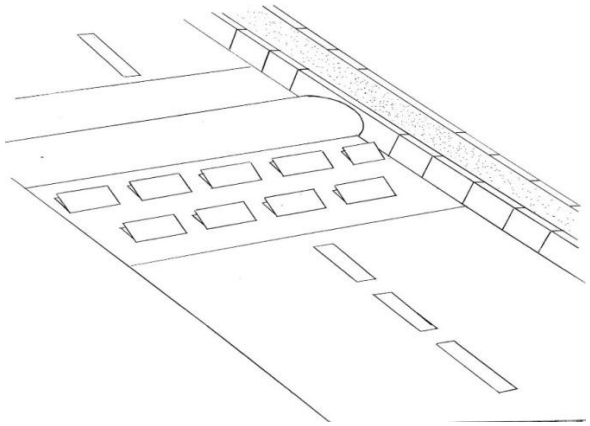

*Fig 9. Top view of the Rack and Pinion Arrangement in rows*

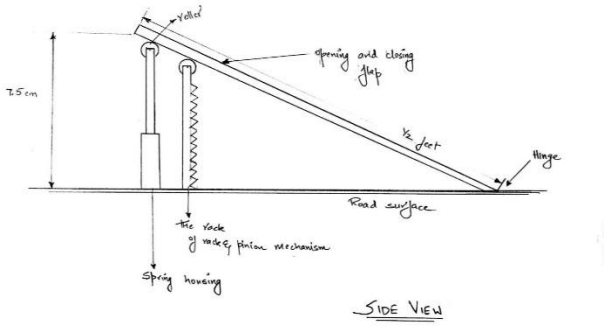


*Fig 10. Side view of the Rack and Pinion Arrangement*

**Parts Shown in Fig 10**:

1. Flap
2. Hinge
3. Rack and pinion mechanism
4. Spring housing
5. Roller

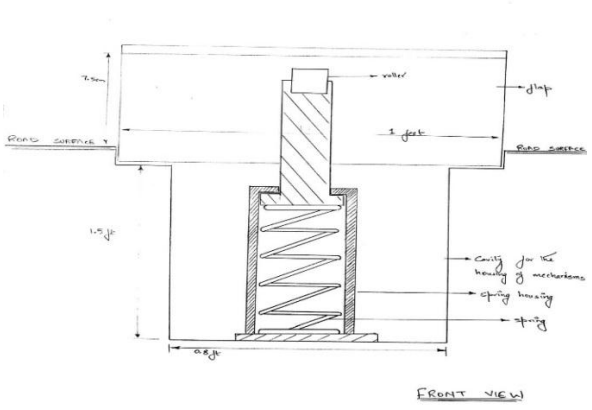


*Fig 11. Front view of the Rack and Pinion Arrangement*

**Parts Shown in Fig 11**:

1. Flap
2. Roller
3. Section to prevent Flap from going below the road surface
4. Sping
5. Cavity for power generating components

**POWER CALCULATION FOR THE NEW SYSTEM:**

Consider

- The open end of flap to be at a distance of 7.5 cm from the road surface
- Length of the flap = 0.5 feet = 15.24 cm
- Width of the flap = 1 feet = 30.48 cm
- Mass of the vehicle = 1000 kg

**Equations used:**

1. Work done = Force x Distance
2. Force = Mass x Acceleration due to gravity
3. Power = Work done / Time
4. Power = Voltage x Current

**Calculations:**

**STEP 1:** Force = Weight of the Body = 1000Kg x 9.81 = 9810 N

**STEP 2:** Distance travelled by body = Height of speed brake = 7.5 cm

**STEP 3:** Output power = Work done/Sec = (9810 x 0.075)/60 = 12.2625W

**STEP 4:** Power developed for 1 vehicle passing over the 1 row of speed breaker arrangement for one minute is 12.2625 W

**STEP 5:** Power developed for 60 minutes (1 hour) = 12.2625 x 60 = 735.75 W

**STEP 6:** Power developed for 24 hours = 735.75 x 24 = 17658 W = 17.658 KW

This value gets multiplied with the number of such rows of Rack and Pinion arrangement.

**ADVANTAGES OF RACK AND PINION ARRANGEMENT FOR POWER GENERATION:**

Using this technology one can get the following benefits:

- No manual work required during generation.
- Pollution free power generation.
- Simple construction, mature technology, and easy maintenance.
- No fuel transportation problem.
- Energy available all year round.
- No consumption of any fossil fuel which is non-renewable source of energy.
- Low maintenance cost
- Low installation cost
- Never decreasing vehicular frequency (input)

**APPLICATIONS:**

The generated power is stored in the battery; one can use this charge to various purposes. Mainly the generated power is used in two aspects.

1. **Street Lights:** A Street light, lamp-post, street lamp, light standard, or lamp standard is a raised source of light on the edge of a road or walkway, which is turned on or lit at a certain time every night. Modern lamps may also have light-sensitive photocells to turn them on at dusk, off at dawn, or activate automatically in dark weather.
2. **Traffic Lights :** Traffic lights, also be known as stoplights, traffic lamps, traffic signals, signal lights, are signalling devices positioned at road intersections, pedestrian crossings and other locations to control competing flows of traffic
3. **Calling Bells:** This mechanism can be arranged at the door step of houses. When someone steps on the door step the weight of the person drives the mechanism and initiates a trigger signal which closes the circuit that finishes an alarm.

**CONCLUSIONS:**

As the demand increases for electricity the new techniques will be evolved to make effective use of all the available energy. Rack and pinion method is an innovative method of green power generation in order to contribute toward developing the world by enriching it with utilization of available resources in more useful manner. The emissions from the system are zero it will be the most eco-friendly reliable one in the scope perception. The mechanism proposed is much simpler and continuously produces the electrical power, and the produced electrical energy is a renewable energy which is pollution free. Another advantage is that, this type of

power generation is identified to be cheaper than many other alternatives and the model has less number of parts and the assembly would cost very less with all the components being available regularly and no model specific parts are to be manufactured.

This research can also be modified by using camshaft and pulley stem or concepts of fluid mechanics can be used instead of gears, so as to minimize the inherent complexities and difficulties. By using the concept of power generation new ideas should be introduce which would help in reduction of friction and increase the efficiency of the generators. Therefore, Rack and Pinion mechanism is efficient as well as cost effective mechanism for generation of electricity from speed breaker.

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