International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Electric Power Generation System from Speed Breaker by using Rack and Pinion Mechanism

Kiran Kolhe[#*] and Amar Pandhare[&]

[#]Department of Mechanical Engineering, University of Pune, India
[&]Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering, University of Pune, India

Accepted 10 June 2017, Available online 18 June 2017, **Vol.7, No.3 (June 2017)**

Abstract

Energy is the prime necessity of survival of each and every organism in the universe. Everything happening in the environment is a result of the flow of energy in one or other forms. Energy can be converted into a number of forms that can be measured in various ways. In this busy and fast moving world, population is multiplying continuously and the conventional sources of energy are getting exhausted at a great pace. The substantial usage of energy has led to an energy crisis over a few years. In order to overcome this problem, we need to execute the techniques of optimum use of conventional sources for conservation of energy. One such technique is explained here. The count of vehicles passing over speed breakers on roads has increased these days. Such speed breakers are designed for heavy vehicles, as it increases the input torque and ultimately results in increasing the power as output. The kinetic energy of the moving vehicles at the speed breaker can be converted into mechanical energy of the shaft by using rack and pinion mechanism. Then, this mechanical energy can be transformed to electrical energy using generator or dynamo which can be stored with the use of a battery. All these conversions take place in an electro-mechanical unit. This energy saved during the daytime can be used at night to light the street lamps. Therefore, by using this arrangement a large amount of energy can be conserved which can be used to fulfill our future demands. The first ever generation of electricity was done by using Faraday's dynamo in the 1800's. Generating electricity by speed breakers is an ingenious and useful concept as it has more advantages as compared to its faults and it is best suited for the current situations.

Keywords: *Speed breaker, Power generation, Rack and pinion, Electricity, Energy, Electro-mechanical unit, Non-conventional sources, Kinetic energy, Mechanical energy, Vehicles.*

1. Introduction

Electricity is required at every point in our daily life and now-a-days, the increased growth in population has resulted in reduction of conventional sources of energy. The availability and consumption of electricity is regarded as the index of national standard of living in the present day civilization. Energy is important taking into account all sectors of a country's economy. Energy crisis is mainly due to two reasons, first, the population of the world has increased rapidly, and second, the standard of living of human beings has increased. The share of global electricity demand of developing countries, jumps from 27% in 2000 to 43% in 2030. According to the International Energy Agency, the world will need almost 60% more energy in 2030 than in 2002. The availability of regular conventional fossil fuels are the main sources for power generation, but there is danger of sources getting exhausted eventually by the next few decades. Hence it becomes necessary that we depend on non-conventional energy sources for power generation. A survey on the energy consumption in India reported that about 85,000 villages in India still do not receive electricity (N. Fatima, *et al*, 2012). With the vast development of technologies and acquaintance with them, many other useful techniques of power generation have emerged. The newly developed techniques focus on cost effectiveness. One such method of power generation is explained in this paper.

In the present day life, a lot of vehicles move over roads and vehicles possess some kinetic energy by virtue of its motion. On Road these vehicles waste tremendous amount of energy due to speed breakers. In India, the total length of national highways was 76,818 km till 2012 according to Ministry of Road Transport and Highways. There are averagely about 15 to 20 highways in every state of India. The number of vehicles running on Indian roads show increase in trends. The vehicle growth in India has increased from 0.3 million in 1951 to more than 45 million in 2001 (S.A. Jalihal, *et al,* 2005). About 58.8 million vehicles

*Corresponding author: **Kiran Kolhe**

were running on roads in 2002, which increased to 72.7 million vehicles in the year 2004. The growth rate of vehicles in India has increased almost 10 percent annually during the last decade (R. Gupta, *et al,* 2013), (A.K. Sharma, *et al,* 2012). The increasing traffic and number of speed breakers these days emphasize on conditions to manufacture an innovative device which can use the energy of vehicles that is wasted on speed breakers to some profitable work. We can capture this kinetic energy at the speed breaker so that it can serve our purpose of electricity generation. An electro-mechanical unit is fixed under the speed breaker which is explained in the paper. This unit converts reciprocating motion into rotary motion. The rotational power (i.e. mechanical energy) is converted into the electrical energy by using gear arrangement and a generator which generates electricity. And this generated electricity can be used in various applications.

Averagely, when we consider speed breaker height of 10 cm (S. Priyadarshani, 15 June 2007), and a 1500 kg vehicle passing over the speed breaker, ample amount of power can be generated. This amounts to 24.52 W of power for 1 minute. Thus in an hour, 1.47 kW of power approx. is generated which will add up to 35.31 kW of power per day. This is equivalent to a large value and is sufficient enough to run 4-6 street lights a day. It contributes greatly to the generation of electricity and thus it will release the load on powerplants and because of this greater equivalents of electricity will be available for industries leading to progressive development of the nation.

2. History

Electricity generation began somewhere around 100 years ago, and before this idea was known houses were lit with help of kerosene lamps, iceboxes were used to cool the food, and rooms were warmed by stoves using either coal or wood for burning. Direct current (DC) electricity was used in arc lights for outdoor lighting. Nikola Tesla pioneered the generation, transmission, and use of alternating current (AC) electricity, in the late-1800s, which could be transmitted over much greater distances compared to direct current.

The first ever generation of electricity was done by using Faraday's dynamo in the 1800's. Almost 200 years later, it was found that we are still using the same basic principles to generate electricity, only on a much larger scale. The standard conventional fossil fuels are the key sources for power generation, but there is a fear of these conventional fossil fuels getting exhausted eventually by the next few decades. Hence it has become mandatory for us to search on some new alternative sources for power generation, which would last for a longer duration (N.V. Bhavsar, *et al,* 2015). Therefore, it is necessary & important that we depend on non-conventional energy sources for power generation. While moving, vehicles possess kinetic energy and some of the kinetic energy is wasted. This kinetic energy which is already being wasted can therefore be utilized to produce power by using a special arrangement called "electro-mechanical unit". Electricity production from a speed breaker is a new concept that is undergoing research.

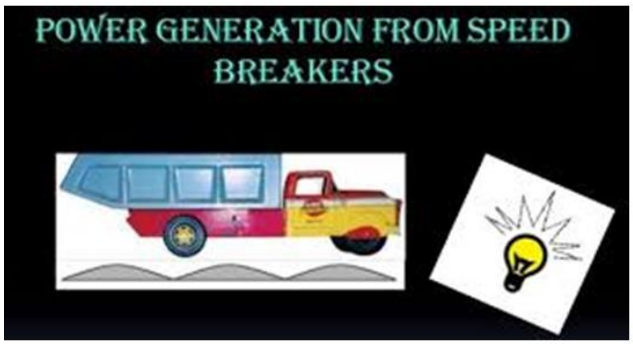

Figure 2.1 Power generation from speed breaker

3. The idea of electricity from speed breaker

The number of vehicles on road is increasing rapidly and if some of the Kinetic energy of these vehicles is converted into rotational motion of generator then a considerable amount of electricity can be produced. At present, there is shortage of electricity leading to energy crisis.

Can electricity be generated using speed breakers? Could this idea be beneficial in any case? The answer is, yes, of course. This idea will be advantageous; for generating electricity for the traffic signals, streetlights, and then for many other purposes. The Transcalm road bump which is a speed breaker was invented by a British engineer Graham Heeks, who dreamed up the concept after examining squeezable children's toys (W. Knight, 21 Aug 2001). Generally, when vehicle is in motion it produces various forms of energy like the "Heat Energy", which is produced due to friction between tyres of vehicle's wheel and the road i.e. rough surface, or when vehicle traveling with a high speed strikes the wind. This heat energy produced is always lost in environment and remains unused which is just the wastage of energy abundantly available around us. In this paper, one such method is referred and explained in order to generate "Electrical Energy". This method uses the principle of "Kinetic Energy to Electric Energy conversion".

Figure 3.1 Speed breaker

Now, one question can rise on the use of speed breakers, that, why only speed breakers should be used? And why not rough roads and uneven surface prove beneficial for this? The answer to this is simple, that rough surfaces are not that apt to provide sufficient torque which is necessary in order to produce electricity by rack and pinion method (F. N. C. Anyaegbunam, 2015).

4. Energies involved in this method

Three types of energies are taking part in this conversion in order to generate electricity.

4.1 Kinetic Energy

Energy possessed by a body due to virtue of its motion is called as Kinetic energy. The kinetic energy of an object of mass *m* traveling at a speed *v* is ½ mv^2 . The kinetic energy of an object is directly proportional to the square of its speed. The kinetic energy of an object is completely described by magnitude alone (scalar quantity).

4.2 Mechanical Energy

Mechanical energy is the energy associated with both the motion and position of an object. Objects possess mechanical energy when they are in motion or if they are at a *zero potential energy position*. An object gains energy, when some work has been done on it. The energy gained by the objects on which, work is done, is known as mechanical energy.

4.3 Electrical Energy

When energy is stored in charged particles which are in an electric field, that energy is known to be electrical energy. The regions or areas which form an envelope around these charged particles are called as electric fields. The electric fields are a result of charged particles, and they exert force on other charged particles causing them to move in the electric field.

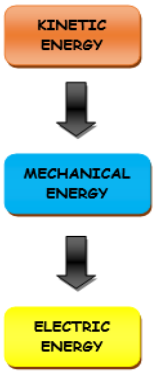

Figure 4.1 Energy Conversion

The basic energy conversion taking place is first from kinetic energy to mechanical energy and then from mechanical energy to electrical energy. The kinetic energy of the vehicle which is wasted at the speed breaker is converted to mechanical energy of the unit below speed breaker by the rack and pinion mechanism. This mechanical energy is later converted to electrical energy by a generator.

5. Mechanism used

The mechanism used in the assembly is rack and pinion mechanism. It converts reciprocating motion into rotary motion. Here, the rack is the element producing reciprocating motion and pinion rotates due to this reciprocating motion. The rack is displaced vertically due to the weight of the vehicle passing on the speed breaker and thus it reciprocates (M. Ramadan, *et al,* 2015). As the rack reciprocates, it turns the pinion to rotate. The rack is the flat part which has teeth, while the pinion is a gear.

Advantages of rack and pinion mechanism

- This assembly gives good mounting convenience.
- Gear losses are maximum up to 5%.
- Approximate efficiency of rack and pinion mechanism is about 95%.

6. Equipment required for the system

6.1 Rack and pinion

A rack and pinion comprises of a pair of gears which convert reciprocating motion into rotational motion or vice versa. The rack is the flat part which has teeth, while the pinion is a gear (A. Kaur, *et al*, 2013).

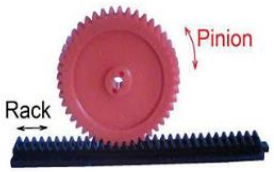

Figure 6.1 Rack and pinion

6.2 Ball bearings

Figure 6.2 Ball bearing

A ball bearing is a type of rolling-element that uses balls to maintain the separation between the bearing races. It permits relative motion between the surfaces which are in contact while carrying loads. The relative motion between the components causes

the balls to roll with little sliding. The ball bearing is used to reduce friction and transmit the motion effectively.

6.3 Spur Gear

A gear is a rotating element which has teeth that mesh with some other part having teeth in order to transmit torque. It is a positive power transmission device with definite velocity ratio (P. Vishnoi, *et al*, 2014). It should have high resistance for wear and tear, and high capacity to absorb shock.

Figure 6.3 Spur gear

6.4 Sprocket and Chain drive

It is a profiled wheel with teeth that can mesh with a chain, or other perforated material. Sprocket is generally a wheel upon which radial projections engage a chain passing over it. Chain drive is used to connect the sprockets in order to transmit power (C. B. Prakash, *et al*, 2014). It is distinguished from a gear, that sprockets are never meshed together directly.

Figure 6.4 Sprocket

6.5 Pawl and Ratchet

A mechanical device which allows motion in only one direction is called ratchet. The ratchet is a gear which has teeth and it is circular in shape. The pawl is a spring loaded hook type structure which is pivoted at one end and the other end makes contact with the teeth of the ratchet. It fits in to the space between the teeth of the ratchet and thus prevents the reverse motion by restricting the backward movement of the ratchet. The pawl is raised when the ratchet rotates in forward motion, and when the rotation of ratchet stops, the pawl rests between the teeth of the ratchet. Thus a constrained one direction motion is achieved by using pawl and ratchet.

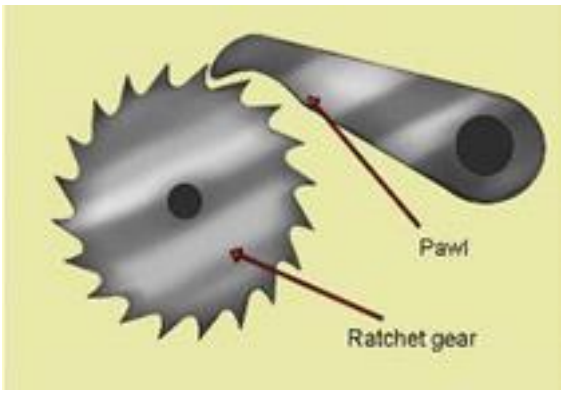

Figure 6.5 Pawl and ratchet

6.6 Flywheel

The primary or main function of the flywheel is to reduce the fluctuations in speed. It is known as an energy accumulator. The flywheel proves to be of great help as, it absorbs extra energy and stores it when demand is less, and releases this stored energy when the demand increases (F. Najuib, *et al*, 2014).

Figure 6.6 Flywheel

6.7 Shaft

It is a rotating element, which is used for transmission of power from one element to another element. It supports rotating elements like gears and flywheels. The shaft is mounted on bearings in order to provide free rotation of shaft about its own axis (M. Sailaja, *et al,* 2015). A shaft is expected to have high torsional rigidity and lateral rigidity.

Figure 6.7 Shaft

6.8 Spring

Spring is an element which possess elasticity and its function is to expand and contract to recover its

original shape when it is loaded or unloaded. It changes its shape according to the load applied. It absorbs energy either due to shocks or due to vibrations. Springs are usually made out of hardened steel. Small springs can be wound from pre-hardened stock, while larger ones are made from annealed steel and hardened after fabrication (S. Srivastava, *et al,* 2011).

Figure 6.8 Spring

6.9 Generator or Dynamo

It is a device which converts mechanical energy into electrical energy. For this energy conversion, the generator or dynamo uses rotating coils of wire and magnetic fields.

Figure 6.9 Generator

6.10 Battery

It is a device which stores energy generated from the generator. The energy is stored in the form of chemical energy in the battery (N. Kumar, *et al,* 2016). This energy can be used as and when it is required.

7. Working

The working of the electro-mechanical unit is facilitated by considering 3 systems-

1) Damper system
2) Motion Conversion system
3) Energy Conversion system.

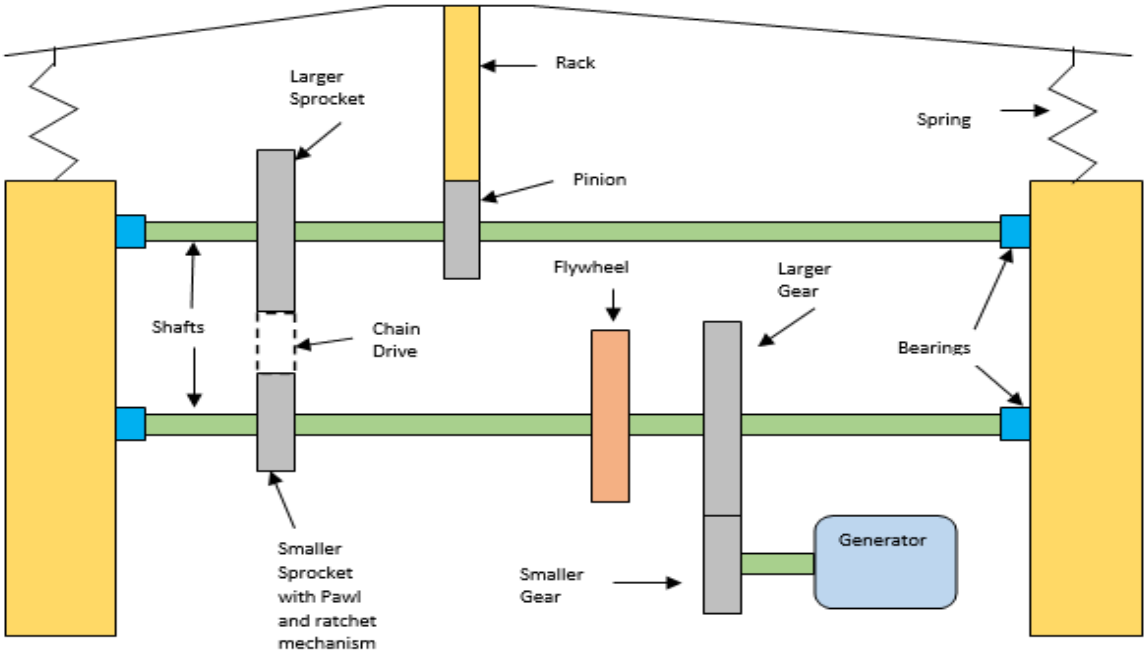

Figure 7.1 Constructional details of Electro-mechanical unit

7.1 Damper system

Damper system is required to support the speed breakers. The speed breaker is made up of materials like recycled plastic, vulcanized rubber etc. The speed breaker designs may be: the "Sleeping Policeman", which has a rounded top; the "Speed Cushion", which is a raised square in the middle of a lane; and the "Speed Table", which is a wide flat-topped speed breaker (S. English, 11 Nov 2005). Damper system consists of a spring which is required to push the speed breaker upwards when it is acted upon by the weight of the vehicle downwards (Ankita, *et al*, 2013). They are also required to absorb the shocks produced when the vehicles pass over the speed breakers.

7.2 Motion conversion system

This system is required to convert the basic vertical reciprocating motion of the damper system into rotary motion of the shafts. For this a rack & pinion mechanism is used. The vehicle load acted upon the

speed breaker is transmitted to rack and pinion arrangements. This vertical motion is converted to rotary motion and transmitted to a sprocket arrangement. The sprocket arrangement consists of two sprockets – one larger diameter and the other of smaller diameter. The axis of the pinion is coupled to the larger sprocket. The pinion and the larger sprocket are mounted on the same shaft. Now the larger and smaller sprocket are connected with each other through a chain drive. Smaller sprocket is mounted on another shaft. The smaller sprocket consists of a pawl and a ratchet which avoids the rotation in reverse direction of the shaft on which smaller sprocket is mounted. Thus, the shaft on which smaller sprocket is mounted rotates in one direction only. i.e. it rotates only when the rack moves downward due to load of vehicle. When the rack moves upward to return to its initial position, the rotation of shaft is avoided by the pawl and ratchet. This is similar to the operation of a bicycle wheel (A. K. Singh, *et al,* 2013). As the sprocket arrangement is connected by a chain drive the speed available at larger sprocket is characteristically multiplied at the smaller sprocket (A. Mishra, *et al,* 2013). Thus a larger speed is obtained. The axis of the smaller sprocket is coupled to a gear arrangement which consists of two gears with different dimensions. The gear wheel with the larger diameter is coupled to the axis of the smaller sprocket and these two are mounted on the same shaft. The speed that has been increased at the smaller sprocket wheel is handed to this gear wheel of larger diameter. The smaller gear is meshed to the larger gear. Therefore, as the larger gear rotates, it increases the speed of the smaller gear and multiplies it to more intensity. Though the speed due to the rotational motion achieved at the larger sprocket wheel is less, the final speed achieved is high, as the power is transmitted to gears. The smaller gear is coupled to the dynamo or generator. Between the smaller sprocket and the larger gear, a flywheel is mounted on the same shaft to adjust the fluctuation in the energy (H. Singh, *et al,* 2016). Flywheel also makes the energy consumption uniform so that the shafts will rotate with certain speed consistently. Thus mechanical energy is available at the output of motion conversion system.

7.3 Energy conversion system

In this system the mechanical energy available at the smaller gear (i.e. at the output of the motion conversion system) is converted to electrical energy by means of a dynamo or generator. The smaller gear is coupled to the dynamo or generator. The conversion will be proportional to traffic density (G. R. Prabu, *et al,* 2015). A Dynamo or Generator consists of a stationary structure, called the stator, which provides a constant magnetic field, and a winding called, the armature, which rotates within that field. The armature is a soft iron core on which a copper coil of turns is mounted and it is connected to the shaft of the smaller gear. So as the smaller gear rotates, the shaft also rotates and relatively the armature is also turned around the shaft axis. The armature has 2 rings, each connected to 1 end of the armature. These rings rotate with the armature. To these rings, brushes are connected. This assembly is known as slip ring & brush assembly. The brushes are stationary part of this assembly and are generally made of carbon. The output of the brushes is connected to outer circuit for measuring current. As the armature rotates with current induced in its arms, the brushes transmit this current to the outer circuit.

The field magnets are designed such that they are concave at the inner side and entirely cylindrical in shape. The reason for this is, it enables the magnets to generate radial magnetic field. As the armature rotates in the radial magnetic field about an axis perpendicular to the magnetic field, an EMF (electro-magnetic force) is generated which induces current in the armature arms. The EMF is generated as the armature cuts the magnetic field flux, already present due to the magnets (K. P. Singh, *et al,* 2014). Now, as the armature continuously rotates, the direction of the current induced in its arms changes constantly. As a result of this we get an alternating current, which has sinusoidal nature characteristic. Thus electric current is achieved and it is stored in storage sources such as a battery and used whenever required.

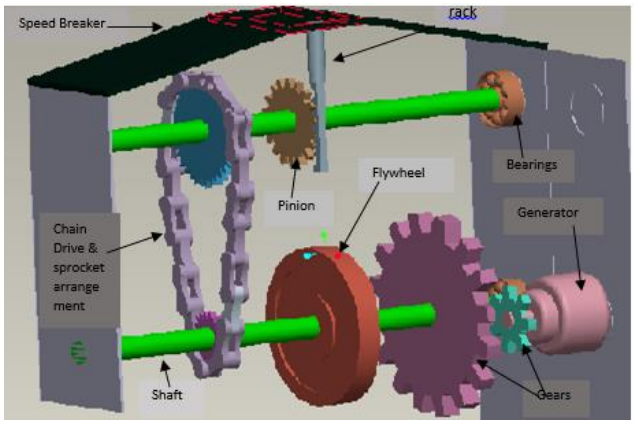

Figure 7.2 Working of the unit (A. Mishra, *et al*, 2013)

8. Power Calculations

Weight of cars vary from 1200 kg -2000 kg (for an average car) approx. The power generation may be greater for heavy vehicles such as trucks, buses etc.
The speed breaker height is generally up to 10 cm (Eastleigh Borough Council, 27 Sept 2006). If averagely, 1500 kg weight and 10 cm height is considered then approx.

(1 N-m = 1 Joule)
1 N-m/s = 1 Watt

Power = Work done /s

Weight of car (W) = mg
m = mass of car

g = gravitational acceleration = 9.81 m/s^2
W = 1500 * 9.81
W = 14715 N
Work done = Weight * displacement (i.e. height of breaker)
= 14715 * 0.10
= 1471.5 N-m
= 1471.5/60
= 24.52 W

Work done = 24.52 Watts

Power = 24.52 Watts for 1 minute
For 60 minutes (1 hour) = 24.52 * 60 = 1471.5 W
For 24 hours (1 day) = 1471.5 * 24 = 35316 W
Approx. **35.31 kW** of power generated **per day**.

9. Block Diagram

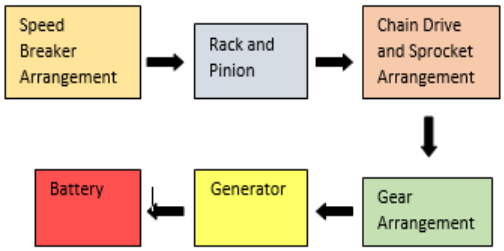

Figure 9.1 Block diagram of system

10. Advantages

1) We can have annual electricity generation with the help of this method without depending on other factors.
2) Power generation takes place reasonably and by using non-conventional energy sources which will help to preserve the conventional energy sources for our adjacent future demand.
3) There is no usage of any fossil fuel hence electricity is generated by renewable means.
4) Pollution less energy generation (A. S. Fawade, 2015).
5) Simple construction, mature technology and easy maintenance.
6) This method requires less measure of floor area and also the traffic is not obstructed.
7) It is economical and not difficult to install.
8) This method is promising due to its good efficiency and energy recovery criteria.

11. Applications

1) Street Lights can be provided with electricity generated by this method.
2) Traffic Signals can be run by using the electricity generated by this method.
3) Sign boards on the roads can be lit with the help of this method.
4) Boards near the bus-stops can be highlighted by using this method generated electricity.
5) This method can also be used on the check posts on highways.

Conclusion

This paper introduces another innovative method of green power generation in order to contribute towards the development of the country by enriching it with utilization of available resources in more useful manner. Due to population explosion, the current power generation has become insufficient to fulfil our requirements. In the upcoming days, as demand of electricity is increasing rapidly, it will prove a great boon to the country and also to the world, since it will save a lot of electricity of powerplants which is wasted in illuminating the street light. This research can be used to develop our country by enhancing more and more utilization of its sources in more appropriate and proficient manner. The development of a country is directly proportional to the way in which it uses power supply sufficiently and efficiently. Now is the need of an hour when these types of inventive ideas should be brought into practice. This idea not only provides an alternative, but also adds to the economy of the country. Development of every country is the development of the world.

Future Scope

According to statistics, in 2009, in India, the average annual domestic electricity consumption per capita in urban areas was 288 kWh and in rural areas was 96 kWh approximately (A. P. Rao, *et al*, 2014). While the worldwide average annual consumption per capita was 2600 kWh and 6200 kWh in European Union (J. Goldemberg, *et al,* 1985). At present India is facing major shortage of capacity to produce electricity.

India is regarded as a developing nation and hence due to growing population, the needs will increase which will indirectly increase the consumption of electrical energy (A. K. N. Reddy, *et al,* 1994). Electricity can be produced from wide range of resources but however, their cost is commercially high and hence the concept proposed in this paper would be useful in future for electricity production as the cost for electricity production is comparatively less.

Suitable at parking of malls as well as multiplexes. Also can be used for toll booths, signals, etc. Such speed breakers can also be designed for heavy duty vehicles, thus increasing input torque and ultimately output of generator. Various government departments can take initiative in implementing these power humps on a large scale. This has a huge scope everywhere, provided the resources are channelled well. Thus the electricity consumed in running the street lights can be saved with the help of these method and this saved electricity can be given to remote villages in India which already do not receive electricity (V. Aswathaman, *et al*, 2011).

References

N. Fatima, J. Mustafa (2012), Production of electricity by the method of road power generation, *Int. J. advances in Electrical and Electronics Engineering,* 1: 9-14.

S.A. Jalihal, K. Ravinder, T.S. Reddy (2005), Traffic characteristics of India, *Proc. Eastern Asia Society for Transportation studies,* 5: 1009-1024.

R. Gupta, S. Sharma, S. Gaykawad (2013), A revolutionary technique of power generation through speed breaker power generators, *Int. J. Engineering. Research and Technology*, 2(8): 1879-1883.

A.K. Sharma, O. Trivedi, U. Amberiya, *et al*. (2012) Development of speed breaker device for generation of compressed air on highways in remote areas. *Int. J. Recent Research and Review,* 1: 11-15.

S. Priyadarshani, (15 June 2007), Generating electricity from speed breakers. *Down to Earth*.

N.V. Bhavsar, V. A. Shah, (2015), Electricity generation by speed breaker using spur gear mechanism, *Int. J. Research in Applied Science and Engineering Technology,* 3(4): 1164-1169.

W. Knight, (21 Aug 2001), Smart speed bumps reward safe drivers, http://www.newscientist.com/article.ns?id=dn1178.

F. N. C. Anyaegbunam, (2015), Electric power generation by speed breaker generators, *IOSR J. Engineering,* 5(9): 17-21.

M. Ramadan, M. Khaled, *et al*. (2015), Using speed bump for power generation, In: *The 7th International Conference on Applied Energy,* Energy procedia, pp.867-872.

A. Kaur, S. K. Singh, Rajneesh, *et al*. (2013), Power generation using speed breaker with auto street light, *Int. J. Engineering Science and Innovative Technology,* 2(2): 488-491.

P. Vishnoi, P. Agrawal, (2014), Power generation by kinetic energy of speed breaker, *MIT Int. J. Electrical and Instrumentation Engineering* ,4(2): 90-93.

C. B. Prakash, A. V. R. Rao, P. Srinuvas, (2014), Road power generation by speed breaker, *Int. J. Engineering Trends and Technology,* 11(2): 75-78.

F. Najuib, N. Gupta, P. Rawat, *et al*. (2014), Energy efficient power generation using speed breaker with auto street lights, *Int. J. Engineering Research and Management Technology,* 1(1): 223-228.

M. Sailaja, M. R. Roy, S. P. Kumar, (2015), Design of rack and pinion mechanism for power generation at speed breakers, *Int. J. Engineering Trends and Technology,* 22(8): 356-362.

S. Srivastava, A. Asthana, (2011), Produce electricity by the use of speed breakers, *J. Engineering Research and Studies,* 2(1): 163-165.

N. Kumar, P. Saini, M. Kumar, (2016), Automatic road light controller through electricity generation from speed breaker, *Int. J. Engineering Technology Science and Research,* 3(4): 17-25.

S. English, (11 Nov 2005), Smart road hump will smooth the way for safe drivers, https://web.archive.org/web/20060113164245/http://www.timesonline.co.uk/article/0,,2-1867157,00.html.

Ankita, M. Bala, (2013), Power generation from speed breaker, *Int. J. Advance Research in Science and Engineering,* 2(2).

A. K. Singh, D. Singh, M. Kumar, *et al*. (2013), Generation of electricity through speed breaker mechanism, *Int. J. Innovations in Engineering and Technology,* 2(1): 20-24.

A. Mishra, P. Kale, A. Kamble, (2013), Electricity generation from speed breakers, *The Int. J. of Engineering and Science,* 2(11): 25-27.

H. Singh, Omprakash. (2016), Energy generation from speed breaker by rack and ratchet mechanism, *Int. J. Advance Research and Innovative Ideas in Education*, 2(3): 4183-4187.

G. R. Prabu, G. Ethiraj, (2015), Electricity generation by speed breaker, *Int. J. Advanced Research in Electrical, Electronics and Instrumentation Engineering,* 4(5): 4799-4808.

K. P. Singh, P. Singh, (2014), Eco-friendly electricity generator from busy road, *Int. J. Emerging Trends in Engineering and Development,* 3(4): 307-313.

Speed limits and reduction. (27 Sept 2006), *Eastleigh Borough Council*, http://www.eastleigh.gov.uk/ebc-3053.

A. S. Fawade, (2015), Air compression and electricity generation by using speed breaker with rack and pinion mechanism, *Int. J. Modern Engineering Research,* 5(1): 23-28.

A. P. Rao, A. K. Kumar, S. Suresh, (2014), Power generation from speed breaker by rack and ratchet mechanism, *Int. J. Current Engineering and Technology,* sp. issue 2: 549-552.

J. Goldemberg, T. B. Johansson, A. K. N. Reddy, *et al*. (1985), Basic needs and much more with one kilowatt per capita, *Ambio,* 14: 190-200.

A. K. N. Reddy, B. S. Reddy, (1994), Substitution of energy carriers for cooking in Bangalore, *J. Energy,* 19(5): 561-571.

V. Aswathaman, M. Priyadharshini, (2011), Every speed breaker is now a source of power, In: *2010 International Conference on Biology, Environment and Chemistry, IPCBEE*, Singapore, pp. 234-23