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HARNESSING ENERGY FROM SPEED BREAKERS: A CASE STUDY

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Abstract*- Speed breakers or road bumps are placed to limit the speed of the moving vehicle in certain portion across the roads. When a moving vehicle rides over the breaker a significant amount of mechanical energy of the vehicle is lost due to the vertical motion. In this work, an attempt is made to investigate the energy recovery possibilities from the speed breakers or bumps for a typical road condition in Bangladesh. A model of speed breaker is fabricated which is capable of serving as the conventional speed breaker as well as working as an energy conversion system to convert mechanical energy to electrical energy by rack and pinion mechanism and chain sprocket arrangement. The idea is that each vehicle pushes down a ramp on the speed bump to drive a generator underground. When the generator spins; it generates power that can be stored in a battery for possible utilization. Investigations on generated voltage and power vs. load and calculation of extracted energy from single system on Chittagong-Kaptai road are carried out in this paper.*

Keywords: Speed breaker, Electromechanical, Rack and pinion, Renewable energy, Generator

1. INTRODUCTION

Energy is the vital ingredient in any industrial developments. Bangladesh has one of the lowest per capita energy consumption in the region and about 51% of its 155 million populations have no access to power. The government of Bangladesh has undertaken a master plan under the Vision-2021 to reach electricity facilities to every village of the country. Approximately 48,754 villages out of 87,372 villages have been brought under electricity facilities till April 2011[1]. Even then, the national power generation capacity is only 4500-4750 MW against a peak demand of 6000 MW. Due to huge demand of energy, the present world is in the brink of severe energy crisis. In order to mitigate this crisis, alternative sustainable energy sources are being explored and the devices and machines that utilize energy of different forms are being made energy efficient. Resource recovery mechanisms are being investigated to extract useful energy from the valuable waste.

Speed breakers and road bumps are temporary obstacles deliberately placed across the roads to control the reckless drive that consumes a significant amount of energy [2-4]. In fact, on roads, vehicles expend a significant amount of energy in undesirable vertical motions that are induced principle by road bumps, and much of that is dissipated in conventional shock absorbers by damping vertical motions. In busy roads with heavy traffic, massive amount of mechanical energy is wasted. If this energy can be harnessed and used in useful ways that would certainly add values in mitigating energy crisis. The energy can be converted to electricity by designing a suitable electromechanical system [5]. So this system can play a very important role to contribute some energy to fulfill the national demand. In 2009, undergraduate students at the Massachusetts Institute of Technology (MIT) have found a way to generate electricity by harnessing energy from small bumps in the road by using a regenerative shock absorber [6]. Again Undergraduate students from Indore Institute of Science and Technology had developed all most all the models and gave the review of different technologies used in generation of energy with the help of speed breakers. But their system has complexity which is quiet lessen in the proposed project [7]. This kind of system is also developed by some students of RUET [8]. In this project chain sprocket system is used to extract power from speed breaker and lessens the complexity of the gear box system. Graphical representation of output generated voltage and power vs. load and calculation of how much energy can extract from single system on Chittagong to Kaptai road are carried out in this paper.

2. PROPOSEDELECTROMECHANICAL SYSTEM

The block diagram of the proposed energy recovery system is shown in Fig. 1. It is a simplified version of the system used in this experiment. The main philosophy of recovering the lost energy of the moving vehicle when it passes over the speed bump is to redesign the bumps so that they can convert the energy into some other tractable forms such as electrical [9]. When a vehicle crosses over a conventional speed bump, potential energy is generated.

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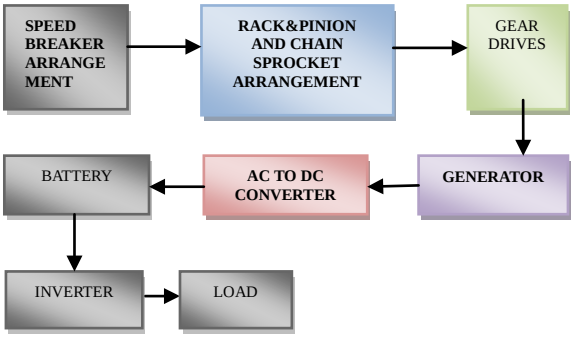

Fig.1: Block diagram of the proposed system.

When conventional speed bumps are replaced by the proposed system, potential energy is not wasted rather converted into kinetic energy using a specially designed mechanism in the form of rotation. The output of a rotating shaft is coupled to a dynamo to convert kinetic energy into electricity. As the nature of the traffic flow is intermittent, the output of the dynamo will not be constant. So, the direct utilization of the dynamo output will not be convenient. The electrical energy produced by the generator can be stored to a bank of battery. A properly designed inverter can convert the DC battery voltage into AC for use in the conventional electrical loads.

3. WORKING PRINCIPLE

In this project a modular speed breaker is designed for generating electricity when a vehicle over it. The principle is the load of the vehicle acted upon the speed breaker is transmitted to a rack and pinion arrangement that is coupled with a dynamo. The moving vehicles generate a reciprocating motion in the breaker. The reciprocating motion of the speed-breaker is converted into rotary motion using the rack and pinion arrangement [5, 7]. The axis of the pinion is coupled with the sprocket arrangement. The sprocket arrangement is made of two sprockets. One is larger size and the other is smaller size. Both the sprockets are connected by means of a chain which serves in transmitting 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. The axis of the smaller sprocket is coupled to a gear arrangement. Here we have two gears with different diameters. The gear wheel with the larger dimension is coupled to the axis of the smaller sprocket. Hence the speed that has been multiplied at the smaller sprocket wheel is passed on to this gear wheel of larger dimension. The smaller gear is coupled to the larger gear. So as the larger gear rotates at the multiplied speed of the smaller sprocket, the smaller gear following the larger gear still multiplies the speed to more intensity. Hence, although the speed due to the rotary motion achieved at the larger sprocket wheel is less, as the power is transmitted to gears, finally the speed is multiplied to a higher speed [7]. This speed which is sufficient to rotate the rotor of a generator is fed into to the rotor of a generator. The rotor

Fig.2: Photographs of the electromechanical breaker.

which rotates within a static magnetic stator cuts the magnetic flux surrounding it, thus producing the electricity. This generated electricity is then sent to an inverter, where the generated electricity is regulated. This regulated electricity is now sent to the storage battery where it is stored during the day time. This current is then utilized in the night time for lighting purposes on the either sides of the road to a considerable distance.

4. EXPERIMENTAL SET UP

The fabricated speed bump with energy conversion mechanism is shown in Fig. 2. Different parts of the system were designed by considering the availability of some of the components that were not available in the local market. The system is of modular type. Many of the identical systems can be coupled together to make a scalable speed breaker. The semicircular bump will protrude on the road surface and the electromechanical system will be housed underneath the road surface. The housing must be robust enough to withstand the running load of the vehicles.

The main structure is constructed by the angle bar of specification of 1in ×1in×1/2in. The dimension of the structure is 12in×18in×18in. that means width is 12 inch,

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length is 18in and height is 18in. Another two bars of length 18 in is welded at the middle of the height for supporting the gear mechanism. The upper and bottom surface is covered by the wood. There is a rectangular shape hole in the upper surface of the structure. Through this hole the speed breaker moves vertically upward and downward. Then the speed breaker is made, it is also made of wood. It is 7in in length, 3in in width and 6 in inch in height. The upper surface of the speed breaker is oval shaped. The components and their specification used in this system are given in the Table 1.

5. EXPERIMENTAL RESULT

When the bump is pressed, the linear motion of the bump is converted to rotary motion that drives a generator. Typical waveforms of the generator output acquired by a digital oscilloscope are shown in Fig. 3 and Fig.4.

Table 1: Components and specification

components	Specification
Rack	Length= 12inch No of teeth= 42
Pinion(2)	Outer diameter= 3.2cm No of teeth= 14 Module= 2
Gear	Outer diameter= 10.1 cm Number of teeth= 59 Module=2
Sprocket	Outer diameter= 15cm Number of teeth= 46
Freewheel	Outer diameter= 5.5cm No of teeth= 18
Roller chain	Roller diameter= 6mm Pitch of chain= 10mm
Bearing	Inner diameter= 15mm Outer diameter= 35mm Width= 8mm
Spring	Total length= 13.7cm Pitch= 11.3mm No of turns= 11 Coil diameter= 2mm

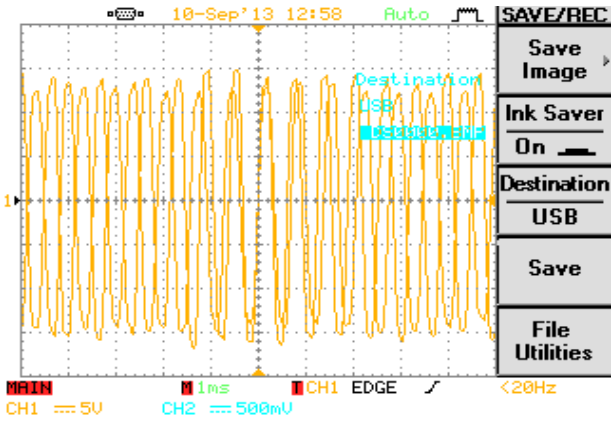

Fig.3: Typical waveforms of the generator output for 80 kg load

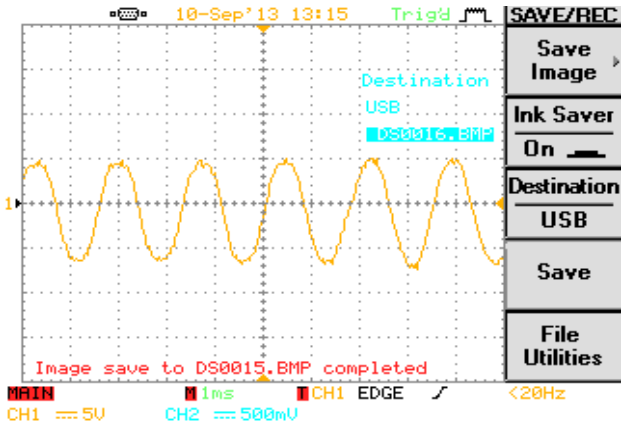

Fig. 4: Typical waveforms of the generator output for 20 kg load.

As the speed of the generator cannot be kept constant and is intermittent and oscillatory, its output is fed to a controller that charges a 12 V battery. A suitably designed inverter can convert the DC voltage to an AC to drive the electrical loads. It can be seen from the oscillograms that the output of the generator depends on the loading condition of the bump.

The average value of the output voltage is recorded for various loads on the bump and the results are plotted in Fig.5. It can be visualized in the figure that the generator output is nearly proportional to the applied load on the bump as expected. The trend line and its equation(X is load and Y is output voltage) are also shown in the figure in the next page.

The average output power for this system is shown in Fig. 6. The figure shows that the output power is nearly proportional to the applied load.

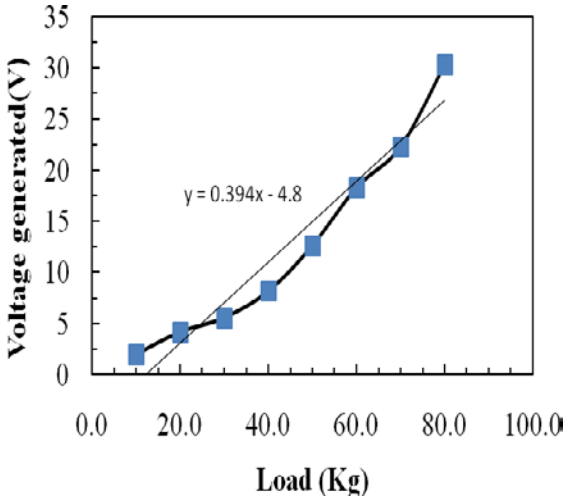

Fig.5: Load versus average generator output voltage.

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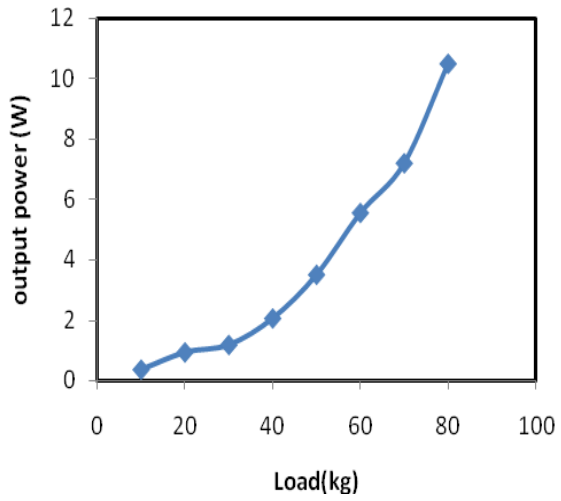

Fig.6: Output power versus load for a single unit breaker

6. CALCULATION OF OUTPUT POWER FOR UNIT SYSTEM ON CHITTAGONG-KAPTAI ROAD

There are many types of vehicle which pass across the CUET gate on Chittagong-Kaptai road. To simplify the calculation different types of vehicle are grouped in a single category by using Per Unit Car (PCU) method. In this method, factors are multiplied to the different vehicle to make them equivalent to car. PCU values need to be considered for different classes of vehicle are shown in Table 2. PCU values of Chittagong-Kaptai road for a typical day traffic condition are shown in Table 3.

Table 2: PCU values for different vehicle classes [10].

Vehicle class	PCU values
Bus/truck	2.8
Car/Microbus/Scooter	1.0
CNG/Tempo	.5
Lorry	3.75
Rickshaw	1.5
Bi-cycle	0.7
Hand drawn cart	4.0

Table 3: Calculation of PCU values of Chittagong-Kaptai road [10].

Hour	Bus/ truck	Lorry	Car/micro/ Scooter	CNG/ Tempo	Rickshaw	Bi-cycle	Hand Drawn cart	PCU per hour
6-7 am	27	0	53	243	18	23	0	335
7-8 am	31	3	88	352	19	21	2	482
8-9 am	32	2	170	356	16	25	0	558
9-10 am	36	3	237	493	25	16	1	749
10-11 am	39	0	284	502	17	19	0	791
11-12 am	31	2	127	532	9	13	0	633
12-01 pm	42	0	148	597	37	14	0	748
01-02 pm	27	0	164	335	32	17	0	522
02-03 pm	24	0	115	289	47	28	0	448
03-04 pm	47	1	143	491	23	31	2	687
04-05 pm	38	0	212	577	55	39	0	789
05-06 pm	28	0	251	500	66	33	0	753
06-07 pm	26	0	175	450	56	45	0	634
07-08 pm	25	2	129	301	29	8	0	458
08-09 pm	9	0	225	225	10	5	0	271
09-10 pm	5	0	41	41	5	2	0	109
10-06 am	85	12	92	50	0	0	0	400
Total number of equivalent car								9317

Whenever a vehicle passes over this system it presses two times, one by the front wheels and another by the rear wheels. For a 200 kg car, for each pair of wheels, 100×10.5/80=13.125 W could be generated. Using the PCU value of table 2, the estimated value of output electrical power can be calculated as;

$$9317\times2\times13.125\times10^{-3}\approx2.4 \text{ kW}.$$

7. DISCUSSION AND CONCLUSION

A preliminary model of the electricity generating speed breaker is presented in the paper. However, the results show that, if the system can be implemented in real environments a significant amount energy can be extracted that will certainly contribute to the efficient use of energy. The model is developed from the locally available materials and components. The concept is modular. If designed properly for a real road condition, several modules can be concatenated to make it scalable to cover the road width. In this project rack and pinion mechanism and chain sprocket mechanism is used to extract the electricity from speed bumps. The correlation for output voltage and power with load is presented. An analysis is also carried out in this paper to evaluate the amount of energy generated from the single proposed system on the Chittagong-Kaptai road. This set up can generate more energy if more efficient generator could be used.

1. REFERENCES

[1] Rural Electrification Board (REB, Bangladesh) www.bangladeshgov.org (12.04.2013)

[2] http://en.wikipedia.org/wiki/Speed_bump. (06.03.2013)

[3] http://www.alternative-energy-news.info/produce-electricity-while-you-drive. (08.03.2013)

[4] http://www.eco20-20.com/Generating-Electricity-from-Bumps-in-the-Road.html. (08.03.2013)

[5] Ankita and Meenu Bala, "Power Generation from Speed Breaker", *International Journal Of Advance Research in Science and Engineering*, Vol.2, February, 2013 ISSN-2319-8354(E).

[6] http://web.mit.edu/newsoffice/2009/shock-absorbers-0209.html. (16.05.2013)

[7] Rajat Gupta, Suyash Sharma, Saurabh Gaykawad, "A Revolutionary Technique of Power Generation Through Speed Breaker Power Generators", *International Journal of Engineering Research & Technology*, Vol. 2, Issue 8, ISSN: 2278-0181, August 2013.

[8] Joardder M. U. H., Kabir M.M, Barua R. and.Hoque M. E, "Loss to asset: Production of power from speed breaker", *International Conference on Mechanical Engineering and Renewable energy(ICMERE)* 2011.

[9] Syed Khalid Rahman, Md.Saiful Islam, ,Jakeya sultana Jyoti, "Generation of Electricity Using Road Transport Pressure", *International Journal of Engineering Science and Innovative Technology*, Volume 2, Issue 3, May 2013.

[10] Bangladesh Roads and Transport Authority www.brta.gov.bd (24.08.2013)

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