Available online at www.sciencedirect.com
ScienceDirect
Energy Procedia 75 (2015) 867 – 872
Energy Procedia

The 7th International Conference on Applied Energy – ICAE2015

Using speed bump for power generation –Experimental study

Mohamad Ramadan[a,]*, Mahmoud Khaled[a,b], Hicham El Hage[a]

[a]Energy and Thermo-Fluid group, School of Engineering, Lebanese International University LIU, PO Box 146404 Beirut, Lebanon
[b]University Paris Diderot, Sorbonne Paris Cité, Interdisciplinary Energy Research Institute (PIERI), Paris, France

Abstract

Designing energy recovery systems that are pollution free has become a significant goal within the research community. One of numerous systems that have been proposed is Speed Bump Power Generator SBPG system that produces electrical power by utilizing the movements of commuting vehicles on highways, boulevards, and streets. When vehicles pass over a SBPG system, the system translates vertically. Consequently, a kinetic energy is produced and transferred into electrical power. In this paper, different types of SBPG systems are presented. An experimental analysis is performed on the rack-and-pinion system. Results have shown that electrical power up to 45 W generated when a mass of 80 kg is applied to SBPG system considered. Extrapolation of results confirms around 0.56 kW powers can be produced when various vehicles with different masses pass through the bumps.

Peer-review under responsibility of Applied Energy Innovation Institute

Keywords: Speed bump, Energy, Prototype, Recovery, Rack-Pinion mechanism.

1. Introduction

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 [1-7]. Nonetheless, 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. Energy can be recovered from several existing systems such as combustion systems where the exhaust gas energy can be recovered and utilized in several applications. Furthermore, the heat rejected from HVAC condensers can also be utilized as heat sources. Without a doubt many applications may be regarded as energy source.

* Corresponding author. Tel.: +00961-1-706881; fax: +00961-1-306044.
E-mail address: Mohamad.ramadan@liu.edu.lb.

Peer-review under responsibility of Applied Energy Innovation Institute
doi:10.1016/j.egypro.2015.07.192

Among these applications are the speed bumps [8-11]. 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 such as *Lebanon*. *Lebanon* suffers from limited natural resources that are used in generating electrical power. 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. In this context, the present work concerns a prototype of speed bumps as well as an experimental study of the system performance.

The rest of this paper is organized as follows. Section 2 is devoted to the different types of speed bump mechanisms. In section 3, the constructed prototype, the experimental results and the corresponding analysis are presented. Finally, section 4 draws the main conclusions of the work.

2. Speed bump power generator

The principle of speed-bump power generators is fundamentally based on converting the kinetic and potential energies to electric energy. Kinetic and potential energies are produced from the vertical displacement when vehicles pass over the speed-bumps.

Speed bumps are built from mechanical and electrical components. The mechanical components include a roller whose center is attached to a shaft that carries a meshed gear. The aforementioned meshed gear is engaged with another meshed gear whose center is fixed to a rotor shaft. In addition, the rotor shaft is linked to a dynamo that generates power when the rotor shaft rotates upon passing vehicles over the roller. The basis of the speed bump system is the mechanical mechanism since it dictates the changeable amount of energy. The most common and efficient mechanisms used in speed bumps are the roller, the crack-shaft, the magnetic and the rack-and-pinion.

2.1- Roller mechanism

In roller mechanism, a roller rotates when vehicles pass over it [8]. This mechanism allows the dynamo which is connected to a rotor shaft to rotate and generate power.

2.2- Crank-shaft mechanism

This mechanism changes the vertical translational motion of the speed breaker to a rotational motion through speed-breaker and crank-shaft connection. Therefore, the dynamo which is connected to a spur gear through a shaft is receiving the rotation, consequently, power is generated.

2.3- Magnetic mechanism

A magnetic mechanism is mainly built from translators and stators [10]. When the vehicle passes over the bump, the translators move downward and generate power in the stators.

2.4- Rack-and-pinion mechanism

Figure 1 depicts a rack-and-pinion system that is constructed such that the rack is connected to the speed breaker [11]. The speed breaker receives a vertical displacement upon vehicles fleeting over it. Clearly the pinion will rotate and the kinetic energy generated due to vertical displacement of the rack motion is transferred to a dynamo that is connected to the pinion shaft.

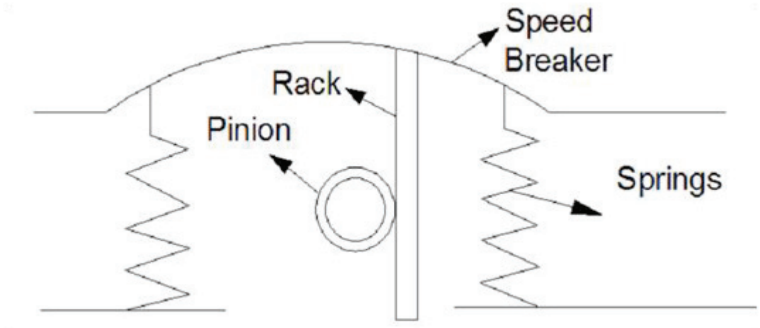


Fig. 1. Rack and pinion mechanism

3. Experimental study and results

A prototype is constructed to reproduce the vehicles' speed-breaker scenario. 41 kg, 65 kg and 80 kg masses are applied on the speed-breaker systems and the experimental quantity produced of voltages, currents and rotational speeds are measured.

3.1- Prototype

Figure 2 shows a schematic of the prototype.

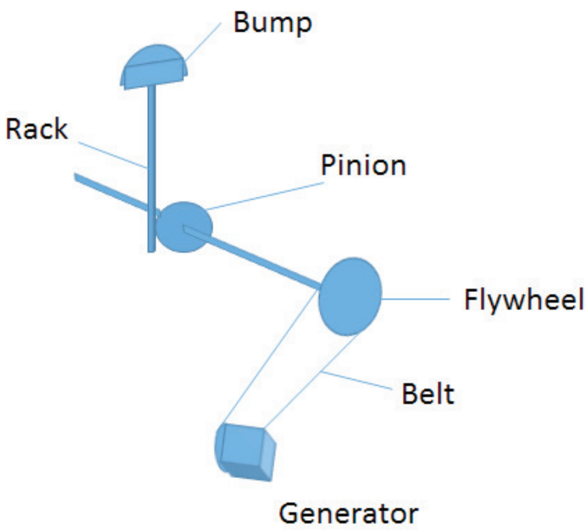


Fig. 2. Details of the speed-bump power generator prototype

The frame's length, width and height are 110 cm, 40 cm and 40 cm respectively. Furthermore, a shaft with 110-cm length and 3-cm diameter is mounted within the frame, namely the bearings of the shaft are supported by front and rear two steel square rods that are welded to the vertical square rods. The shaft has three pinions along with a flywheel. Obviously, each pinion is in contact with a rack so that the rack-and-pinion mechanism is guaranteed, furthermore, each of the three rack-and-pinions along with two pistons, shock absorbers, and a spring form a speed-breaker system, therefore, the prototype has three speed-breakers systems.

3.2- Experimental results

Three different masses, 41 kg, 65 kg and 80 kg, are applied on the speed-breaker systems and the produced amounts of voltage, current and angular speed are measured. It was observed (Figure 3-a) that as the mass increases the produced voltage increases linearly. For illustration a mass of 41 kg, produces 5.0 V. This voltage reaches 15.6 V for a mass of 65 kg and 21.5 V for a mass of 80 kg.

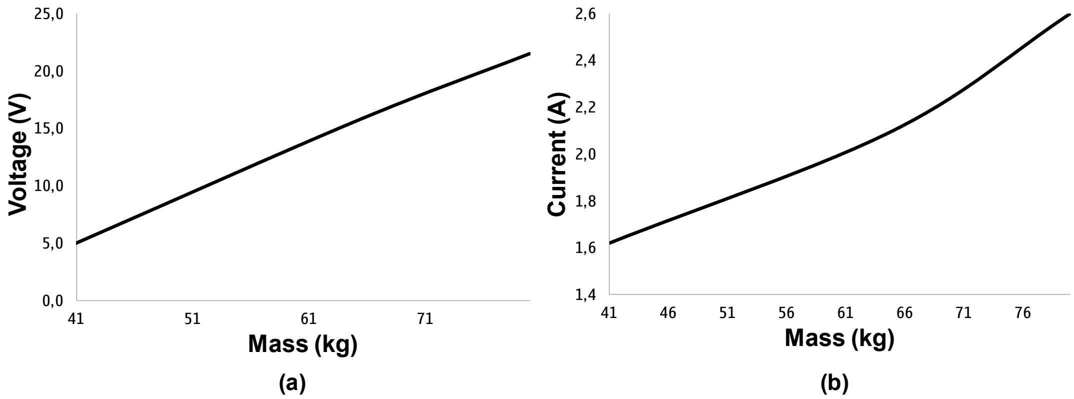


Fig. 3. (a) Variation of the voltage in function of mass; (b) variation of the current in function of mass

Furthermore, and as expected, the trend of measured current trembles the measured voltage. Figure 3-b portrays that the current increases from 1.6 A to 2.6 A as the mass increases from 41 to 80 kg. The produced measured currents and voltages is employed to calculate the output powers (Figure 4).

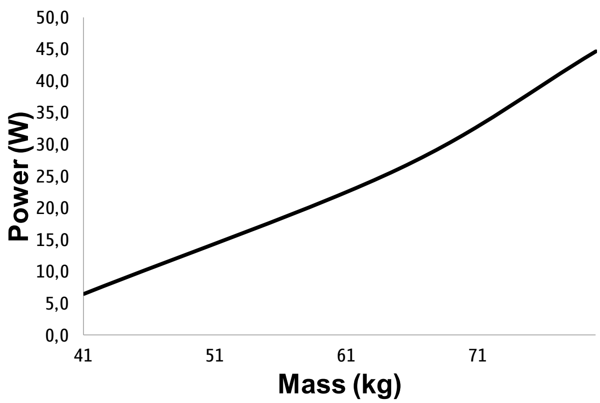


Fig. 4. Variation of the power in function of mass

41 kg, 65 kg, and 80 kg masses generate 6.5 W, 26.2 W and 44.7 W respectively. Therefore, Figure 4 demonstrates clearly that the output power also varies linearly with the mass. Nonetheless, the aforementioned calculated powers produce 0.16 W/kg, 0.40 W/kg and 0.56 W/kg respectively, therefore, it can be said that the power generation per unit mass increases as the mass, applied to the speed-breaker system, increases. Consequently, the average power generation per unit mass of 0.37 W/kg shows a potential regarding the performance of speed-breaker systems, hence constructing such systems on existent vehicles fleeting roads is worth to investigate.

The former recommendation to implement the speed-breaker systems on roads is based on the fact that the average mass of a vehicle is about 1500 kg. Therefore, the expected power corresponding to this mass is estimated to be about 0.56 kW per car. Consequently, it is strongly believed that the generated power will be sufficient to supply the needed electrical demand to lighten roads during night-time, and supply power to electrical devices installed on roads such as cameras, sensors and radars.

4. Conclusions

Speed-breaker power generator is a system that is capable of using the kinetic energy of vehicles and converting them into electrical energy. In this work, a prototype is constructed and an experimental study is performed.

Nonetheless, it was 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.

References

[1] Shi L.S, Yit Lin Chew M. A review on sustainable design of renewable energy systems. *Renew Sust Energ Rev* 2012; 16:192-207.

[2] Panwar N.L, Kaushik S.C, Kothari S. Role of renewable energy sources in environmental protection: A review. *Renew Sust Energ Rev* 2011; 15:1753-1766.

[3] Solangi K.H, Islam M.R, Saidur R, Rahim N.A, Fayaz H. A review on global solar energy policy. *Renew Sust Energ Rev* 2011; 15:2149-2163.

[4] Joselin Herbert G.M, Iniyan S, Sreevalsan E, Rajapandian S. A review of wind energy technologies. Renewable and Sustainable Energy Reviews 2007; 11:1117-1145.

[5] Mardiana-Idayu A, Riffat S.B. Review on heat recovery technologies for building applications. *Renew Sust Energ Rev* 2012; 16:1241-1255.

[6] Ramadan M, Khaled M, Hachem F, Al Shaer A, Chahine K, Assi A. Design and Analysis of an HVAC-Based Heat Recovery System. *International Conference on Microelectronics ICM 2013 Special Issue on Renewable Energy*, Beirut, Lebanon, 2013.

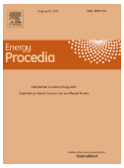
[7] Khaled M, Ramadan M, Gad El Rab M, Chahine K, Assi A. Recovering Chimney Waste Heat for Water Heating: Prototype Implementation and Experimental Analysis. *International Conference on Microelectronics ICM 2013 Special Issue on Renewable Energy*, Beirut, Lebanon, 2013.

[8] Gupta A, Chaudhary K, Agrawal B.N. An experimental study of generation of electricity using speed breake. *Int. J. Mech. Eng*. 2012; 1:35-40.

[9] Fatima N, Mustafa J. Production of electricity by the method of road power generation. *Int. J. Adv. Electrical Electronics* 2012; 1:9-14.

[10] Partodezfoli M, Rezaey A, Baniasad Z, Rezaey H. A Novel Speed-Breaker for Electrical Energy Generation Suitable for Elimination of Remote Parts of Power Systems where is Near to Roads. *J. Bas. Appl. Scient. Resear.* 2012; 2:6285-6292.

[11] Joardder M.U.H, Kabir M, Barua R, Hoque M. Loss to assets: production of power from speed breaker. *Int. Conf. Mech. Eng. Renew. Energ.* 22- 24 December 2011, Chittagong, Bangladesh



Biography

PhD in computational mechanics from Ecole des Mines de Paris and diploma in Mechanical Engineering. Post-doc for two years at the Ecole Centrale de Nantes-France. Assistant Professor at the Mechanical Engineering Department of the Lebanese International University since 2013.