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Design and Manufacture of A dual System for Generating Electrical Energy from Speed Bumps

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Abstract: Excessive energy consumption leads to a shortage of energy supplies in the coming years. To solve this problem, we must adopt practices that maximize energy use from traditional sources. In this research, we demonstrate how to harness the energy emitted when a car bounces over a speed bump. One of the many proposed systems is the Speed Bump Power Generator (SBPG), which generates electrical energy by harnessing the movement of vehicles on highways and streets. When vehicles pass over the SBPG system, the system moves vertically through the comb and gear. Thus, mechanical kinetic energy is produced and converted into electrical energy, which will be stored in a battery used to power streetlights and traffic signal boards at night. In this project, a generator for electrical power is designed and manufactured using used tools and spare parts from cars that are guaranteed for manufacturing and operation and have excellent operational durability. The results show that it is possible to generate electrical power of up to 1.9 kilowatts from the designed system. The results showed that an electrical power of 45 watts is generated when an 80 kg mass is applied to the SBPG system. The analysis of the results confirms that approximately 0.56 kilowatts of energy can be produced when different vehicles with varying masses pass over speed bumps.

Keywords: speed bumps, energy, energy recovery, SBPG, kinetic energy

1. Introduction

Currently, renewable energy and energy recovery are considered among the most efficient strategies for reducing the financial and environmental drawbacks of excessive fossil fuel use, However, most investigations focused on solar energy, wind energy, and wave energy, On the other hand, many of the systems currently in use lack sufficient optimization. This strongly suggests that significant energy waste persists, despite the potential for recovery. Many existing systems, like combustion systems, can recover energy and use it in various applications. There is no doubt that many applications can be considered a source of energy. Among these applications are speed bumps. Vehicles passing over speed bumps generate motion, converting the generated kinetic and potential energies into electrical energy. Speed bump systems move vertically, and the mass of the moving vehicle undergoes a vertical transition that results in potential and kinetic energy. (Tayyeh et al.,2025)

Speed bumps have been used worldwide and can be considered one of the road safety features to alert road users to speed limits where vehicle speeds are legally mandated at a predetermined low speed, typically 40 km/h (25 mph) (5 to 10 mph) in residential areas, school crossings, or parking lots. These devices can be designed to perform two functions; in addition to road safety, they can also generate a certain amount of electrical current based on the concept of a generator and can be used to illuminate their warning signals where the device is placed. Most importantly, it is an environmentally friendly device (12). The generator transforms mechanical energy from an external source into electrical energy for output (13). The current study focuses on designing and manufacturing a practical application model for a dual system that generates energy from speed bumps, with the goal of implementing it at the vehicle exit gate of Wasit University.

The core issue highlighted in this article is the inefficient use and lack of optimization in existing energy recovery systems, resulting in substantial energy wastage despite their promising potential. While renewable energy sources such as solar, wind, and wave energy have been thoroughly explored, innovative solutions like energy-generating speed bumps have not been fully utilized or adequately optimized. These speed bumps present a valuable opportunity to harness kinetic and potential energy from vehicles, yet their capability to generate electricity and support sustainability remains largely untapped and under-implemented on a broader scale. (Ramesh et al., 2022).

2. Materials and Methods

- **The Basic Principle**

When in motion, vehicles possess some kinetic energy. A special arrangement known as the electromechanical unit can harness this kinetic energy to generate power. We generate and store energy using both mechanical and electrical techniques. The electromechanical unit, resembling a dome, functions as a speed breaker. When the vehicle crosses the dome, it presses down, compresses the dome's springs, and causes the holder at the bottom of the dome to move downward in a reciprocating motion. The gears, a type of freewheel gear that rotates in only one direction, convert the reciprocating motion of the rack, or the toothed shaft, into rotary motion. This gear rotates the main shaft, which in turn is connected to the flywheel, whose function is to maintain the rotation of the shaft that ultimately connects to the electric generator. (DC). Only when the dome presses down does a freewheel gear cause the main shaft to rotate in a single direction. When the dome returns to its normal position, this gear prevents the shaft from rotating in the opposite direction. Until the next pressure from the dome provides additional torque, the flywheel operates to maintain the continuous rotation of the shaft at a steady and specific rate. In this manner, the generator at the end of the main shaft generates direct current (DC), transforming mechanical energy into electrical energy. The conversion will be proportional to the traffic density. Placing a device on the right side of the dome (the speed bump) and another on the left side can increase the production of electric power, while ensuring that the movement mechanism and electric power generation on the right side remain isolated from the left side. Various batteries can store electric energy, and speed bumps generate electric power through a variety of mechanisms:

- Spring coil mechanism.
- Rack-pinion mechanism.
- Crank-shaft mechanism.
- Roller mechanism.
- The Practical Part

Researchers have designed and manufactured a device, the movable bump, using recycled materials to generate electrical energy from mechanical motion. The mat's design comprises an upper part that compresses when vehicles pass over it, and a lower part that houses the mechanical system. (Kadhim et al., 2024)

The weight of the car presses down on the top part of the bump as it passes over it. This pressure generates a downward movement in the upper part of the bump.

- After removing the vehicle's weight, the springs support the suspension and assist in returning the upper part to its original position. In addition to several benefits, they absorb shocks and improve the distribution of the vehicle's weight on the suspension, providing balanced movement and maintaining the stability of the system's performance.
- The ramp's upper section, attached to a toothed shaft, transmits its downward motion to a side internal shaft, which rotates accordingly.
- The motion cutter, in conjunction with the cross shaft, ball bearings, and pulley, transforms the vertical motion of the toothed shaft into continuous horizontal rotational motion that transfers to the device's main shaft.
- Using the flywheel on the main shaft, we ensure the continuity and smoothness of the movement.
- The electric generator receives motion transfer from the horizontal main shaft and converts it into electrical energy (DC).
- Two generators with a capacity of 180V DC, as shown in figure number. (11).

- To organize the charging and stabilize the energy, a charge controller (inverter) was used to manage the battery charging with direct current and within the permissible charging range for the battery.
- Even when there is no movement on the mat, the battery stores the energy the generator generates and provides stable and reliable power. You can use it to power electrical loads or store energy for later use.

The article's objective is to present the design, manufacturing process, and functionality of an innovative energy-generating device. This device, constructed using recycled materials, aims to harness mechanical energy from vehicles passing over it and convert it into electrical energy. The system is engineered to provide sustainable energy generation while maintaining road safety and stability. (Kadhim et al., 20223)

System Workflow

The vehicle presses down as it passes over the bump, compressing the springs attached to the bump cover, causing the cover to move up and down. The bump cover's vertical toothed shaft reciprocates up and down. The vertical toothed shaft's teeth engage with gears, converting the vertical shaft's reciprocating motion into a single-directional rotation of the gears connected to the horizontal shaft. We fixed the coupling to the horizontal shaft to ensure the continuous rotation of the horizontal shaft. A securely fixed pulley directly connects the horizontal shaft to the generator shaft, converting mechanical energy into stored electrical energy in batteries. This is according to the system diagram shown in the figure (1).

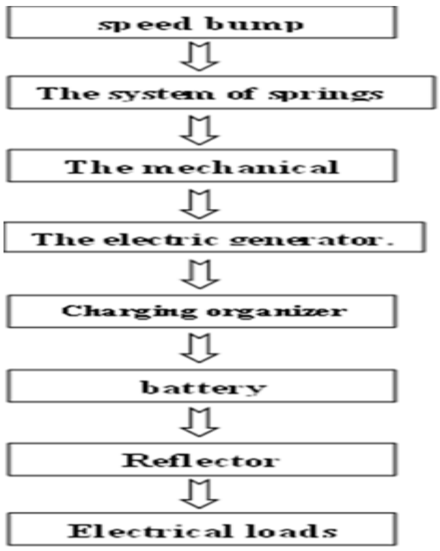

Figure 1. Workflow diagram of the generation system.

Parts of the Device

The system consists of several essential parts that work together to convert the kinetic energy generated by the movement of vehicles into electrical energy, here are the specifics of the device's primary components:

The bump refers to the elevated portion of the road that vehicles pass over, as depicted in figure (2).

Figure 2. The upper part of the bump

A steel frame designed to support the stability and rigidity of the platform while vehicles pass over it, rectangular in shape, containing the mechanical parts of the system, buried underground with a thickness of 4 mm, a length of 2 meters, a width of 40 cm, and a height of 80 cm, as shown in figure (3).

Figure 3. The external structure of the bump

Spiral springs are responsible for returning the bump to its normal position after the vehicle passes, as shown in figure (4).

Figure 4. Spiral springs

A vertical toothed shaft that moves due to the vehicle's movement over the bump, going up and down with the bump, measuring 65 cm in length and 5 cm in diameter, as shown in figure (5).

Figure 5. A vertical toothed shaft

Shaft a moving cross that is 20 cm long and has a diameter of 6 cm, as shown in figure 6.

Figure 6. A Shaft a moving cross

Ball bearing with a thickness of 6 mm and a diameter of 30 mm as shown in figure (7).

Figure 7. Ball bearing

A belt connected to the freewheel gear as shown in figure (8).

Figure 8. A belt

Fear of the type of free-moving wheel that rotates in only one direction, as shown in figure number (9).

Figure 9. The freewheel moves in one direction

A main shaft made of solid steel, with a diameter of 30 mm and a length of 30 cm, as shown in the figure. (10).

Figure 10. A **main shaft**

A flywheel weighing 15 kg is used for the continuity of motion, as shown in the figure. (11).

Figure 11. A flywheel

Generate (180V – DC), as shown in the figure. (12)

Figure 12. Generator

A charging controller (Inverter) that manages the charging of the battery with direct current and within the permissible charging range for the battery, as shown in the figure. (13).

Figure 13. Inverter

A lithium battery or any other type of rechargeable battery uses the electrical energy generated during the movement of the vehicle and can be used to power electrical loads or to store energy for later use, as shown in the figure. (14).

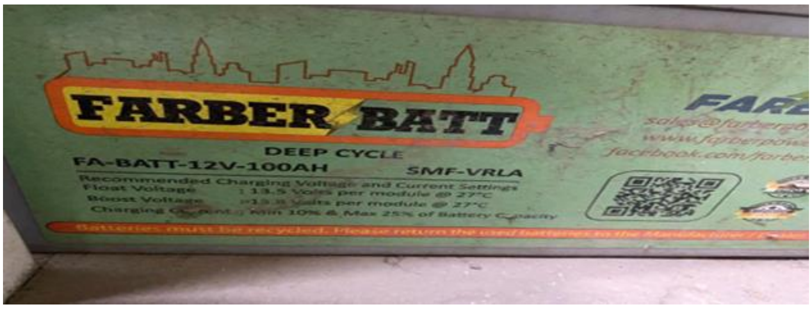

Figure 14. A lithium battery

The previously mentioned equipment and devices (number 2) will be duplicated to have two systems for generating electricity from the kitchen, with the first-generation system installed on the right side inside the iron structure and the second system installed on the left side inside the iron structure, as shown in the figure. (15).

Figure 15. The speed bumps with its two generation systems.

- **Plans**

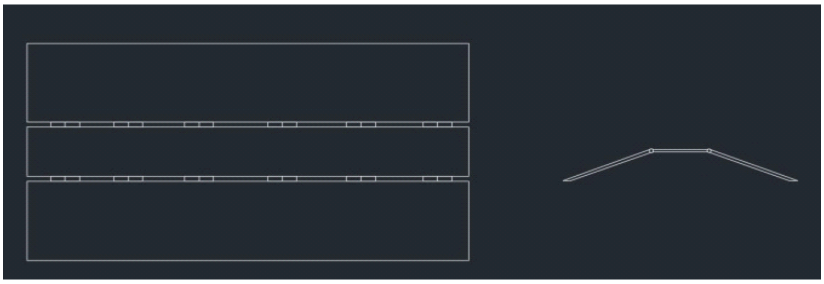

Figure 16. **The upper part of the bump**

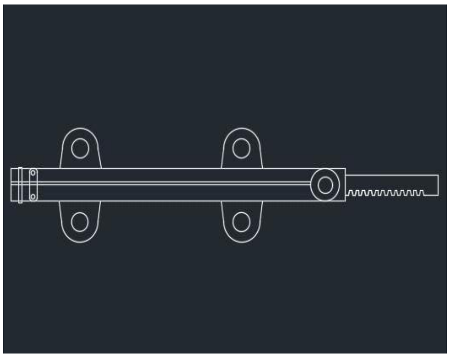

Figure 17. A vertical toothed shaft

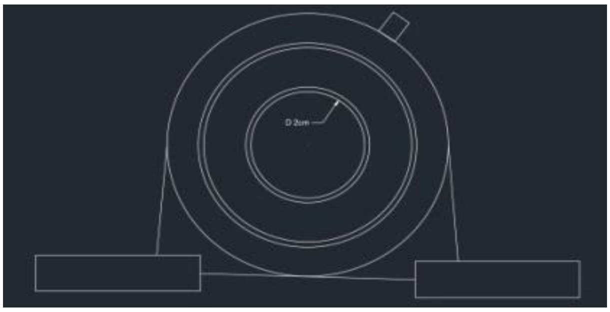

Figure 18. Ball bearing

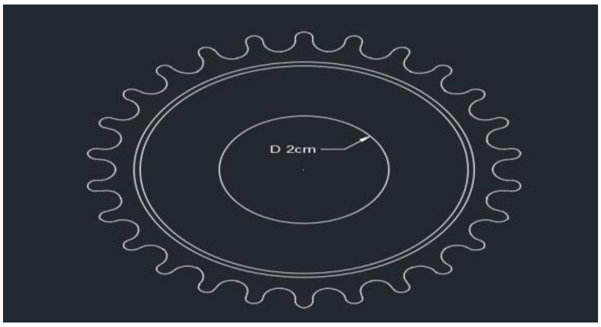

Figure 19. The freewheel moves in one direction

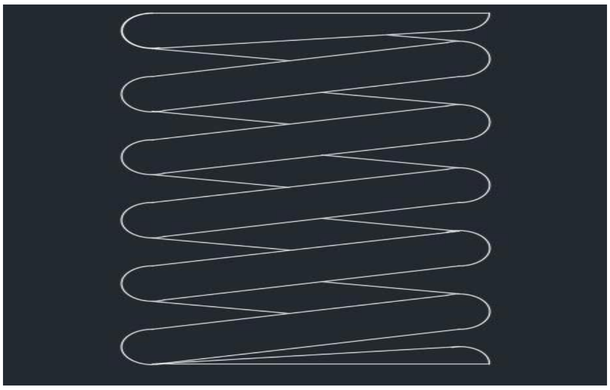

Figure 20. Spiral springs

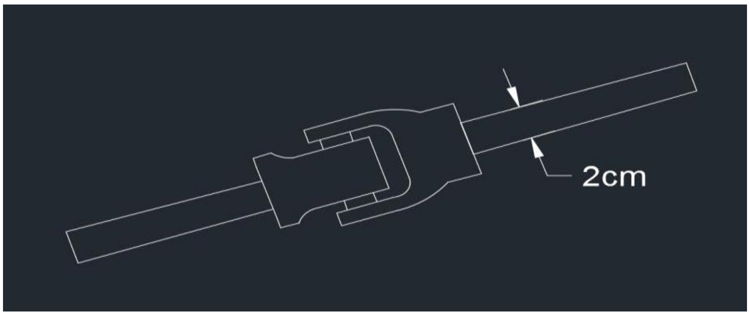

Figure 21. A Shaft a moving cross

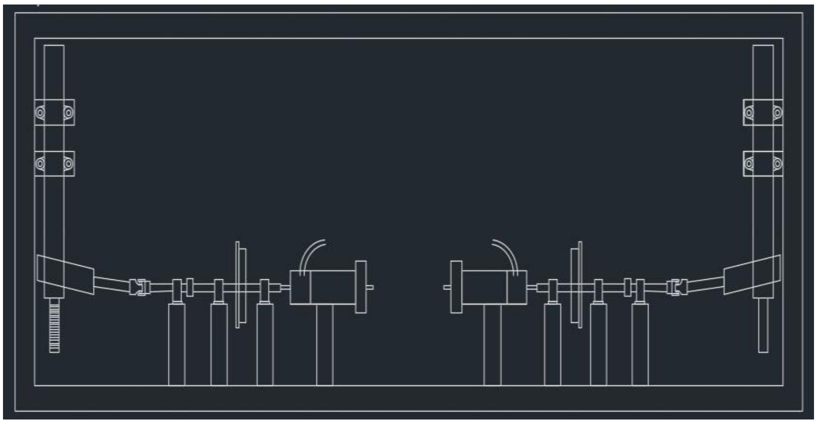

Figure 22. The speed bumps with its two generation systems.

3. Results and Discussion

The manufactured trap generates an electrical power of 160W per system for each compression stroke. Given that the trap consists of two systems, its total electrical power will be (160 - 2 = 320). Assuming that the number of cars passing is one car per minute during 16 hours in the daytime, which amounts to 960 cars, and one car every five minutes during 8 hours at night—assuming that traffic is lighter at night, resulting in 96 cars—the total estimated number of cars passing over the speed bump in a full day would be 1056 cars. Since each car generates two impacts on the bump, one from the front wheels and one from the rear wheels, the total estimated number of impacts generated would be 1056 × 2 = 2112, with each impact occurring in one second. Therefore, we will measure the energy production throughout the day in kilowatt units. It is an hour.

Daily Energy = (0.32 kW × 2112 stroke × 86400 s/day) / (3600s/h) = 16.2 kWh/day

Table 1. The total cost of manufacturing a speed bump for generating electrical energy

No.	Item Name	Description	Quantity	Unit Price
1	**Bump**	1	100.00	100.00
2	**External steel structure**	1	200.00	200.00
3	**Spiral springs**	2	100.00	20.00
4	**A vertical toothed shaft**	2	40.00	80.00

5	**A Shaft a moving cross**	2	15.00	30.00
6	**Ball bearing**	6	10.00	60.00
7	**A belt**	4	10.00	40.00
8	**The freewheel moves in one direction**	2	20.00	8000
9	**A main shaft**	2	40.00	40.00
10	**A flywheel**	2	25.00	50.00
11	**Generator**	2	100.00	200.00
12	**Inverter**	2	30.00	60.00
13	**A lithium battery**	2	300.00	600.00
14	**Metalworking and machining**	1	500.00	500.00
	Total			1.658.00

4. Conclusions

This technology is a pioneering project that serves as a sustainable source for environmentally friendly electrical energy generation, not only at Wasit University but also across Iraq and the Middle East. This innovative design addresses the shortcomings of traditional speed bumps by integrating two systems for electrical energy generation into a single bump, thereby enhancing its speed, standard design, and energy recovery capabilities. It can contribute to powering street lighting without the need for the national electrical grid, and it helps reduce carbon dioxide emissions and the carbon footprint of Wasit Governorate. It also provides job opportunities for the youth of the province, enriches experience, and contributes to raising awareness among the residents. The increasing investment in this technology, along with its improvement, has yielded satisfactory results in areas such as background and significance, design planning, system control, and experimental testing, thereby bolstering the sustainable development of land transport. Expect an increase in the share of speed bump systems generating electrical energy in the national energy mix, which will contribute to achieving energy independence. However, we must consider the challenges this technology faces, including the initial investment costs, environmental impacts, and operational issues. Future success requires collaboration and joint efforts between the public and private sectors, along with strategic guidance from the government to support this sector and promote technological development.

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