

Design and Construction of Dome Shaped Mechanical Speed Breaker Electricity Generator

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DOI: <https://doi.org/10.51583/IJLTEMAS.2025.140500048>

Received: 28 May 2025; Accepted: 04 June 2025; Published: 10 June 2025

Abstract: Vehicles such as cars and trucks use a lot of energy because of friction when they pass over speed limiters. Nonetheless, it is possible to transform this energy into electrical power. Innovative techniques for utilizing renewable energy have been developed in response to the pressing need for sustainable energy solutions. As a novel method of producing electricity from vehicle motion, this project explores the design and construction of a mechanical speed breaker in the shape of a dome. In four distinct load scenarios—5 kg, 7.5 kg, 10 kg, and 15 kg—we contrasted the experimental findings with theoretical projections. When a 15 kg weight was applied, the maximum power produced was 0.335W. We have included a chain sprocket for effective energy transfer in order to enable power generation with lighter vehicles going over the speed breaker.

Keywords—Efficiency, Load, Power, Sustainable development, Vehicles

I. INTRODUCTION

Indian roads are seeing a sharp increase in daily traffic because of a steadily growing population and increased transportation spending. The best ways to lessen the negative effects of excessive use of fossil fuels on the environment and the economy are currently thought to be energy recovery and renewable energy [1]. Renewable energy sources like solar, wind, and wave power have been the focus of most of the research. However, many of the systems in use are not sufficiently optimized in their mode of operation. Despite the possibility of reuse, this data shows that a sizable amount of energy is still being wasted. Energy can be extracted from a variety of current systems; for example, the energy contained in exhaust gases has many uses in combustion processes. The increasing demand for electricity leads to a decrease in conventional energy sources and an increase in emissions of pollutants. To reduce greenhouse gas emissions, renewable energy technologies are widely used to generate electricity. We propose using speed breakers to generate power to lessen dependency on various renewable and non-renewable energy sources. To decrease collisions caused by speed, speed breakers are frequently used traffic calming devices [2]. Speed breakers cause significant discomfort at higher speeds because they are designed to be navigated at a certain comfortable velocity [3]. The number of cars on the road is trending upward. One creative way to maximize the use of available resources is to install a speed breaker that produces electricity. Due to friction and heat dissipation, a significant amount of energy is wasted at the speed breaker [6]. This method will precisely assess the capacity to exploit the squandered energy from road speed breaker. Installing an electrical generation unit can harness a substantial quantity of energy. The rack and pinion mechanism transforms the kinetic energy of a vehicle into mechanical energy within the shaft. Consequently, mechanical energy can be converted into different kinds of energy, which may subsequently be stored in a battery for later utilization [7]. This energy can be converted into electrical energy, which can then be employed for various purposes such as road lighting, traffic signals, digital billboards, highway checkpoints, and toll plazas. This study was conducted with an emphasis on energy sources, operational expenses, spatial factors, and environmental impact.

Abraham et al. (2017) originally suggested incorporating a flywheel as a crucial element in their project. However, due to the flywheel's limitations, we opted for a chain sprocket that rotates under lighter loads, ensuring that the system would still function effectively when smaller vehicles cross the speed breaker [4]. In another study, *Venkata Rao et al.* proposed the addition of vital components like the crankshaft and connecting rod. Nevertheless, we have devised a more cost-effective solution by designing a straightforward speed breaker that eliminates the need for these components, thereby lowering both initial and maintenance expenses [5]. The innovative idea of generating electricity from speed breaker offers a potential solution to energy shortages. By replacing traditional speed breaker with technical mechanisms, we can capture the kinetic energy from vehicles driving over them. This energy can then be transformed into electricity using a generator, making it a sustainable and practical approach due to its low workforce requirements and minimal production costs. Implementing specially designed speed breaker capable of power generation could significantly enhance environmental sustainability and meet energy demands. Electricity generation by speed breakers is currently utilizing three different processes [13]. The mechanisms include the Roller type mechanism [8], the Rack-Pinion mechanism [9] and the crank-shaft mechanism [5]. Singh et al. examined the rack and pinion mechanism for the purpose of power generation. The proposed device utilizes a chain-driven sprocket and springs with a rack and pinion system to create electricity. The vehicle was propelled by passing it over the mechanism, which caused the gears to rotate and the shafts to move due to the rack and pinion system. *Das et. al;* presented a technique in which electricity was generated through the conversion of kinetic energy from a speed breaker [11]. He successfully passed CNG auto rickshaw over a speed breaker resulting in the generation of a terminal voltage of 12.83 volts and a current of 1.7 amperes. *Mishra et.al;* focused on flywheel for the development of speed breaker. *Jude Ezechi Dara et.al.* Proposed the development of a physical speed-breaking electricity generator that functions using two actuating strokes. The mechanism transforms the straight movement of the rack gear, which is pushed down by the motion of the vehicle, into the circular movement of a pinion gear that is attached to a shaft and the alternator [12]. *Santosh et al. (2014)*

constructed their machine utilizing the roller mechanism [14]. The idea involved arranging metal tubes, referred to as rollers, in a parallel manner and securing them to the frame using rolling contact bearings. According to *Teja et al. (2016)*, the crank-shaft system was found to have balancing difficulties and was susceptible to mechanical vibration [15]. He noted that the roller system was difficult to maintain and frequently experienced collision issues. In the past, certain authors have examined the pinion and rack mechanism. A rack and pinion machine are a linear actuator consisting of two gears that transform rotational movement into linear motion. The pinion, a circular gear, meshes with tooth on a linear gear bar known as the rack. When linear motion is delivered to the rack, it forces the pinion to move in relation to the rack. This translates the axial movement of the pinion into rotational motion. Every set of the conjugated involute profiles corresponds to a basic rack, which serves as the profile for the conjugated gear with an infinitely large pitch radius, resembling a toothed straight edge.

This study examines a prototype of a speed breaker and conducts an experimental analysis of the system's performance. In this project, we developed a method for generating electricity using speed breaker found on roadways. The movement of passing vehicles is essential for maximizing power output. Our approach employs a system involving rack and pinion mechanisms. This device captures the kinetic energy produced by moving cars as they travel through speed breaker, converting it into electrical energy. The system capitalizes on the energy generated from both the downward and upward motions of the rack; the downward motion arises from the weight applied, while the upward motion is produced by the restoring force that utilizes energy stored in springs.

II. Methodology

When a vehicle encounters a speed breaker, the suspension system moves downwards, resulting in linear motion. Two pinions are affixed to a rack, which transforms the straight-line movement of the rack into rotational motion. Both pinions exhibit unidirectional motion, similar to a bicycle sprocket. Two gears are affixed to the pinion shaft to transmit mechanical power to the common shaft, which is equipped with a single gear. A flywheel is employed at the end of the shaft to ensure consistent and steady motion. A belt is employed to transmit the mechanical motion from the common shaft to the DC generator. Guide slots prevent any possibility of slippage between rack and pinions.

The speed breaker is a rigid framework comprising of several components including rack and pinion gears, chain and sprocket, securely attached on shafts. It also incorporates additional components such as bearing, rectifier, helical springs, and a dome-shaped hump. The concept behind generating electric power via a speed breaker mechanism is straightforward. It operates on the same fundamental concept as other methods of electricity generation, such as hydroelectric power plants, thermal electric power plants, nuclear power plants, geothermal energy, wind energy, tidal energy, and so on. The conversion of mechanical energy from plants into electrical energy occurs. In this configuration, mechanical energy is also transformed into electrical power through the utilization of a direct current (D.C.) generator. The vertical movement of the top of the speed breaker is transformed into rotational motion, which then rotates the generator and produces power.

The rack is linked to the speed breaker, and two pinions engage with the rack. The downward movement of the rack is caused by the weight on the speed breaker, resulting in linear motion. The rack is rotated by the pinions, which are attached on both sides. At this juncture, the linear motion of the rack is transformed into angular motion. The power is only transferred through the right-sided pinion, while the pinion on the left side continues to rotate without any power transfer. Figure 1(b) illustrates the rack and pinion gear. As a result, only the left-sided pinion transfers power, while the right-sided pinion continues to rotate without power transfer. This process allows for a complete cycle of linear to rotational motion. The number of teeth in rack is 72 and number of teeth in pinion is 25.

The spring functions as a shock absorber in this project. When the spring undergoes compression and extension due to the vehicle traversing the speed bump. One of the conditions before designing the spring is that it must remain open until the maximum service load is achieved. The failure is caused by the torsional moment (T) generated in the wire. Therefore, the wire experiences torsional stress. The spring has 18 coils, 2.2mm wire size and 15mm outside diameter according to ASTM A313 spring temper standards.

The chain sprocket may be affected when the vehicle encounters a speed breaker. This engagement has the potential to power a generator by translating rotational motion into electrical energy.

In the electricity generation unit, two gears were used. Gears as shown in Figure 1(e) were made by Plastic. The diameter of the larger gear was 80 mm and several teeth was 56, while the diameter of the smaller gear was 40 mm and several teeth was 25. The thickness of both the gear were 1.25mm. Table I represent the design parameter for Gear.

III. Results and Discussion

Fabrication

A damper system was necessary to support the speed breaker. The system was constructed with a plywood aluminum sheet and a wooden rod casing situated beneath it. The dimensions of the dome are 240 mm in height, 370 mm in breadth, and 860 mm in length. When the vehicle's weight applied pressure on the speed breaker, a spring was utilized in the damping system to return the speed breaker to its previous position. Furthermore, they had to withstand the vibrations generated by automobiles crossing the speed breaker. The speed bump lowered as the car traversed it, delivering energy to the pinion in the process. This rack and pinion mechanism transformed reciprocating momentum into rotary motion. In this context, the primary shaft operates as a pinion. We

have employed wood for the framework of our project, which will function as a base for affixing various components such as gears, chain sprockets, rectifiers, and others. The overall system dimensions are 680 mm in length, 490 mm in breadth, and 460 mm in height.

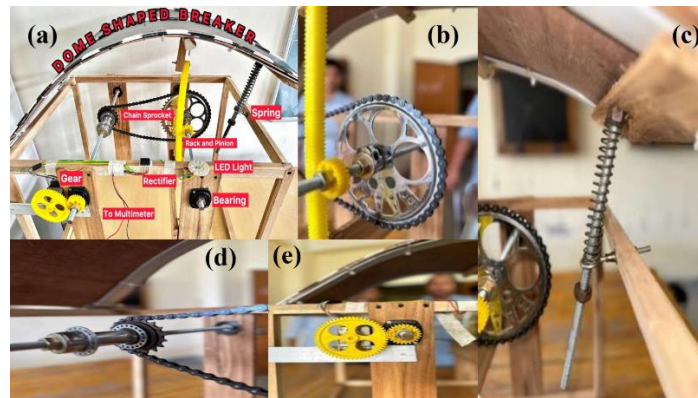


Fig.1 (a) view of the dome shaped speed breaker (b) View of Rack and Pinion Gear(c) view of springs (d) view of Chain Sprocket Pictographic (e) view of Spur Gear.

Performance of the mechanical speed breaker electricity generator

Following the design and construction of a mechanical speed breaker for electricity generation, the machine underwent essential testing to assess its functionality. These runs are essential for acquiring comprehensive understanding of the system operations. Additionally, it is crucial to ascertain the amount of power produced by the machine. The generator underwent testing with a mobile load weighing 100 kg at various velocities. The following factors were considered during the test. The generator was fastened on a wood medium. The load moved in a direction that was at a right angle to the axes of the machine.

The load was distributed evenly among the spring.

All measuring tools were accurately calibrated prior to the test. Calculation;

For 5 kg,

Height of the speed breaker= 0.24m Weight = mg

$$= 5 \times 9.81$$

$$= 49.05 \text{ J}$$

$$P_{th} = (49.05 \times 0.24) / 60$$

$$= 0.1962 \text{ W}$$

Power developed for 1 hour = 11.772W Power developed for 24 hour = 0.71Kw

Figure 2(a) illustrates the fluctuation in the electrical power output of the speed breaker under different design schemes as the loads vary and compared with theoretical power. Various loads were exerted on the mechanical speed breaker and the resulting power was measured. It has been noted for a load of 15 kg, 0.3552W of electricity produced. The resulting results were compared with the findings of prior studies. The power output is directly proportional to the load, indicating that the size of the vehicle will dictate the quantity of electricity generated. The height of the speed breaker, which is the distance the vehicle will depress the springs upon rolling over them, is highlighted as another aspect that affects the amount of electricity to be generated. Figure 2(c) illustrates a direct correlation between voltage generated and test load.

Table I. Design Parameters for Gear.

Sl. No	Parameters	Gear 1	Gear 2
1	Pitch Diameter	0.18	0.08
2	Number of Teeth	56	25
3	Circular thickness	0.012	0.012
4	Module	0.0032	0.0032

In the load and Current graph, we can visualize from the Figure 2(a) that increase in the load increases the value of current. At 7.5 Kg Load the value slightly decreases than maintain a steady growth as we increase the load. The difference between theoretical

load and experimental load is in between 20 -25% which is due to low load condition. The voltage also shows increase pattern when increase in the load.

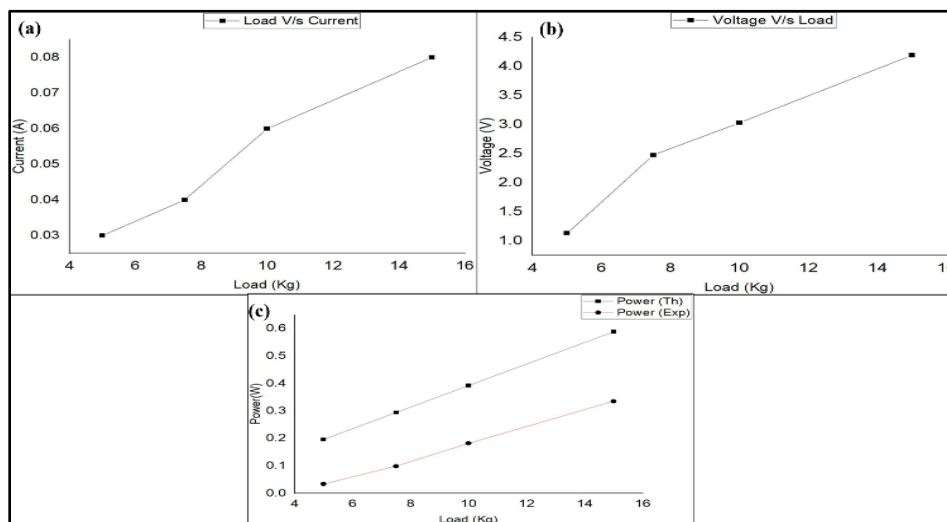


Fig 2. (a)Graph between Load and Current (b) Graph between Voltage and Load(c) Graph between theoretical and Experimental Value

IV. Discussion

Despite resistance from certain road users, speed breakers are effective tools for enhancing road safety. Additionally, their use in power generation provides a supplementary benefit. The generated energy could be utilized to illuminate the roads and provide electricity to traffic signs. Adequate lighting, particularly during nighttime, improves visibility for individuals using the road and helps to deter illegal actions, as many criminals carry out their unlawful deeds under the protection of darkness. The mechanical speed breaker was tested and found to produce 0.3352W of electrical power every cycle. This project successfully designed and manufactured a dome shaped mechanical speed breaker generator. The machine was produced using effective design and careful material selection criteria.

V. Conclusion

Energy efficiency is crucial for the development of any nation, and this project is designed to support that goal. During the day, the electricity produced can be stored in batteries, and at night, it can be used for a variety of purposes, including toll booth management, traffic signal operation, and highway lighting. Our system can produce several kilowatts of power by utilizing the rack's upward and downward movements. It can generate 0.335W of power and has a rack height of 24 cm and a weight limit of 15 kg.

VI. Future Scope

This project focuses on utilizing the kinetic energy generated by vehicles as they drive over speed breaker to create electrical power. Various other principles, such as electromagnetic induction or piezoelectric materials, can also be applied to convert mechanical energy into electrical energy. Furthermore, performance could be enhanced by modifying the height of the dome-shaped speed breaker.

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