Road Speed Breakers Power Generation

Ammar A. Al Talib[1*], Abdel Wahab Sameer[1], Amar Rizuan[1], Sarah Atifah[2], Ayu Idayu[1]

[1] Faculty of Engineering, Technology and Built Environment, UCSI University, Malaysia
[2] Faculty of Engineering and Mechatronics, University Malaysia Pahang, Malaysia

***Email:** ammart@ucsiuniversity.edu.my

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Abstract: The relentless and unchecked rise in global energy consumption necessitates the development of innovative energy generation methods. Renewable energy offers a promising solution, utilizing lost energy and addressing both environmental and engineering concerns. As the number of registered cars on roads increases, traffic, pollution, and energy usage surge, highlighting the need for sustainable alternatives. This study aims to create and evaluate a power-generating speed bump, effectively capturing the energy dissipated during vehicle braking on speed breakers. Employing an innovative mechanism of rack and pinion, complemented by a compound gear train. The proposed solution combines the strengths of existing designs while rectifying their drawbacks through component integration. To ensure long-term reliability, the mechanism undergoes ANSYS simulations. The direction of passing over the bump and the weight of the passing load have been studied in this research. Each trial was repeated for 20 times, and the average value was considered to ensure the reliability of results. A maximum and minimum power generation of 35.6W and 23.4W have been obtained.

Keywords: Speed breakers; rack and pinion; renewable energy

Introduction

World energy demand has been increasing as population worldwide increases, (Tan C.S. et.al, 2013) this calls for an immediate action to solve the problem. Increasing the worlds renewable energy usage percentage is essential to be maintained.

According to U.S. Energy Information Administration (EIA), only 12.4% of the energy consumption in the United States is in the form of renewable energy in year 2021. United Nations has acknowledged the efforts of using renewable energy and it showed an increase of 25% of energy used to become from renewable sources between 2010 and 2019 (UN SDG's).

This study is being conducted in Malaysia where the number of registered vehicles is 22 million cars (Anthony, L., 2022).

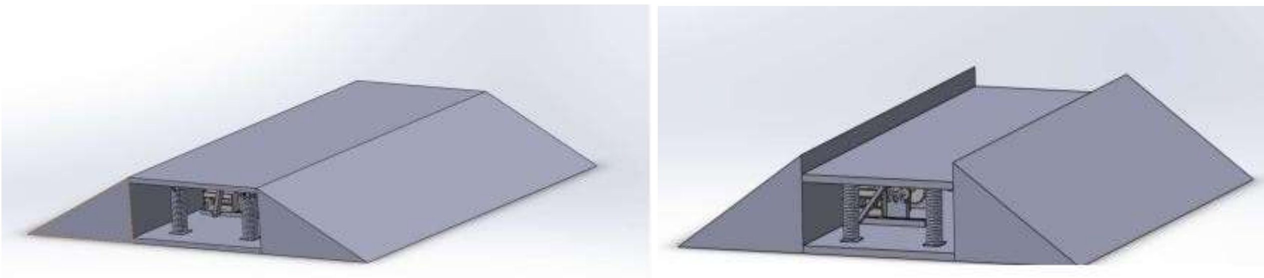
Speed breakers is a method used to create a physical obstacle in the road to force incoming traffic to slow down (Kosakowska K., 2022). Vehicles lose energy when slowing down therefore conversion of that energy into a renewable energy source is the objective of this study.

Although various designs are created by researchers (Rao,, K. et al.,2014; Felix, N.C. et.al., 2015), the designs have drawbacks in the aspects of practicality and implication, this comes from not considering weights on the corners, maintenance and installation of the speed breakers as road works have to be made when installing or maintaining them. In this study a new design is proposed, tested, and discussed with the values obtained from a physical prototype testing.

Methodology and Experimental Setup

A design has been proposed by using SolidWorks software. This design consists of top and bottom plates, ramps, with a gear train mechanism which is used to amplify and transmit the power.

The design is as shown in Figures 1 (a) and(b) with previews of the design being unloaded and loaded respectively.



(a) (b)

Figure 1: Design loaded and unloaded.

The design proposed as shown in Fig 1 with the two stages in which the design is in the unloaded condition shown in Fig 1(a) and with the loaded condition shown in Fig 1 (b), apart from thisthe internal mechanism of the design which is responsible for the power transmission is as shown in Figure 2.

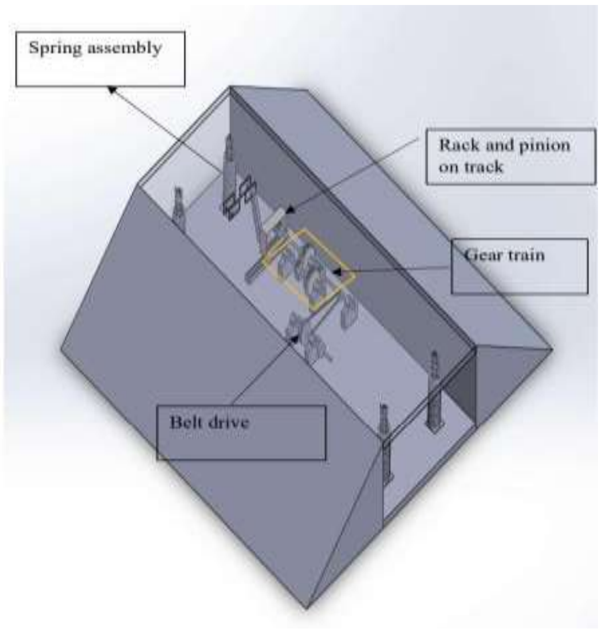
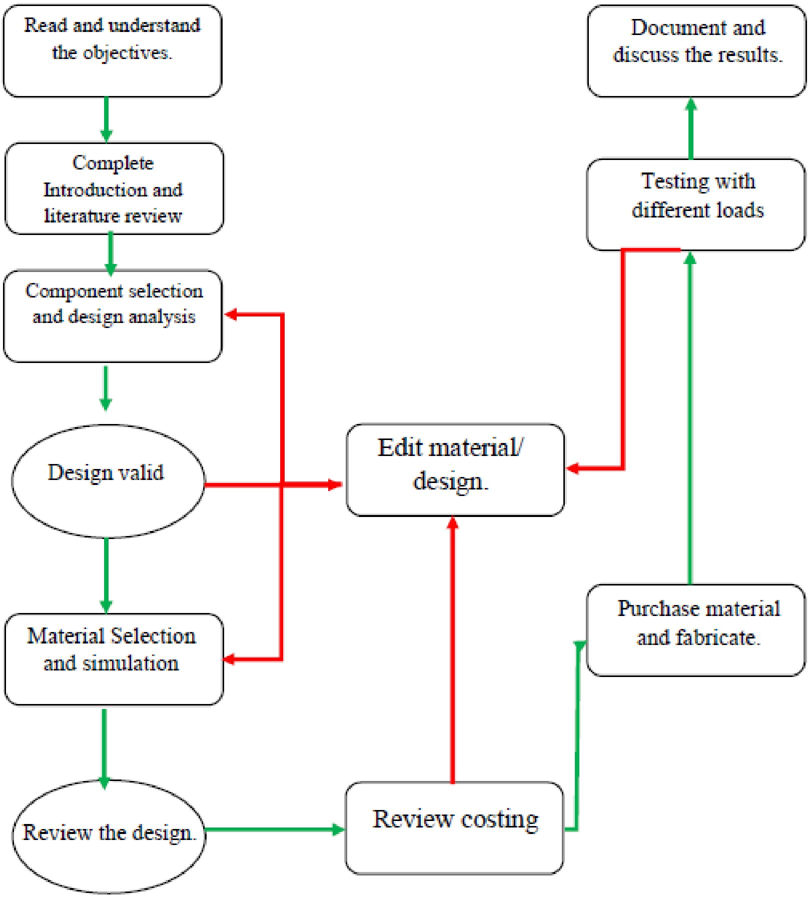


Figure 2: Internal mechanism of the design

The following flow chart can explain the steps of conducting the tests.



Flow chart Explaining the steps for conducting the tests

The speed bump mechanism is made up of several parts, such as a flywheel, racks and pinions, double springs, a belt drive, and a generator. The top plate compresses down as a vehicle crosses over the speed bump, and the motion is then transmitted through racks and pinions to drive a few gears, which in turn move the generator shaft. Electricity is produced as a result, and a battery stores it for later use. Energy conversions take place during the process, with kinetic energy changing to potential energy when the vehicle crosses the speed bump, and its altitude rises and velocity falls. The internal operation of the mechanism then causes the potential energy to be changed back into kinetic energy, which is then changed into electrical energy. In comparison to earlier designs, the proposed speed bump offers a number of benefits.

It makes use of double epicentral springs of varying stiffness; it enables various vehicles to activate the mechanism according to their weight. It uses a horizontal rack combination with two pinions, in contrast to earlier vertical rack designs, to maximize energy generation from both upstroke and downstroke motions. The new design is also more compact, which means that roadworks during installation is no longer necessary. In general, these improvements make the suggested speed bump design more adaptable, effective, and economical.

To test the mechanism, a multimeter is attached to the generator to measure the voltage and power generated under various loading conditions. The loading is accomplished by having two volunteers to ride through the design. Readings are recorded and interpreted using Microsoft Excel to calculate the power generated. The highest value of current is assumed to be 215mA, which is then used to calculate the power output. The two variations of weight inclusive of 5kg bicycle are 80kg and 90 kg for the two volunteers M and J respectively.

Results and Discussion

Using the fabricated prototype testing mechanism discussed earlier, volunteers have proceeded to pass through the speed breaker while the multimeter is connected. Recordings are taken from both volunteers crossing over the speed breaker in turns, while going for 20 trials per volunteer in each direction, direction changing has shown that when direction of travel changes the voltage also changed due to having a different moment from the rack and the energy required to start moving the rack is increased. Figure 3, shows the scatter plot for both volunteers in both directions.

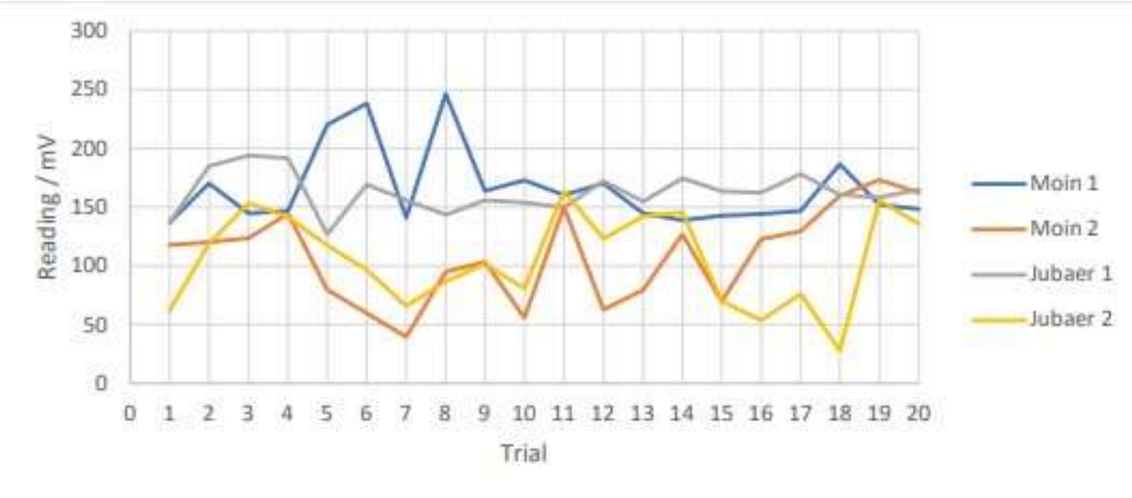


Figure 3: Scatter plot of all results

It can be seen, M's average in the first and second directions is higher and covers a larger area of the graph, whereas J's values are depicted as decreasing. This is because M is heavier than J, which causes the rack to move more when a stronger downward force is applied.

M managed to have an average of 165.785 mV whereas J have an average of 162.58 mV, resulting in a percentage difference of 1.93% and a difference of the average of 3.205 mV for the firstdirection when comparing the first directions of the two volunteers. In the second direction, M was able to achieve an average of 108.86 mV while J, on the other hand, had an average of 105.975 mV; adifference in the average value of 2.885 mV was used to determine the percentage difference of 2.65%.

Using the average values stated, the power generated is calculated and the time taken to charge a Samsung Galaxy S21 Ultra battery which has a capacity of 4000mAh, is then calculated. The mechanism takes 18.6 hours of constant pressuring to charge the battery from 0 to 100%. This, and in relations to the minimum tariff set by Tenaga Nasional which is the national electricity provider inMalaysia can save 10.5 cents per charge when using a 12V charger.

Power Generated by each volunteer is as shown in Table 1, by which the volunteer M who has the higher mass, has generated a higher average power than J. M has generated 35.6W and 23.4W in his first and second directions as an average while J generated 35W and 22.8W respectively.

Table 1: Average Power Generated

Volunteer	Average Voltage (mV)	Average Power (mW)	Average Power (W)
M 1	165.79	35643.78	35.64
M 2	108.86	23404.90	23.40
J 1	162.58	34954.70	34.95
J 2	105.98	22784.63	22.78

Conclusion

This project has been conducted to produce renewable energy from all the energy wasted by vehicles when passing over a speed breaker. Design, calculations, and a prototype have been fabricated to prove the idea. The experimental results have shown promising results. This research can be considered as a significant milestone in the field, as the prior studies required extensive road modifications, whereas the current prototype has proved that digging and such modifications could be avoided by constructing the rack to move horizontally rather than vertically.

According to the experimental test findings and by utilizing a 12V generator, a number of variables were found influential in the speed breaker output or efficiency. The location of the rack, which encourages sliding in that direction, affects the power generated depending on the direction of movement over the speed breaker. The load on the speed breaker is the second important factor.

When the load is higher, the rack tends to move farther, producing more rotation and a higher output. The rider's path, which is another important factor, can help move the rack because it requires less force to move the rack fartheraway from the link connection. The different experimental tests on the prototype have shown a maximum and minimum power generation of 35.6W and 23.4W respectively.

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References

Anthony, L. (2022, June 14). Total number of active vehicles in Malaysia at around 23 million – 11.37 mil vehicles are dormant or inactive. Paul Tan's Automotive News. https://paultan.org/2022/06/14/total-number-of-active-vehicles-in-malaysia-at-around-23-million-11-37-mil-vehicles-are-dormant-or-inactive/

Felix, N. C., Pradeep, A. S., & Swetha, M. (2015). Power generation from a renewable energy source - speed breaker generators. International Journal of Electrical & Computer Sciences, 15(5), 1–4.

Kosakowska, K. (2022). Evaluation of the impact of speed bumps on the safety of residents—Selected aspects. Transportation Research Procedia, 60, 418–423. https://doi.org/10.1016/j.trpro.2021.12.055

Rao, K., Mahesh, K., Kumar, K. R., & Deepthi, P. (2014). Design and fabrication of power generation system using speed breaker. International Journal of Current Engineering and Technology, 4(4), 2697–2702.

Tan, C. S., Mahlia, T. M. I., & Jannifar, A. (2013, April). Electricity energy outlook in Malaysia. IOP Conference Series: Earth and Environmental Science, 16(1), 012026. https://doi.org/10.1088/1755-1315/16/1/012026

United Nations. (n.d.). Sustainable Development Goals (SDGs). United Nations Department of Economic and Social Affairs. https://sdgs.un.org/goals