Original Research Article

Design and fabrication of Speed Breaker Mechanism for power generation: a case study of Ikpoba Hill Benin City, Nigeria.

ABSTRACT

This study presents the design and implementation of a small scale model speed breaker electric power generator by harnessing the kinetic energy from vehicles with goal of generating electric power. The model was developed utilizing available electrical and mechanical components such as flywheel, the battery, the inverter, spring, the rack and pinion, the DC motor. To this end, the aim of this paper is accomplished by demonstrating the process of conversion of kinetic energy to electrical energy using a movable speed breaker mechanism and show that it can produce adequate amount of power for streets lights and traffic lights. In light of the above, methodology employed to achieve the above includes the construction of a small scale model of the speed breaker generator; using adequate power calculations, design specification with proper review of related works. In conclusion, the proposed model was developed and constructed in such a way that little applied pressure manually (by hand) on the speed breaker caused generation of electrical power. The technical feasibility of this model is illustrated in real case scenario at Ikpoba hill in upper mission extension in Uteh community employed as a case study.

Keywords: Speed breaker generator, Energy conservation, flywheel, DC motor, power inverter

Introduction

Electricity plays a very important role in our lives (Miller R, et al 1970). Due to population explosion, the current power generation has become insufficient to fulfil our requirements. This study presents a technology that can be used to generate electricity from speed breaker in which the system used is reliable and this technique will help conserve our natural resources. In coming days, this will prove a great boom to the world since it will save a lot of electricity from power plants that gets wasted in illuminating the street lights. As the conventional sources are depleting very fast, it's high time to think of alternative resources. In light of the above, this idea does not only provides alternative but also adds to the economy of the country, vehicular traffic in big cities is more causing environmental and social problems, but this project shows a means by which this can be utilized for power generation by the means of the Power Hump. It has advantage that it does not utilize any external source (Nota et al. 2005). Now the time has come to put forth these types of innovative ideas and researches should be done to upgrade their implication.

In the present day scenario, Electrical power has become the major need for human life. Energy is an important input in all sectors of any country's economy. The day to day increasing population and decreasing conventional sources for the power generation, provides a need to think of alterative/ non-conventional energy source. This project is geared towards conserving the kinetic energy that goes wasted while vehicle moves. The number of vehicles plying the roads and moving over speed breakers is increasing daily. According to the Road Transport Data released by National Bureau of Statistics (NBS) in 2017, Nigeria has an estimated vehicle population of over 11.5million cars nationwide; just imagine all those useful energy being wasted.

To this end, beneath the speed breaker we could set up an electro-mechanical unit known to be power hump, which would help us in conserving this energy and use it for power generation. The electrical output can be

improved by arranging these power humps in series. This generated power can be stored by using different electrical storage devices and this prompted this study as it could aid in the sufficient and reliable supply to immediate loads like street lights in our environs and thus leads in cost saving and improvement country's economy.

Literature Review

Related Studies

This section presents the current state of knowledge by reviewing prior studies that have been made on this study. Apart from establishing a substantial body of knowledge in the area of speed breaker generators, the literature review serves to understand the difficulties and limitations that may be faced during the design of the machine.

To begin with, the following sections present various works by different people showing the various methods used and analysing the results obtained from each method before a conclusion will be made to serve as a guide in the designing of the generator model.

The work by **Deepali et al. (2009)** focused primarily on using a different kind of speed breaker hump called Rollers. Rollers are tyre shaped and can rotate when a tangential force is applied to any point on its surface when it is fixed to a point.

The project worked successfully and it is easy to install requires less maintenance but the main problem it faced is that the vertical distance obtained is small and thus voltage produced is very limited.

Samiullah et al. (2010) aimed at designing the generator with the common speed breakers seen on roads with some few modifications.

One of such modifications involved using a steel mould rather than a cement casted mould. This aided internal jointing of various other components through welding that would have been impossible if the mould were made of the usual cement casting.

Other materials used include:

- Rack
- Pinion
- Sprocket wheels
- Chain
- Spur gears
- Springs

The project was successful and produced adequate electrical power. He managed to design the generator in such a way that it could be implemented on any road and supply a substantial amount of power for consumption.

The major drawback of the project was its susceptibility to corrosion (rust). Most of the materials used had low resistance to rust and were not protected against it and over time this would have led to rapid deterioration of the machine well below its life expectancy.

Several attempts have been made to harness the kinetic energy of vehicles via speed bump and converting it to electrical energy. These attempted designs include Mechanized Speed Bump installed at Burger king Drive-Through; A.K. Singh et al.(2016) made use of spring in the speed breaker design, Aswathaman.V and Priyadarshini.M employed the use of rack and pinion, Noor Fatima made use of slider crank, Shakun Srivastav wrote on how every speed breaker can be used as a power source, Ankit Gupta and Kuldeep Chaudhary explained the production of electricity using speed breaker.

From the review of previous works, the best components for the speed breaker generator include:

Flywheel

A flywheel is a mechanical device specifically designed to efficiently store rotational energy. The way to change a flywheel's stored energy is by increasing or decreasing its rotational speed by applying a torque aligned with its axis of symmetry. Flywheels are typically made of steel and rotate on conventional bearings; these are generally limited to a maximum revolution rate of a few thousand RPM

Common uses of a flywheel include:

- Smoothing the power output of an energy source
- Energy storage systems
- Delivering energy at rates beyond the ability of an energy source
- Controlling the orientation of a mechanical system, gyroscope and reaction wheel
- instrumentation for ship stability and satellite stabilization (reaction wheel) (Stewart, 2018)

Figure 1: Pictures of the flywheel

The flywheel also acts as a speed multiplier. It multiplies the speed of the generator to 1000rpm in order for the generator to be able to generate electricity for charging the batteries. It is gotten out of a Mercedes Benz automatic transmission car.

Bendix

Bendix drive is a type of engagement mechanism used in starter motors of internal combustion engines. The device allows the pinion gear of the starter motor to engage or disengage the flywheel of the engine automatically when the starter is powered or when the engine fires, respectively. It is named after its inventor, Vincent Hugo Bendix.

The main drawback to the Bendix drive is that it relies on a certain amount of "clash" between the teeth of the pinion and the ring gears before they slip into place and mate completely; the teeth of the pinion are already spinning when they come into contact with the static ring gear, and unless they happen to align perfectly at the moment they engage, the pinion teeth will strike the teeth of the ring gear side-to-side rather than face-to-face, and continue to rotate until both align. This increases the wear on both sets of teeth. (Revolvy 2017)

Figure 2: Picture of a Bendix

The teeth of the Bendix are attached to the teeth of the flywheel thereby receiving rotation from the rotation of the flywheel through the teeth. It is situated on the shaft of the generator thereby transmitting rotation to the other rotating parts of the generator for electricity generation.

Returning Spring

A spring is an elastic object that stores mechanical energy. Springs are typically made of spring steel. There are many spring designs. In everyday use, the term often refers to coil springs. When a conventional spring, without stiffness variability features, is compressed or stretched from its resting position, it exerts an opposing force approximately proportional to its change in length Springs are made from a variety of elastic materials, the most common being spring steel. Small springs can be wound from pre-hardened stock, while larger ones are made from annealed steel and hardened after fabrication. (McMaster-Carr catalog 2010)

Types of Mechanical Springs

- **Compression Spring:** A compression spring squeezes together to create a load. You will often find these inside switches, automotive suspensions, and jacks- in-the-box.
- **Extension Spring:** The extension spring stretches apart to create load. They often have little loops on the ends to attach to things. You may find these on the screen door hinge, garage door hinge, and bouncy decorations that hang from the ceiling..
- **Torsion Spring:** The torsion spring rotates around an axis to create load. They release their load in an arc around the axis. They are commonly found in mouse traps and rocker switches. They are good for things that rotate less than 360 degrees.
- **Constant Force Spring 1:** Also called a "clock spring", because it is often found in clockworks. This spring is made of a band of steel wrapped around it a number of times to create a geometric spiral. The idea is to create a rotational force that releases a constant amount of load, instead of a quick burst of power. Besides clocks, they are found in all sorts of wind-up toys. Be careful when removing these from a mechanism. They tend to unravel with a dynamic flair and much excitement.
- **Constant Force Spring 2:** This type of clock spring is used when more power is required. It has many fewer rotations and a much thicker band of steel. They are used in automotive seat recliners
- **Belleville Spring:** Belleville springs are a coned disk spring typically containing a hole in the centre for non-permanent fasteners. With proper design (selection), Belleville springs can be used for a "snap-acting" mechanism.

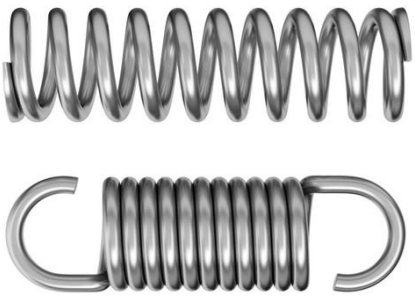


Figure 3: picture of elastic metal springs

The returning spring helps to return the speed breaker back up when a car moves across it. They are four in total (with two for each shaft of the barrel). The returning springs are of low resistance and low tension.

DC Motor

DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Small DC motors are used in tools, toys, and appliances. A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.) The total amount of current sent to the coil, the coil's size and what it's wrapped around dictate the strength of the electromagnetic field created. The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a torque on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor.

If external mechanical power is applied to a DC motor it acts as a DC generator, a dynamo. This feature is used to slow down and recharge batteries on hybrid car and electric cars or to return electricity back to the electric grid used on a street car or electric powered train line when they slow down. This process is called regenerative braking on hybrid and electric cars. In diesel electric locomotives they also use their DC motors as generators to slow down but dissipate the energy in resistor stacks. Newer designs are adding large battery packs to recapture some of this energy. (William and Warne 2003)

Figure 4: Picture of DC Motor

The generator is a dc motor serving as a dc generator. The dc motor rotates when voltage is applied to it but it can also work in the reverse situation i.e. it can produce electricity when its shaft is rotated. The dc motor used is a 12 Volts DC motor and it is gotten from a Ford E350 radiator fan.

Batteries

Electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations.

Categories and Types of Batteries

Primary batteries

These are designed to be used until exhausted of energy then discarded. Their chemical reactions are generally not reversible, so they cannot be recharged. When the supply of reactants in the battery is exhausted, the battery stops producing current and is useless.

Secondary batteries

These can be recharged; that is, they can have their chemical reactions reversed by applying electric current to the cell. This regenerates the original chemical reactants, so they can be used, recharged, and used again multiple times. Some types of primary batteries used, for example, for telegraph circuits, were restored to operation by replacing the electrodes. Secondary batteries are not indefinitely rechargeable due to dissipation of the active materials, loss of electrolyte and internal corrosion. Secondary batteries, also known as secondary cells, or rechargeable batteries, must be charged before first use; they are usually assembled with active materials in the discharged state. Rechargeable batteries are recharged by applying electric current, which reverses the chemical reactions that occur during discharge/ use. Devices to supply the appropriate current are called chargers. The oldest form of rechargeable battery is the lead–acid battery.

Figure 5: Picture of Battery

On the speed breaker power generator we have an 18Amps 12V battery. The battery is the part of the machine that stores electricity. The electricity it stores is used to power the street lights when its night time. In order to reduce the opposing magnetic field created by the motor we use a low rated battery because the higher the rating of the battery the higher the opposing magnetic field in the generator will be.

Rack and Pinion Mechanism

A rack-and-pinion gear set is enclosed in a metal tube, with each end of the rack protruding from the tube. A rod, called a tie rod, connects to each end of the rack. The pinion gear is attached to the steering shaft. When you turn the steering wheel, the gear spins, moving the rack. The tie rod at each end of the rack connects to the steering arm on the spindle. The rack-and-pinion gear set does two things:

- It converts the rotational motion of the steering wheel into the linear motion needed to turn the wheels.
- It provides a gear reduction making it easier to turn the wheels.

On most cars, it takes three to four complete revolutions of the steering wheel to make the wheels turn from lock to lock (from far left to far right). The steering ratio is the ratio of how far you turn the steering wheel to how far the wheels turn. For instance, if one complete revolution (360 degrees) of the steering wheel results in the wheels of the car turning 20 degrees, then the steering ratio is 360 divided by 20, or 18:1. A higher ratio means that you have to turn the steering wheel more to get the wheels to turn a given distance. However, less effort is required because of the higher gear ratio. These smaller cars are light enough that even with the lower ratio, the effort required to turn the steering wheel is not excessive. Some cars have variable-ratio steering, which uses a rack-and-pinion gear set that has a different tooth pitch (number of teeth per inch) in the centre than it has on the outside. This makes the car respond quickly when starting a turn (the rack is near the centre), and also reduces effort near the wheel's turning limits. Power Rack-and-pinion is the rack-and-pinion in a power- steering system; the rack has a slightly different design. Part of the rack contains a cylinder with a piston in the middle. The piston is connected to the rack. There are two fluid ports, one on either side of the piston. Supplying higher- pressure fluid to one side of the piston forces the piston to move, which in turn moves the rack, providing the power assist. (Howstuffworks 2018).

Figure 6: Picture of Rack and Pinion Mechanism

The model's rack and pinion is gotten from a Toyota Camry. This mechanism is in every car. It is the part that allows the front wheel of a car to steer to either left or right. It is situated horizontally in a car but in the speed breaker generator it is situated vertically. The vertical position of the rack and pinion enables us to convert the vertical movement of the speed bump to rotational movement or force. The working mechanism of the rack and pinion is lubricated in a car with steering fluid or transmission fluid but in this machine the lubricant used is soft grease (eliminates incorporating a steering pump).

Power Inverter

Power inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process. Circuitry that performs the opposite function, converting AC to DC, is called a rectifier. A typical power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter. Examples include:

- 12V DC, for smaller consumer and commercial inverters that typically run from a rechargeable 12 V lead acid batteries or automotive electrical outlet.
- 24, 36 and 48V DC which are common standards for home energy systems.
- 200 to 400V DC, when power is from photovoltaic solar panels.
- 300 to 450V DC, when power is from electric vehicle battery packs in vehicle-to- grid systems.

An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design (Windsun 2019).

The dc that is generated can only light up bulbs that are designed to work with dc. Thus for bulbs that use ac there is need to concert the produced electricity to a form suitable for it. The inverter works by switching the dc current in a very high frequency and as a result it turns to an alternating current.

Lighting Point

An electric light is a device that produces visible light from electric current. It is the most common form of artificial lighting and is essential to modern society, providing interior lighting for buildings and exterior light for evening and night time activities. In technical usage, a replaceable component that produces light from electricity is called a lamp.

Categories of Electric Light

- Incandescent light bulb
- Halogen lamp
- Fluorescent lamp
- LED lamp
- Carbon arc lamp
- Discharge lamp (Keefe 2007).

Figure 7: Picture of Incandescent bulb

The model has an energy saver bulb. This is used because the power produced by the generator is required to last as long as possible even throughout the night. An energy saver bulb produces even more lighting effect than regular electric bulb.

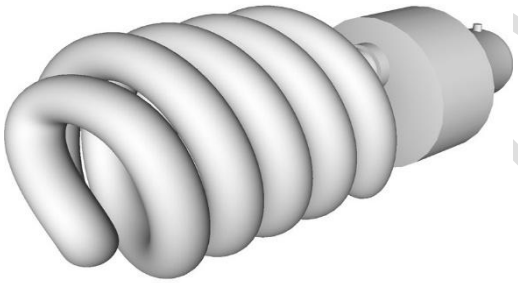


Figure 8: Picture of Energy saver Bulb

Voltmeter

Multimeter or a multi-tester, also known as a VOM (volt-ohm-milli-ammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. Analog multimeter uses a micro ammeter with a moving pointer to display readings. Digital multimeter (DMM, DVOM) have a numeric display, and may also show a graphical bar representing the measured value. Digital multimeter are now far more common due to their cost and precision, but analogue multimeter are still preferable in some cases, for example when monitoring a rapidly varying value. A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems. (Hyper physics 2019)

Figure 9: Picture of Fluke Multimeter

The multimeter is used to measure the amount of electricity produced whenever a car steps across the speed breaker. The voltmeter helps to display the electricity produced and the voltage level of the battery if it's under or over charged. An overcharged condition can make the battery explode. To prevent this, the charging process is very slow.

Bearings

Bearings are highly engineered, precision-made components that enable machinery to move at extremely high speeds and carry remarkable loads with ease and efficiency. This serves as a tolerance for wear and tear when two metal rub each other this tends to creates heat, this heat will make the heated part to come close to melting point thereby it becomes soft and this causes wear and tear. To prevent that, a bearing is incorporated into all the rotating part of the speed breaker generator. It is made up of round metal ball bearings and a metal ring; it has an inner ring and an outer ring. In between the rings are the round metal balls which are free to rotate forward, backwards or sideways without any obstruction. During high speed rotation, the ball bearing prevents the rotating and non-rotating parts from touching thereby creating a smooth run between the two surfaces.

Bearing Types and Application

- Ball Bearings Cylindrical & Needle
- Roller Bearings Tapered Roller Bearings Spherical Roller Bearings
- Ball Bearings
- Cylindrical & Needle Roller Bearings
- Low friction, medium to heavy radial loading
- Tapered Roller Bearings
- Spherical Roller Bearings (American Bearings 2017).

Figure 10: Picture of Deep Groove Bearing

There are 4 bearings in total in the speed breaker power generator. It has one on the centre shaft (front and back) and two on the pinion (front and back).

Structuring of Model

The frame work of the machine is made of angle iron. This iron serves as the cradle for all the components and also acts as the pillar that holds up the upper part of the machine. The rack and pinion are vertically wielded to the angle iron for firmness, a sheet metal of 2mm is bent like a C-shape facing downwards to form the bump which appears on the road for cars to move across. The barrel is made out of one inch steel pipe. It is lubricated with soft grease because it is one of the moving parts of the machine.

Benefits of the Machine

1. It can produce electric power in times of no wind or sunlight when windmill or solar cannot do so provided cars are plying the road.

2. This generator can be used as a battery charger to charge external batteries when there are no other means of charging.
3. In an undeveloped area or locality where there is no electricity yet but has a busy road, this machine can serve as a source of generating electricity in such places.
4. Scrap parts can be used as new parts for this generator. It is made possible by recycling them and using them as new parts in the generator. For example, the steering rack of any car can be used to build this speed breaker generator, and the flywheel of an automatic transmission of a car can be used to multiply the rotation of the speed of the generator. The radiator fan dc motor can also be used to make the generator.
5. It serves as a speed breaker thereby reducing road accidents.

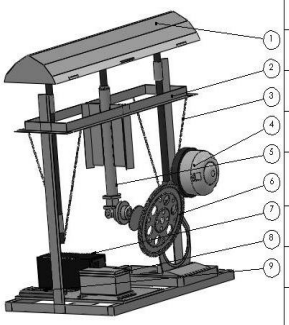
Limitations of the Machine

1. This machine is an underground machine this is prone to the possibility of flooding thus damaging the machine. To prevent this, it can be situated in sloppy area with good drainage system.
2. The dc motor tends to have a very high opposing magnetic field because of this to press down the speed bump is very difficult and requires a lot of force at least 100Kg and thus an average man cannot generate electricity by stepping on it.
3. It requires frequent attention.

Research Methodology

The research methodology employed in this study are outlined as follows;

(a) Carried out comprehensive literature review
(b) Proper design analysis and specifications
(c) Study of the case study area for accurate meteorological data.
(d) Fabrication of the proposed design model
(e) Implementation of the design and test evaluation.



ITEM NO.	PART NUMBER	QTY.
1	Bump	1
2	Frame	1
3	Spring	4
4	Dc Motor	1
5	Rack and pinion system	1
6	Flywheel	1
7	Inverter	1
8	battrery	1
9	Meter	1

Figure 11 the Speed Breaker Generator

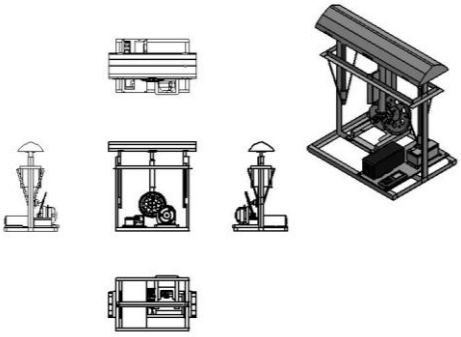


Figure 12 Front, Plan and Side View of Speed Breaker Generator

Block Diagram

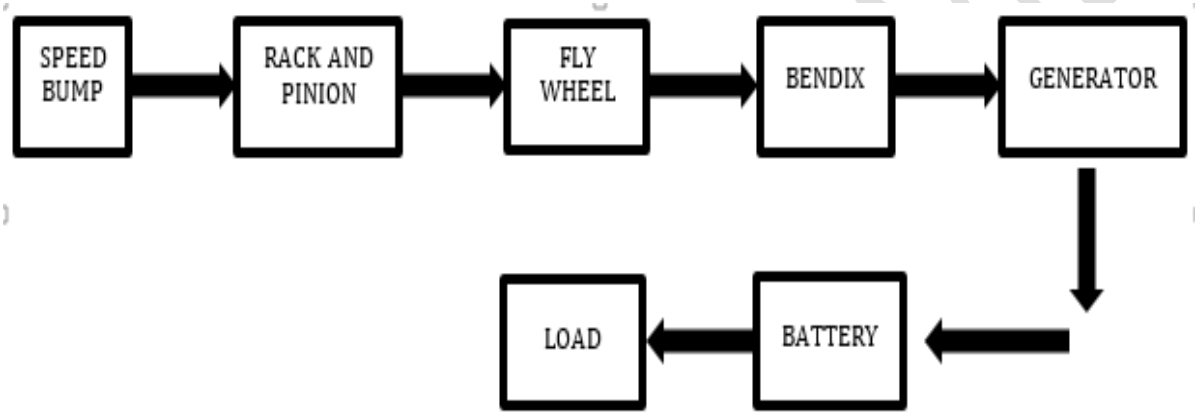


Fig 13 Block Diagram of the Speed Breaker Generator Model

The Speed Bump

This is part of the machine that is above ground. It is made of bent sheet metal. It receives the applied force and transmits it to the rack and pinion mechanism that is attached to it through arc welding joints.

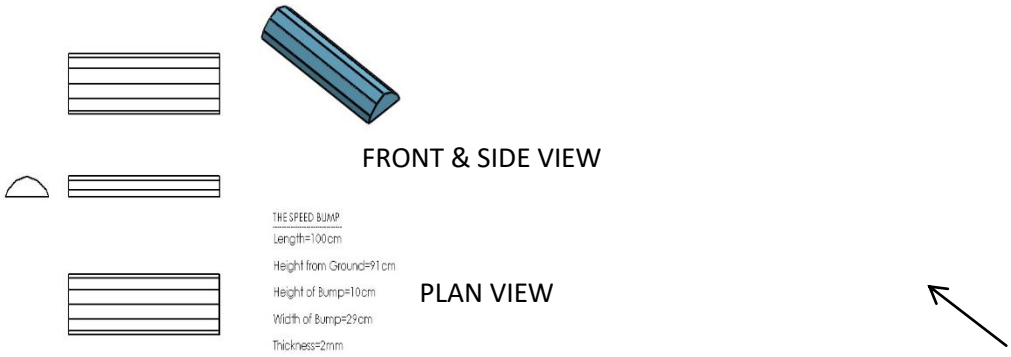


Figure 14: Front, Side and Plan View of the Speed Bump

Speed Bump Specifications

Length of bump = 100cm

Height of bump = 10cm

Height from ground = 91cm

Width of bump =29cm

Radius of bump = 38cm

Vertical distance travelled by bump = 12cm

Thickness of sheet metal used = 2mm

Rack and Pinion Mechanism

This is the mechanism that receives the vertical motion of the speed bump and converts it to the required rotational motion. It is installed in a vertical position which enables us to convert the vertical movement of the speed bump to rotational movement or force. It is made of vanadium to increase to wear and tear and overheating.

Specifications of Rack And Pinion

Length of mechanism = 61cm

Radius of mechanism = 3.5cm

Flywheel

This acts as a speed multiplier. It multiplies the speed of the rack and pinion mechanism by a certain factor called *SPEED RATIO* to a higher speed required to drive the generator.

Specifications of Flywheel

Material = vanadium

Number of teeth = 120

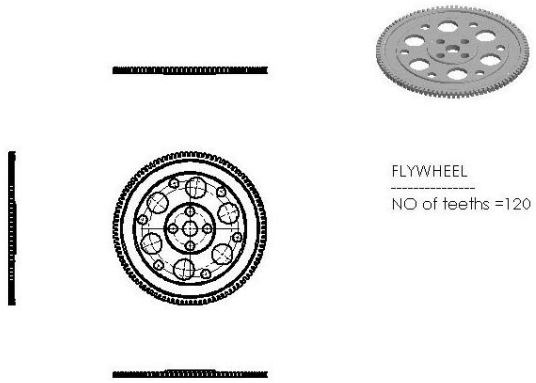


Figure 15 Front, Side and Plan view of Flywheel

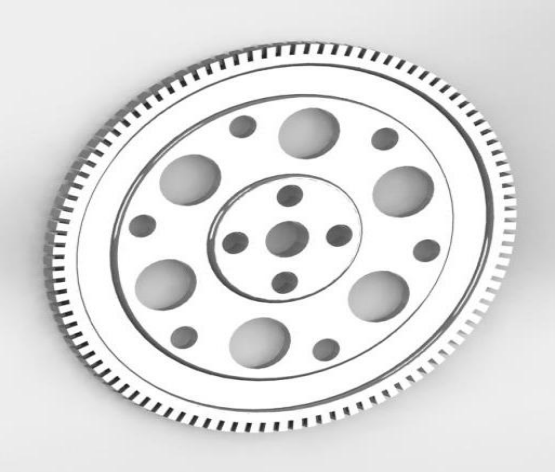


Figure 16 Model Flywheel

Bendix Drive

This is a mechanism used is electrical machines to serve as an interface between the pinion mechanism and the rotor of the machine. It transfers the increased rotational speed from the flywheel to the rotor of the generator.

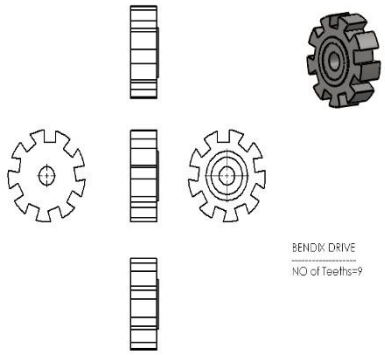


Figure 17 The Front, Side and Plan view of Bendix Teeth

Specifications of Bendix Drive

Number of teeth = 9

Made of vanadium

Speed Ratio

$$SPEED\ RATIO = \frac{\text{NO OF TEETH OF LARGER WHEEL (FLYWHEEL)}}{\text{NO OF TEETH OF SMALLER WHEEL (BENDIX)}}$$

$$SPEED\ RATIO = \frac{120}{9} = 13.3333$$

Therefore, the speed ratio of the machine is 13.333. This implies that the speed of the generator will be about thirteen (13) times that of the speed created by the applied force (Khurmi & Gupta 2018).

Returning Spring

This helps to return the speed breaker back up when the applied force is removed. It is attached to the barrels that are attached to the speed bump.

Specifications of Returning Spring

Number of springs = 4

Resistance of spring = low

DC Generator

It converts the rotational motion produced to electrical energy. The generator's rotor receives the rotational motion from the Bendix causing it to rotate in a magnetic field to generate electricity.

Figure 18 the Dc Generator

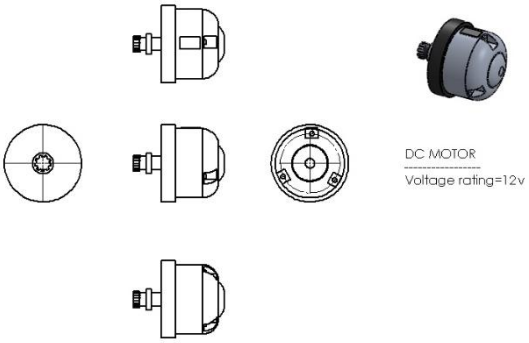


Figure 19 The Front, Side and Plan View of the Generator

Specifications of DC Generator

Voltage rating = 12V

Frequency = 50Hz

Maximum speed = 3000rpm

Battery

The battery is the part of the machine that stores electricity. The electricity it stores is used to power the street lights when its night time.

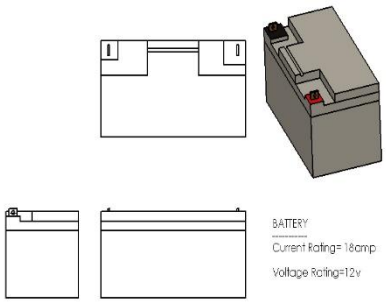


Figure 20 Front, Side and Plan View of the Battery

Specifications of Battery

Current rating =18AH

Voltage rating = 12V

Inverter

This is the part of the machine that converts stored dc voltage from the battery into a suitable ac form that can be used by the lighting points.

Specifications of Inverter

Rating = 500W

Wave = Sine wave

Structuring

The support structure of the machine is made from angle iron which is used to form the pillar and base holding up various components. There is also a barrel attached to the speed bump and springs to take the speed bump back up immediately the applied force is removed.

Dimensions of Structure

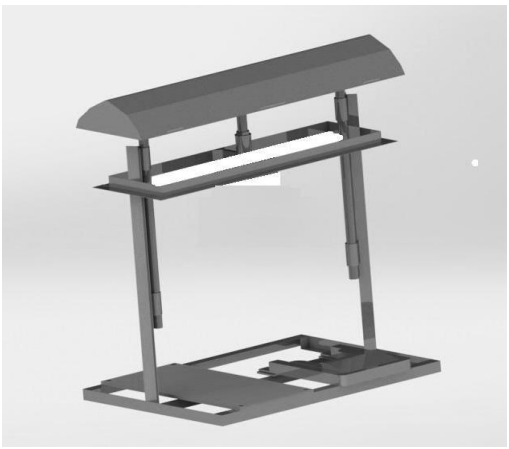


Figure 21 the Support Structure of the Model

Size of angle iron = 4cm

Length of vertical iron = 91cm

Number of vertical iron = 4

Size of barrel = 3.81cm

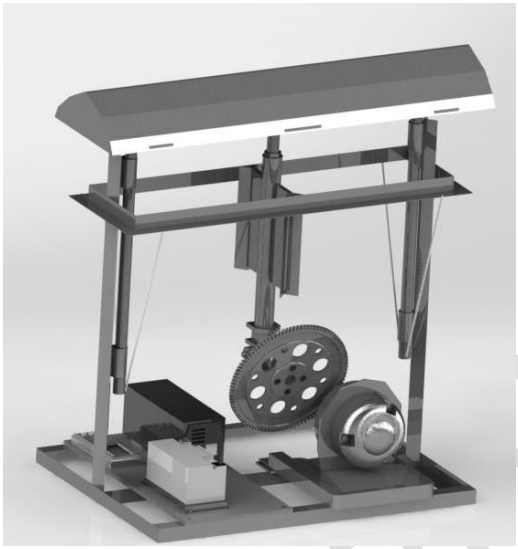


Figure 22 Front View of the Model

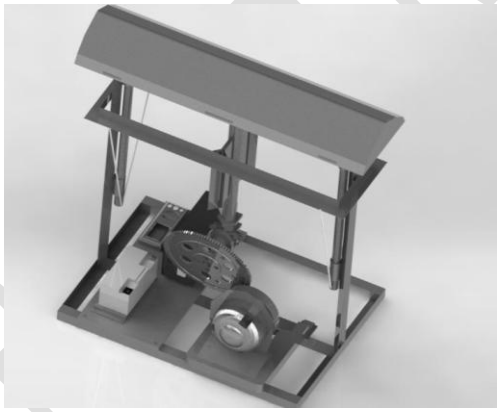


Figure 23 Plan View of the Model

Power Calculation

Considering a mass = 94Kg

The distance of travel of speed breaker = 10cm

Work done = weight of body x distance travelled by the speed bump

Weight of body = 94 x 9.81 = 922.14N

Therefore, Work done = 922.14 x 0.1 = 92.214J

Assuming this is the power generated per second, then,

Power generated in one minute = 92.214/60 = 1.53W

Power generated in one hour = 60 x 1.53W = 92.214W

Power generated for 24 hours = 24 x 92.214 = 2.2KW

Case Study

In the context of this study, a survey was carried out on the power generation using speed breakers at a convenient location. It could be situated here in Benin City. The choice of the location was affected by some topological factors of the road in the designated area and the efficiency of the drainage system, the absence of street lights and speed breakers on the road.

Ikpoba hill in upper mission extension in Uteh community was chosen as a suitable location because it fits all the aforementioned criteria. An average distance of 1.4km was covered starting from the end of the Ikpoba river bridge passing along Tenboga junction, all the way to Erediawa junction.

Based on the distance covered (1.4km) an average of 65 lighting points would be needed.

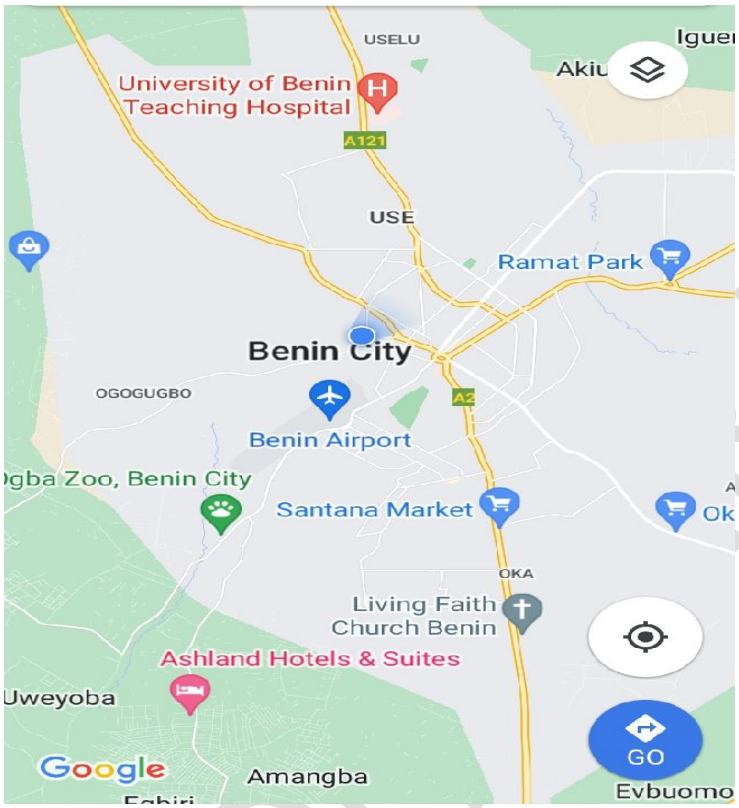


Figure 24 Google map location of uteh community

Power Calculation

Assuming:

The mass of the average vehicle travelling over the speed breaker = 300kg

Height of speed breaker = 10cm

Then,

Work done = weight of the body x distance travelled by the vehicle

Weight of body = 300kg x 9.81 = 2943N

Distance travelled by the body = height of speed breaker = 10cm

Power = work done/second = (2943 x 0.1)/60 = 4.905W

The output power developed for 1 vehicle passing over the speed breaker for one minute = 4.905W

Assuming 30 vehicles passes over the speed breaker for one minute, then power generated = 30 x 4.905 = 147.15W

Therefore power generated for one hour with 30 cars per minute = 147.25 x 60 = 8.829KW

Power developed from 7am – 7pm (12 hours) = 105.9KW

Assuming power factor = 0.85

The total power developed = 105.9KW/ 0.85 = 124.644KVA

To estimate the number of batteries to be used we calculate using reactive power.

Voltage = 240V

Recall Q = AV

A = Q/V=124.644KVA/ 240V = 519.35A

Capacity of battery, C = A x Hours, Hours = 12hrs

C = 519.35 x 12 = 6232AH

Number of batteries needed = 6232/ 200 = 31 batteries

The street light to be used is a High Pressure Sodium Lamp (Van Vliet and de Groot, 1986).

The number of street lights to be installed on the road = 65 street lights (150w each)

Therefore, the total power consumption = 65 x 150 = 9750 = 9.75KW

Converting to apparent power,

Power = 9.750KW/ 0.85 = 11.471KVA

Therefore, a 12.5 KVA inverter will be used.

The power generated is more than enough to supply the load and has enough capacity in case of future extension.

Principle of Operation of the Speed Breaker Power Generator

The project is concerned with the generation of electricity from a speed breaker setup. The load (the weight of the person applying the downward pressure) acting upon the speed breaker setup, is thereby transmitted to the rack and pinion arrangement.

Here the reciprocating motion of the speed breaker is converted into rotary motion using the rack and pinion arrangement. The axis of the pinion is coupled to a flywheel. The teeth of the flywheel are connected to the teeth of the Bendix at 90̊ (which is coupled to the rotor shaft of the motor, which serves as a generator). The flywheel multiplies the speed of the Bendix which makes the speed sufficient to rotate the shaft of the generator. The generator produces the DC current. This DC current is now sent to the storage battery where it is stored. This current is then utilized for lighting purpose.

Results and Discussion

Test

1. Output voltage with load battery

2. Output voltage without load (battery)

Result

Output with Load

Voltage = 3.23V

Figure 25: Multimeter voltage output with load (battery)

Output without load (Battery)

Voltage = 4.46V

Figure 26: Multimeter voltage output without Load (Battery)

Analysis

I. The output voltage of the generator when the battery is not connected is higher than when the battery is connected.

II. The maximum voltage obtained during several trials was about 5 volts, thus the suitable battery size for this study would be a 6 volts battery but those are not readily available and so a 12 volts battery is suitable.

Advantages of Power Generation System using Speed Breaker

1. Pollution free power generation
2. Simple construction, mature technology, and easy maintenance.
3. No manual work necessary during generation

4. No fuel transportation pro
5. No consumption of any fossil fuel which is non-renewable source of energy

Conclusions

This study opined the design of a speed breaker mechanism for power generation. Based on the experimental results obtained from our study, this paper presented a model, experimental setup, analysis, design and challenges of the proposed mechanism. In addition, the viable immediate load applications are outlined, and an up to date review of key findings and limitations of this study on existing research, with research trends in speed breaker mechanism are also presented. Further, the research relevance and improvements on traditional speed breaker systems are highlighted and further success in the performance evaluation with regard to the voltage generated to the variation in load and also are outlined as follows:

1. Assuming the weight of the body moving over the speed breaker is kept constant on the speed breaker. Now the voltage produced is dependent on the variation in speed at which the speed bump was pushed downward. If the bump is pressed down slowly, then it certainly applies the pressure on the speed breaker for a long time so the voltage is produced over a longer period but it has a small value. While we keep on increasing the speed at which the speed bump moves, the period of pressure is small but speed is high and thus a higher voltage is produced but over a short time.
2. Assuming the speed at which the speed bump is pushed by different types of cars is kept constant, it becomes that the voltage produced varies with the weight of the body (vehicle) on the speed breaker. Assuming least load capacity was applied and then it will certainly apply a very low pressure that will result in the least voltage produced. Now as the load increases the produced voltage also keeps increasing because the pressure on the breaker keeps increasing with the load.
   Furthermore, study was successful albeit some slight limitations one of which was the value of voltage produced was lower than expected but with the implementation of minor rectifications a suitable voltage can be obtained, hence this study is subjected to future research.

Recommendations

The following recommendations for the speed breaker power generator mechanism are given

1. A charge control circuitry should be installed in future works to ensure proper charging of the batteries to elongate its life span.
2. An Automatic Switching system should be installed to switch on and off the lights at appropriate time.
3. More than one rack and pinion connected to generators can be incorporated under the same speed bump so as the increase the general electrical output produced by one passing vehicle.
4. A casing can be incorporated to serve as protection for the internal components of the machine.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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