RECYCLING KINETIC ENERGY FROM SPEED BUMP TO GENERATE ELECTRICITY

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ABSTRACT

Speed Bump one of the safety devices that use for the road. Even though it have the ability to make people reduce speed, most of the road users have a negative perception with the speed bump because it can cause damage to the car and sometimes can cause danger to the users if it not use with the right way. A system called electricity generating speed bump will be developed to change people negative perception about speed bump by expanding the speed bump function to be a source of current. This system is a combination of mechanical part that contact with speed bumps. The combination then use by generator to produce electricity. Mechanical part then consists of gear combinations, ramp and shaft. The current produced by the generator is stored in batteries to be use of the equipment. This system involved the knowledge of the generator function with Faraday's Law concept, gear ratio, generator rotating rate and also the charging process. Analysis done to know the effectiveness of this system to be used in the real world. The analysis done with two parameters which are number of vehicle hit speed and weight applies to speed bump. From the two parameters, the ability of this system to produce output can be known. Since this system was developed with the small ratio, calculation needs to be done to know the ability of this system in huge scale which is applied in the real world. This system will be applied in low vehicle speed and high number of users. Thus, this effective system not only use for the safety element in the road but also contribute to electricity supply.

ABSTRAK

Bonggol penghalang kelajuan merupakan salah satu kaedah yang digunakan sebagai elemen keselamatan di jalanraya. Penggunaan system ini dilihat mampu mendorong pengguna mengurangkan kelajuan kenderaan apabila ingin melaluinya. Malangnya penggunaan bonggol ini masih lagi tidak mendapat sambutan baik daripada pengguna jalanraya kerana kadangkala bonggol ini boleh mengakibatkan kerosakan pada kenderaan sekaligus mengakibatkan bahaya kepada pengguna jalanraya. Satu sistem baru akan dibangunkan dimana sistem ini dilihat mampu mengubah tanggapan buruk pengguna jalanraya terhadap penggunaan bonggol.apabila bongol ini bukan sahaja berfungsi sebagai bonggol penghalang kelajuan malahan ianya mampu menjadi sumber tenaga elektrik. Dengan gabungan bonggol, elemen mekanikal dan penjana, system ini mampu menghasilkan tenaga elektrik. Elemen mekanikal terdiri daripada rangkaian gear, spring dan aci yang mampu menukarkan tenaga keupayaan dihasilkan oleh kenderaan melalui bonggol kepada tenaga kinetik untuk menggerakkan generator. Tenaga yang dihasilkan kemudian akan di caskan kepada bateri untuk digunakan oleh peralatan elektrik. Pengetahuan meneganai Hukum Faraday's, nisbah gear, kadar keupayaan penjana dan proses mengecas digabungkan dalam projek ini. Keupayaan system ini untuk diaplikasikan pada kehidupan seharian di kaji melalui ujian yang dijalankan pada model yang dibangunkan. Parameter utama yang digunakan ialah kadar kekerapan bonggol di gunakan dan berat kenderaan yang menggunakan bonggol ini. Kadar keluaran voltan yang dihasilkan dijadikan sebagai parameter keluaran bagi ujian dan analisis. Sistem ini akan dibangunkan dikawasan tumpuan ramai yang memerlukan pengguna mengurangkan kelajuan kenderaan mereka. Siatem ini bukan sahaja mampu menjadi elemen keselamatan di jalanraya malahan mampu menjadi sumber tenaga elektrik kepadapengguna.

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LIST OF SYMBOLS AND ABBREVIATIONS

cm	-	Centimeter
m	-	Meter
km/h	-	Kilometre per hour
mph	-	Metre per hour
Kw	-	Kilowatt
LED	-	Light Emitting Diode
V	-	Voltage
rpm	-	Revolution per minute
W	-	Watt
OFF	-	Operation stop
ON	-	Operation start
Mv	-	Milivolt
kg	-	Kilogram
emf	-	Electromagnetic Force

CHAPTER 1

INTRODUCTION

1.1 Overview

The speed bump is a speed reducing feature design to slow off traffic or reduce their speed through vertical deflection mechanism. A speed bump is a mechanism with a plain piece installed on the roadway at a gradient and the heights ranging between 3 and 4 inches (7.6 and 10 *cm*). The depth of mechanism buried approximately 1 foot (30*cm*) contrasting with the width approximately 10 to 14 feet (3.0 to 4.3 *m*). The speed bumps can be made of recycled plastic materials, metal, asphalt or rubber that is durable. It can be constructed of various sizes and can be installed on a road, adapting pairs of either four foot or six foot devices separated each for either side of the road with the lowest gradient facing the coming traffic and connected across the entire road surface. The speed bumps was utilized around the world and can be regarded as one of the road safety features to alert the road users on the speed limit where vehicle speeds are statutorily mandated to be at predetermine low speed, usually 40 *km/h* (25 *mph*), or 8 to 16 *km/h* (5 to 10 *mph*) in residential area, school crossing or car parks. These device act as dual function, beside for the road safety it

also can produce some amount of electric current from generator concept[1] of design and can be utilized for lighting or it's caution beacon where the device was placed. Most of all, it's an environment friendly device. This is an advantage as the device is self sustained and cheep to implement.

Electric generator is a device that converts mechanical energy obtained from an external source into electrical energy as the output. It is important to understand that a generator does not actually create electrical energy. Instead, it uses the mechanical energy supplied to it to force the movement of electric charges present in the wire of its windings through an external electric circuit. This flow of electric charges constitutes the output electric current supplied by the generator. This mechanism can be understood by considering the generator to be analogous to a water pump, which causes the flow of water but does not actually create the water flowing through it. The modern-day generator works on the principle of electromagnetic induction discovered by Michael Faraday in 1831-32. Faraday discovered that the flow of electric charges could be induced by moving an electrical conductor, such as a wire that contains electric charges, in a magnetic field. This movement creates a voltage difference between the two ends of the wire or electrical conductor, which in turn causes the electric charges to flow, thus generating electric current[2]. One of the interesting application can be develop using this concept is expanding the speed bump to be a current generator. Speed bump typically use to reduce the speed of vehicle in term of road safety. Beside the typical function, the features can generate electricity. The basic and simplest technology of the transition from kinetic to electrical energy by incorporated a generator. This is no doubt served as an interesting source of the renewable energy that they would demand.

Renewable energy can be defined as the energy generated using natural resources that are infinite and can be renewed. In other word, because of the natural source use, this energy can be use continuously or save. This can be classified as an environment friendly energy that cause a minimal or zero effect to green house, in contrast to the fossil fuel, as the name suggests exist perpetually and abundant quantity in the environment. Renewable energy is ready to be harnessed, inexhaustible and the more important it is clean alternative to the fossil fuel[3]. There are many sources for renewable energy such as wind, heat or light from sun,

ocean wave, geothermal energy, potential energy of running water, energy from waste and other. Renewable energy is becoming more popular to be research and development now days because of its advantages. Many countries are already switching to renewable energy. Apart from looking for the clean energy source from the environmental point of view, the search for new energy source as substitutes for the depleting fossil fuel is the main factor constitute to such drive. With a projected world population of 10 billion by the year 2050, the increasing global energy demand will propel a more rapid depletion of world's fossil fuel reserve. Such possible tightening of energy supplies in the future wills inevitably result in an upsurge of fuel demand thus contribute to higher electricity prices. Renewable energy can reduce the reliance on the exhaustible source of fossil fuels. Developing countries spending huge amount of investments in the development of renewable energy technologies. It can be envisaged that when those equipments and system mature enough to produce on a large scale, the unit price of electricity to generated could be comparable to that of conventional fossil fuel burning process[4].

1.2 Problem Statement

The increasing number of accident occur increase force us to find the cheaply solution to prevent it. The use of speed bump is well known nowadays. The usage of this speed bump show the risk of dangerous in road can be reducing. Speed bumps are 3-4 inches high and 12-22 feet long. They are found on residential. It works by forced the driver to slow the speed until 16-40 *km/h* in order to avoid driver discomfort. Although speed bumps are very effective in keeping vehicle speed down, their use is sometimes controversial as they can cause noise and possibly vehicle damage if taken at too great a speed. But it seems to be more effective base

on the chart in figure 1.1. Figure 1.1 shows the effect of bump type on crash frequency. Figure 1 shows, the crash rate decreased 48 percent on 14-foot bump streets, from 0.76 to 0.39 crashes per year. On 22-foot bump streets, the crash rate decreased 32 percent, from 3.76 to 2.55 crashes per year. The 22-foot bump streets have higher crash frequencies because they have higher traffic volumes and longer street sections. It shows that all of the speed bump type will reduce the number of crashes per year[5]

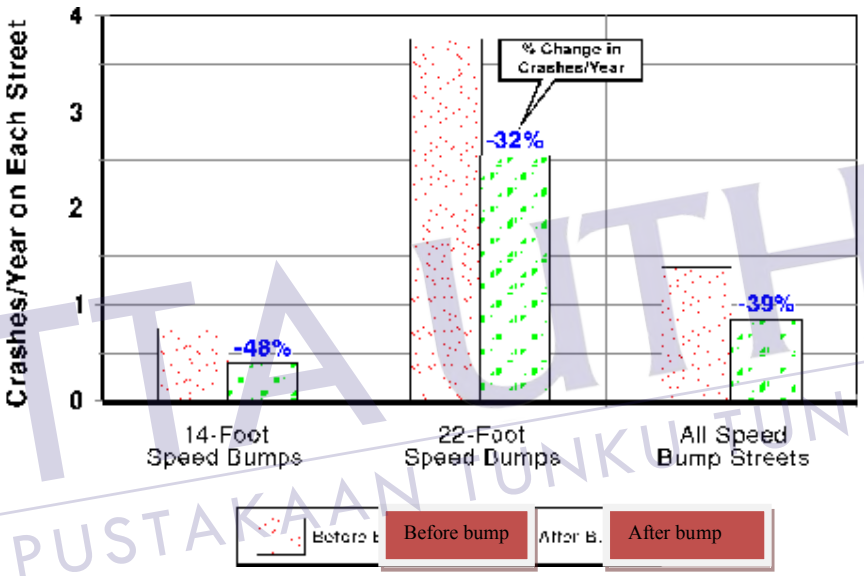

Figure 1.1: Effect of Bump Type on Crash Frequency[5].

The installation of speed bump got negative feedback from the road user because it can cause some disadvantages such as cause damage to some vehicles, can increase traffic noise, especially when vehicles pass by and many more disadvantages. In order, to make sure the installation of speed bump seems to give more advantages for the user, the function of speed bump can be expanded to be a current generator.

In Malaysia, the types of source usual use for electricity generation stations are from hydro and thermal. The hydro type usually comes from the water and river in some part of Malaysia. While for thermal type, usually use of source such as gases, petroleum and coal. There are many types of power plant in Malaysia that

have link with Tenaga Nasional Berhad to in order to supply electricity for overall country. Since this type of source is the only suitable source in Malaysia, it still used until today even the overall cost for this system is high. The high cost of this method due to the cost of high technology equipment use to generate the electricity and high price of fossil fuel. The raw chart of the price of gas and how much it has gone up since 1919 (the first year of available EIA statistics) show in figure 1.2. It can be seen that a low of $0.17/gallon in 1931 rise all the way up to $3.53/gallon in 2011[6].

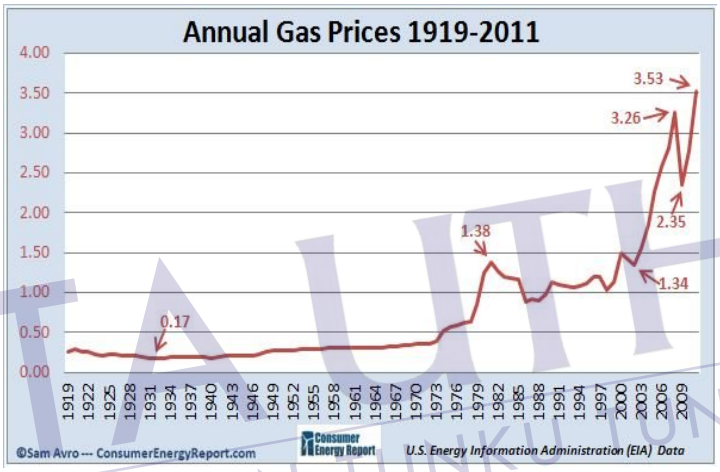

Figure 1.2: Raw Chart of Annual Gas Price from 1919 to 2011[6]

This entire source is generated in Malaysia and it becomes the main source of country income. In term of economy part, the more sources can be selling more income for our country. Thus it needs to reduce the use of these sources in our country as we can by replace it with cheaper source.

The main value of electricity generated from power plant in our country is about 500kV. This value of electricity send to main substation before it can be delivered to the consumer. Sometimes there is phenomena occur when the needs are exceed the supply. This call overloads phenomena due to the growth of high power equipment used today. Figure 1.3 shows the increment of power consumption in Malaysia. The graph indicates that the numbers of power need increase as time increase due to development of our country[7].

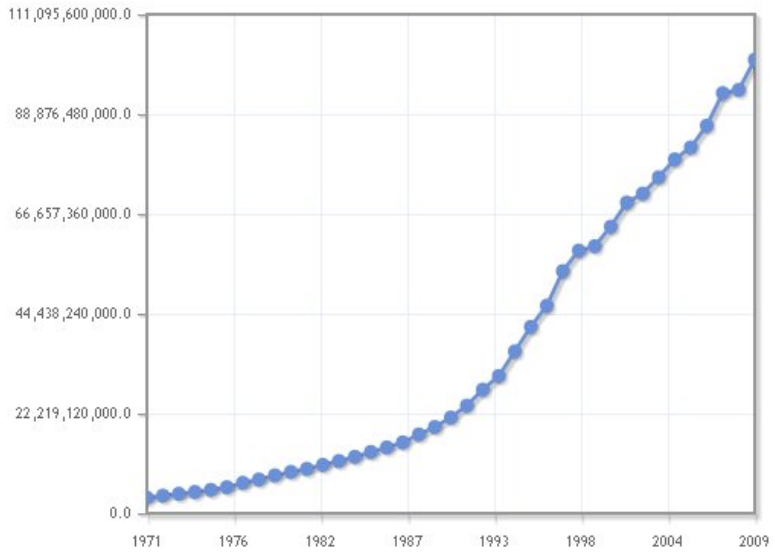

Figure 1.3: Graph of Increment Power Consumption in Malaysia[7]

Study on electrical energy use in residential area show that the high use of electricity need in our country. From the study, there are about 275 *kW* electric powers consumed by the 50 residents during morning (7.00 am to 12.00 pm). At the evening (12.01 pm to 6.00 pm), the power consumed are about 184 *kW*. The highest power consumed during night, about 365 *kW*. But this study only refers to the residential area without considering other areas especially industrial area. Due to the increasing of electricity consumption there are need to find an alternative solution especially for small electricity used equipment[8].

Nowadays use of source such as gas and coal is not continuous since it cannot be renewable. Some study show the prediction make about the continuity of this source show that this source will be end someday.

Due to the problems found, there are need to produce something that can generate electricity power by apply renewable energy on everyday use term. This system can be the most efficient and easy use of system to generate electricity. One of the effective methods by producing the electricity generation speed bump.

1.3 Objectives

The objectives of the project are:

i) To investigate how electrical power can be harvested using proposed system call electricity generating speed bump.
ii) To develop a system of electricity generating speed bump that can produce electricity power.
iii) To test and evaluate the effectiveness of this system particularly can be used in the real world.

1.4 Project Scope

In order to finish this project, there are five scope need to be followed:

i) The calculation is done by considering minimum of voltage 3.0 Volt
ii) The system of electricity generation bumper is developed in small scale of the usual size of the normal speed bump. The range size is about 20 % of the actual size of speed bump.
iii) All of the mechanical part size use for prototype is suitable with the ability of the system to give electricity to a Light Emitter Diode (*LED*) as the reference.
iv) The main part of analysis for this project focused on the relationship between the numbers of cars hit a speed bump and weight of transport hit speeds in some range to the output voltage.
v) This project model will be done for prototype and demonstration use only.

1.5 Design of Prototype

1.5.1 Devices Used and Size

To develop the prototype, the item use only base on the project scope where the system develops for demonstration is used for giving the electricity to a Light Emitter Diode (*LED*) by minimum charging power is 0.09 watts and 3*V*

1.5.1.1 Speed Bump

Known as a sleeping policeman, use in road to reduce the vehicle speed in certain places. Actual size about 14 inches or 35 *cm*. For the prototype the size will be 20% of actual size which is about7 *cm*. Figure 1.4 shows the Speed Bump

Figure 1.4 : The speed bump [9].

1.5.1.2 Gear

A rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source[10]. Figure 1.5 shows the gear. For this project, two type of gear uses which are:

- Spur gear

First gear

Diameter =1.9 *cm*

Tooth number=10

Second gear

Diameter=4*cm*

Tooth number =80

- Rack gear

Diameter= 0.6*cm*

Tooth size=12 .

Figure 1.5: Gear[10]

1.5.1.3 Gear Shaft

Gear shaft connect with the generator. It usually uses to move the generator which is connect to the mechanical part. Figure 1.6 show the picture of gear shaft

Figure 1.6: Gear Shaft[11]

1.5.1.4 Dynamo

A dynamooriginally another name for an electrical generator. Generator that produces direct current with the use of a commutator. Today, the simpler alternator dominates large scale power generation, for efficiency, reliability and cost reasons[12]. Since the power need to generate is 0.09 watt for charging battery with resistance of 100 ohm, the voltage need from dynamo is $3V$. Figure 1.7 show the dynamo.

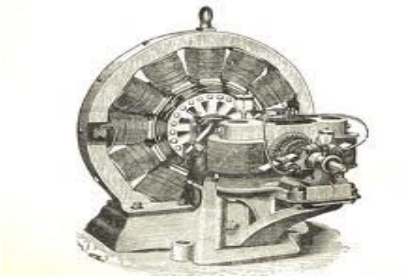

Figure 1.7: Dynamo[12].

1.5.2 Circuit Use

1.5.2.1 Charge Controller Circuit.

This circuit use to control the charging process for the battery. The current generates from the generator will be stored in the battery. This circuit can control the process especially to avoid overcharging that can cause damage to the battery. Figure 1.8 shows the example of the circuit diagram of the charge controller circuit.

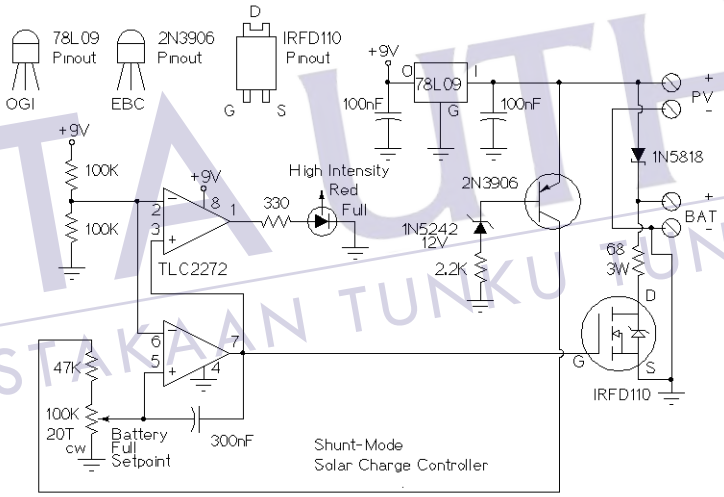

Figure1.8 : Charge Controller Circuit.

Most quality charge controller units have what is known as a 3 stage charge cycle that goes like this :

- During the Bulk phase of the charge cycle, the voltage gradually rises to the Bulk level (usually 14.4 to 14.6 volts) while the batteries draw maximum current. When Bulk level voltage is reached the absorption stage begins.
- During this phase the voltage is maintained at a Bulk voltage level for a specified time (usually an hour) while the current gradually

tapers off as the batteries charge up.

- After the absorption time passes the voltage is lowered to float level (usually 13.4 to 13.7 volts) and the batteries draw a small maintenance current until the next cycle.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss about the overview of the project roughly on how it can work. Some previous method that related to this project also discuss in this chapter.

2.2 How Speed Bump Can Generate Electricity.

Basically, the method of expanding speed bump function can be divided into two parts which are mechanical operation which use to start the generator and generation part. The main concept applies to this system the transition of kinetic energy applies by mechanical part to operate the generator in order to produce electricity.

For the first part which is mechanical part is a combination of drive and driven to produce the movement of a shaft which is connected straight to generator. The main source of force for gear movement come from the surface of speed bump

where weight of vehicle give potential energy. In other word potential energy is the beginning operation of this speed bump system. When the vehicle step on the speed bump surface, the force will make the first gear (rack gear) move to drive the second gear and then third gear (spur gear). The second gear then connects with shaft to operate the generator. For energy storage function, the generator connected with the charge control circuit and the energy produce store in a battery. Figure 2.1 show the basic design of this speed bump for generates electricity while figure 2.2show the connection for mechanical part applies in the speed bump system.

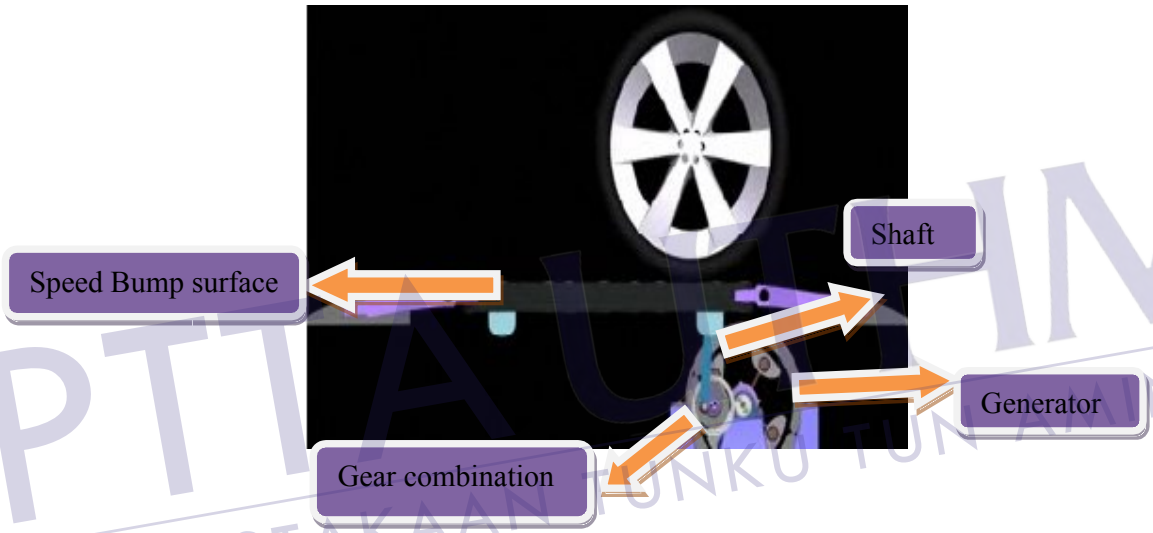

Figure 2.1: Basic design of the Speed Bump for generating electricity[13]

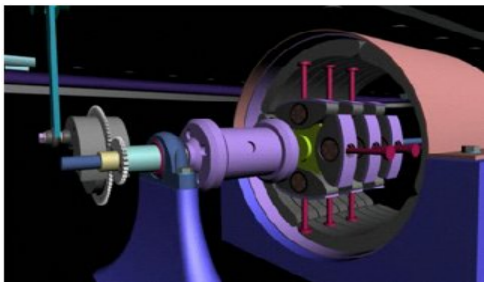

Figure 2.2: Connection for Mechanical Part applies in Electricity Generating Speed Bump[13].

While for second part which is generation part, it involves the operation in the generator. Basically generator operation is based on the principle of

electromagnetic induction. When conductor move right angle with the magnetic field, a voltage will induce [2].

2.3. Related Research and Previous Method

2.3.1. How Generators & Regulators Work

This electronic article paper retrieved from.venselenterprises.comdiscussed about the generator and regulator in term of technical part. Generator consists of armature, field coil and commutator. An armature is a bare hardened steel shaft that added with a series or group of non-insulated copper wires wound close together. The complete in turn of non insulated copper wires then called a loop. The loops of wire are then embedded in a series of slots in an iron core. This iron core is then attached to the armature shaft where the shaft spins and helps to generate the electrical current. Thus the size of the wire and the number of wires in the loop will affect the output of the generator[14].

The commutator is a series of segments or bars that are also attached to the armature shaft at the rear of the armature. It functions to complete the circuit form as there is connection between the wire ends from the loops of the armature windings in the iron core that is attached to the commutator[14].

Field coils are windings or the group of wires that are wrapped around the pole magnet which is function to increase the current produce by generator until it can be used by the battery or load. It is done this function by bringing the current drawn to the pole of the magnet and built it up. The increased strength in current will force even more current to be drawn to the pole magnets, which will continue to build up current[14].

After the generator develops the current, it is the brushes that carry the current to the field circuit and the load circuit, thus the electricity can be used by the

battery and the accessories. This process is called commutation. The brushes will ride on the commutator segments of the armature. Brushholders hold the brushes in position by way of spring tension. The insulated brush is the positive brush and is connected to the terminal of the generator, and to one end of the field coils. The other end of the field coil is connected to the insulated terminal of the generator[14]. Figure 2.3 show the internal part connection of generator.

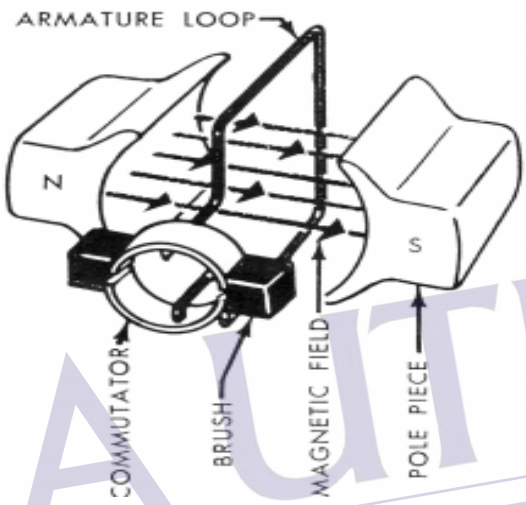

Figure 2.3: Internal Part Connection of Generator[14].

Generator function starts when the armature loop is place between two pieces of magnet with different pole. Weak voltage produce as the armature loop is rotate clockwise but the voltage increase after the current generated flow at the armature and then to the field coil. As already known field coil increase the current strength. The continuous process of armature rotating that cut the current produce by field coil produce more current and stronger voltage[14]. Knowledge of generator operation from this research help for the project since the generator is the main part of electricity generation speed bump project.

2.3.2. Combining the Wind Power Generation System with Energy Storage Equipments

The journal paper published by Ming-Shun Lu Chung-Liang Chang (senior member, IEEE), Wei-Jen Lee (Fellow, IEEE), Li Wang (senior member, IEEE) discussed about the requirement of the energy storage equipment and how it influences the reliability of the wind energy. Discussions include how the combination of the energy storage equipment with a wind energy system reduces the fluctuation of the wind power. The energy storage application for reducing the output variation during the gust wind is also studied. The research conducted by running the simulation to produce waveform of power produced versus time. The simulation is done in two conditions of wind speed which is a small variation of wind speed and large variation of wind speed. Some parameter also taken as consideration by varying the storage capacity and maximum discharging and charging power rating requirement for the energy storage equipment.

Base on the discussion, the model of the wind turbine and energy storage built base on the study system consisting of wind turbine and energy storage devices where dynamic modules related to the proposed wind generation are established. The collection of wind turbines, wind speed information, wind turbine parameters, generator parameters, and the characteristics of the control systems are included. The dynamic model used for simulation is shown on figure 2.4. This model can be used to simulate a wind gust by varying input wind speed to the turbine model. For energy storage module, EPRI battery model CBEST is used. It has the ability to simulate the dynamic characteristics of a battery. This model simulates power limitations going into and coming out of the battery as well as ac current limitations of the converter. The model assumes that the battery rating is large enough to cover all energy demand that occurs during the simulation[15]. Battery efficiencies both in the retrieval and in the storage of energy are taken into consideration.

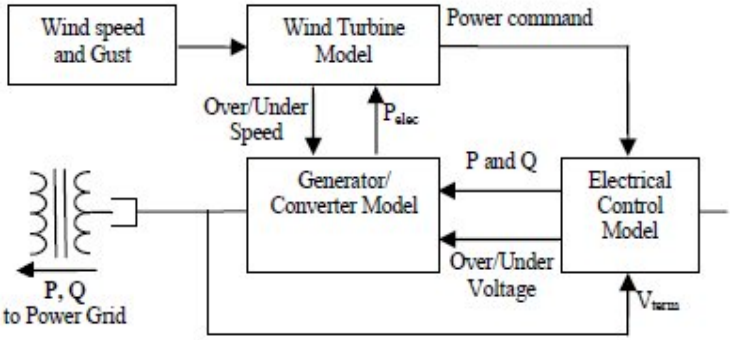

Figure 2.4 :Dynamic model of GE 3.6 MW wind turbine[15]

Figure 2.5 shows the simulation result obtained for small variation of speed while figure 2.6show the simulation result obtained for large variation of speed. Both simulation results show that by using the energy storage equipment increase the reliability and increase the fluctuation of wind power.

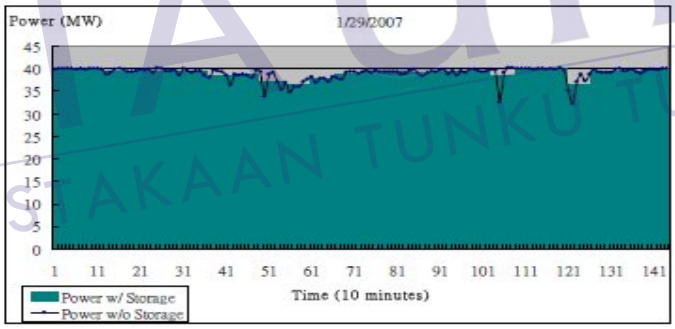

Figure 2.5 : Simulation Result Obtained for Small Variation of Speed[15]

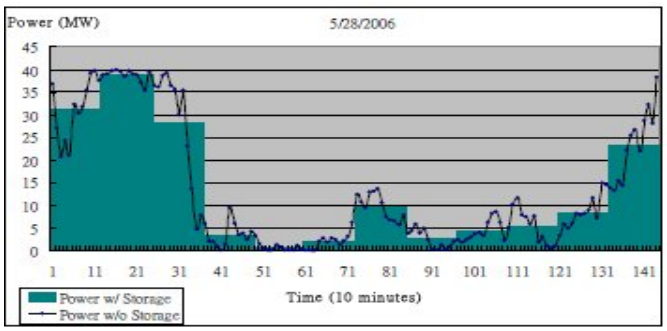

Figure 2.6 : Simulation Result Obtained for Large Variation of Speed[15]

This research shows that the need of the energy control circuit to get the best result in term of the performance producing output power. The model used and important parameter need to be taken such as storage capacity and maximum discharging and charging power rating requirement of the energy storage equipment can be used as reference for the project.

2.3.3. Energy Harvesting From a Rotating Gear Using an Impact Type Piezoelectric MEMS Scavenger.

A conference paper published by P. Janphuang(EcolePolytechniqueFédérale de Lausanne (EPFL), D. Isarakorn, D. Briand (Institute of Microengineering (*IMT*)), and N.F. de Rooijfrom(Sensors, Actuators and Microsystems Laboratory (SAMLAB), Neuchâtel, Switzerland) are about a system to harvest electrical energy by using scavenger energy. Scavenger energy defined as the energy that from the external sources such as solar power, thermal energy, wind energy, salinity gradients and kinetic energy captured, and stored for small, wireless autonomous devices. The method used to harvest energy by using a gear driven by an inertial mass system and a piezoelectric transducer located over the gear in order to keep the system as compact as possible. The piezoelectric transducer, which is a cantilever structure in our case, is coupled to the inertial mass system through a tip at the free end of the cantilever. When the gear start moving, the piezoelectric cantilever set into motion by the impact between the gear teeth and the tip of the cantilever. In consequence a part of kinetic energy accumulated in the inertial mass system is converted to electrical energy through the impact on a piezoelectric structure. The system is demonstrated by using a motor as the inertial mass. A silicon substrate served as a support layer of the piezoelectric material since silicon micromachining allows the easy fabrication of an AFM like cantilever including a silicon tip[16]. This paper shows the best dimension and design of piezoelectric harvester to harvest maximum energy. The main parameter that needs to be considered it thickness of the

piezoelectric bender. The use of gear and motor also calculated to produce the 25 rpm of speed for testing purpose. The test conducted to investigate the variation of voltage produces with different tip depth. Figure 2.7 shows the schematic diagram of the experimental setup used for testing the impact type *PZT MEMS* harvester.

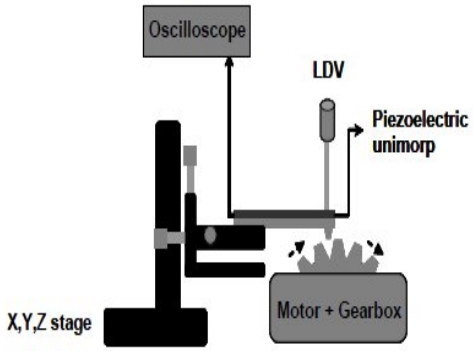

Figure 2.7: Schematic diagram of the experimental setup used for testing the impact type *PZT MEMS* harvester[16].

From the result obtained, as the tip death decrease, the number of displacement also decreases. Because of both factor decreases, the output voltage produced also decrease. The knowledge about gear and piezoelectric can produce electricity can be the reference for the project.

2.3.4 Gear Ratios and Structures

The electronic article paper wrote by Henri deVick discussed about the calculation of gear ratio and the structure of gear. The gear ratio can be defined as the ration number of teeth in one gear divide by number of teeth in other gear. It is shown in the example in figure 2.8.

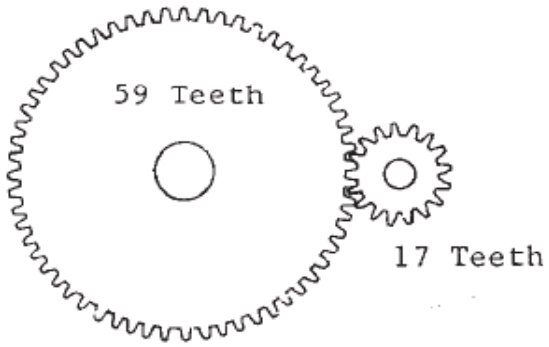

Figure 2.8: Example set of gear[10].

From figure 2.8, the gear ration can be calculated using formula Teeth in gear 1 ÷ Teeth in gear 2 = 59/17or 17/59. In term of writing the gear ratio usually be written using semicolon sign, (59:17) where it represents fifty-nine seventeen or seventeen fifty-nine. Usually the big number will be mentioned first. For the gear with a small number of teeth it can be called as pinion where it can be small size or big size.

In gear structure discussion, the paper explained about the gear with high number of teeth run with gear with a small number of teeth. This combination called gear and pinion. For gear rotation, the gear basically can be turned clockwise and anticlockwise. Important theory need to be considered is when pinion rotates in a clockwise direction; the gear will rotate in anticlockwise condition. If the pinion turns anti clockwise direction, the gear will turn clockwise direction. The speed of gear rotation measure in revolution per minute, rpm where if 16 cycles complete in 1 minute, so the speed is 16rpm. There also the calculation for speed ratio with the formula of *RPM* of one divided by the *RPM* of the other *RPM* 1: *RPM* 2. The speed of pinion need to be big or goes faster compare with gear. The main key mentioned is multiplying any number by a fraction that has a small number on top and a large number on the bottom will give a smaller number for an answer. The example in figure 2.9 and figure 2.10 show the right calculation.

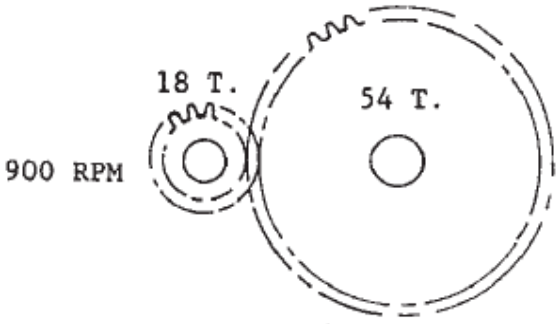

Figure 2.9: Example of Gear Speed Calculation[10].

Solution:

Step 1. : 54 T. Gear is bigger, so it will go slower.

Step 2 : 900 × 18/54 = 300 *RPM*.

300 is less than the speed of pinion which is 900, so the calculation is correct.

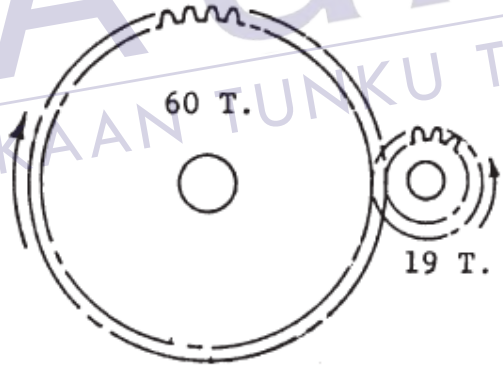

Figure 2.10: Example speed calculation for pinion[10].

Solution:

Step 1.: 19 T. Pinion is smaller, so it goes faster.

The answer will be bigger than 81 *RPM*.

Step 2 : 81 × 60/19 = 255.79

255.79 are bigger than the speed of gear which is 81, thus the calculation is correct.

The gear structure consists of outside diameter, face and hub. This diameter is called the outside diameter. Figure 2.11 shows the outside diameter of the gear.

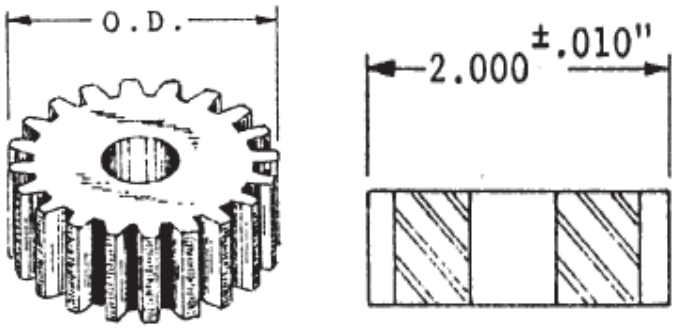

Figure 2.11: Outside diameter of gear[10].

The outside diameter of a gear is shown in millimeters or inches with a fairly loose tolerance. The dimension is called the face of the gear, or the face width. It's given in millimeters or inches with a loose tolerance. Figure 2.11 shows the face of the gear.

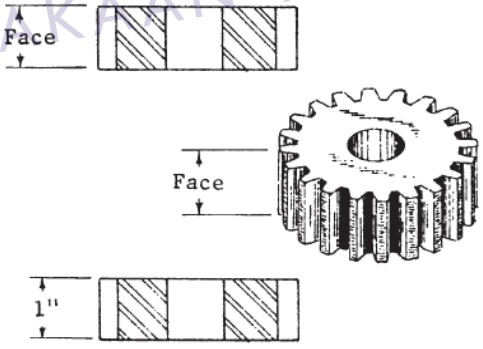

Figure 2.11: The Face of the Gear[10]

The lug or shoulder projection found on some gears is called a hub, or hub projection. Figure 2.12 show the hub of the gear[10].

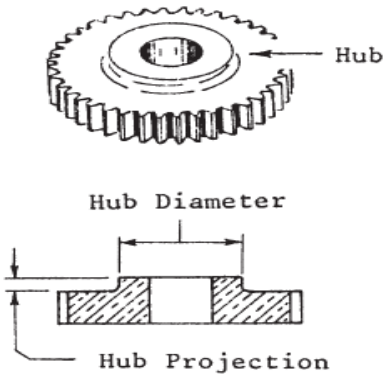

Figure 2.12: Hub of the gear[10].

There are three types of normal gear structures or construction. Gears can be Plain, Webbed, or Spoke[10]. Knowledge about the gear is related to speed bump generate electricity project where fair use to produce rotating in generation part.

2.3.5. Handy Formula to calculate the output of any generator at any given RPM

This webpage article published by windstuffnow retrieved on May 28, 2012 discussed on how to calculate the output voltage produced by the generator. Base on the rpm given, the desired output voltage and desired rpm can be calculated. The basic parameter need to know which are RPM, Open voltage at that RPM, and Ohm's of the stator coil. The formulas given are:

- $\frac{\text{measured } RPM}{\text{open voltage}} = RPM \text{ per volt}$ (2.0)[17]
- $\text{volt} + (\text{amp} * \text{ohms}) = \text{open voltage}$ (2.1)[17]
- $\text{open voltage} * \text{RPM per volt} = RPM \text{ needed for desire output}$ (2.2) [17]

REFERENCES

1) Schlabbach, K., *Traffic Calming in Europe*. ITE, 1997: p. 38-40.
2) Rozenblat, L. *How Generator Work*. 2008 [cited 2012 April 5]; Available from: http://www.generatorguide.net/howgeneratorworks.html.
3) Department, E.a.M.S. (1995) *Know About Renewable Energy*. **Volume**,
4) *Advantages of Renewable energy*. 2010 [cited 2012 May 11]; Available from: http://www.going-green-challenge.com/definition-of-renewable-energy.html.
5) *Effect of Speed Bump to the Accident*. 2009 [cited 2012 May 10]; Available from: http://www.portlandonline.com/transportation/index.cfm?a=85425&c=35934.
6) *How Have Gas Price Increase by The Year*. 2009 [cited 2012 May 11]; Available from: http://www.consumerenergyreport.com/2012/02/27/how-high-have-gas-prices-risen-over-the-years/.
7) *Malaysia - electric power consumption*. 2009 [cited 2012 May 12]; Available from: http://www.indexmundi.com/facts/malaysia/electric-power-consumption.
8) Saiman, A.P.E.S.S.A.J.u.M.I.M.A.C.S., *a Study on Electrical Usage at the Residential Area*, in *1st Engineering Conference of Energy and Environment*. 2007, Enc<<n2007: Kuching, Sarawak.
9) *Speed Bump*. 2012, Wikipedia.
10) deVick, H. *Gear Ratios and Structures*. **Volume**, 13
11) Tallberg, E. *What is gear shaft?* 2003 [cited 2012 May 6]; Available from: http://www.wisegeek.com/what-is-a-gear-shaft.htm.
12) Favre, J.L. *The Brush Dynamo*. 2009 [cited 2012 May 12].
13) LTD, H.E.S. *Speed Bump*. 2008 [cited 2012 Mac 7]; Available from: http://www.hughesresearch.co.uk/index.php?option=com_content&view=category&layout=blog&id=29&Itemid=48.
14) venselenterprises, ed. *How Regulator and Generator Work*. 2008, venselenterprises.
15) Wang, M.-S.L.C.-L.C.W.-J.L.L., *Combining the Wind Power Generation System*

16) *With Energy Storage Equipments*. ieeeexplore, 2009. **45**(6): p. 2019-2115.

17) Janphuang, P.I., D. ; Briand, D. ; de Rooij, N.F. , *Energy harvesting from a rotating gear using an impact type piezoelectric MEMS scavenger*, in *Solid-State Sensors, Actuators and Microsystems Conference (TRANSDUCERS), 2011 16th International*. 2011, ieeeexplore: Beijing.

18) *Handy Formula to calculate the output of any generator at any given RPM*. [cited 2012 May 12]; Available from: http://www.windstuffnow.com/main/generator.htm.

19) Awar, D.M.A.D.S.D.N.A., *Beirut Streets*

20) *Generate Electricity*. 2011, lebanonsustainability.com.

21) Gautreau, A.B.M.C.A. (2007) *Power Generating Speed Bump*. How does it work?, methodology **Volume**, 5-7

22) Bhd, P.E.S. *specifications of car*. [Proton Edar Home Page] 2012 21 January 2012 [cited 2013 21 January]; Available from: http://www.proton-edar.com.my/Experience/Special-Promotions/CNY-2013-Promotion.aspx.