

Dynamo Stairs as Alternative Source of Energy

INTERNATIONAL SUSTAINABLE WORLD ENERGY ENGINEERING &
ENVIRONMENT PROJECT OLYMPIAD

(I-SWEEEP)



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PREFACE

In the name of God, the most gracious and the most merciful, we are able to complete and finish our project. This proposal is aimed to participate *International Sustainable World Energy Engineering & Environment Project Olympiad* which titled “Dynamo Stairs as Alternative Source of Energy”.

In arranging this proposal, we have got so many invaluable assistant, critics, comments and corrections from many people. Therefore, we would like to to owe our gratitude to

1. Mr. Fatih Yildirim as the General Manager of Kesatuan Bangsa School.
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3. Dr. Adha Imam Cahyadi as our lecturer.
4. Mr. Hidayberdi as our ISWEEEP supervisor.

We realize that this proposal is definitely far from perfection. Because of that, we apologize from our deepest heart. Critics and suggestions are crucially needed for the improvement of our project in the future.

Finally, we hope that this proposal is useful for the country, community and every reader.

Yogyakarta, April 2013

Talia Pandan Sari and Rika Nuraini

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ABSTRACT

In the modern era, the use of electricity has been increased significantly. However, energy resources to generate the electricity are very limited. Thus the energy crisis cannot be avoided. This makes the alternative resources of energy crucially needed. Therefore, in this research a simple, cheap, and friendly user mechanism system electricity generator will be designed, developed, and examined. The developed tool is based on the principle of energy conversion between mechanical and electrical energy. In this work, a generator is attached into the stairs to produce electricity. Even though the energy that has been produced is not as effective as electricity generator, this small scaled dynamo can produce energy that is enough to support the primary electricity utilization. Later, we put this tool in a crowded place, such as stadium, campus, train station, etc to enable bigger energy production. Based on experiment, examination, and calculation, the tool has up to 56.41 % efficiency and will be increased further as the research goes by. Therefore, this could be likely gives us significant role for the future because the cost that is needed to produce the electricity is almost zero.

Keyword: alternative energy, mechanical energy, electricity, generator, efficiency

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CHAPTER I

INTRODUCTION

1.1 Background of The Study

Electricity is energy that cannot be felt by senses. In this modern era, electricity is never separated from our life. It is used to help human activities such as, lighting, ironing, operating electronic materials for example TV, computer, etc. Electricity which is distributed to the consumer is produced by the power plant through the process of generation, transmission, and distribution. In the power plant, kinetic energy is converted into electric energy by generator. There are several kinds of power plant like Hydro Power, Nuclear Power Plant, Geothermal energy, Steam Energy, Solar cell, and so on. Those power plants have strength characteristics and also the weaknesses. Like Nuclear Power Plant which uses nuclear energy that is produced by nuclear reaction inside a reactor. Electricity that is produced from this energy has huge quantity than other kind of power plants. Nuclear power plant does not produce pollution, it produces radioactive instead. The risk is very big if there is a leakage of radiation. Besides, the uncontrolled characteristic of nuclear can cause a huge explosion and radiation that can cause deformity, destruction even death. Another type of power plant is solar cell, which uses the free sunlight as the source of energy. It can be set everywhere like in yard or on the roof. But it needs high cost, complicated system, and has little efficiency. Moreover, it is hard to get the sunlight

in winter and rainy season. Generally electricity is from fossil fuel like petroleum, coal, and gas. Fossil fuel is more common but it can pollute the environment. Moreover, its availability is predicted to be extinct within the next 20 years (Alpensteel, 2013). As we know, if the fossil fuel is used continuously, it causes the greenhouse effect that leads to the global warming. On the other hand, the natural source of energy like water, wind and sunlight is cleaner, but their potency is very hard to be harvested.

The usage of electricity in this world is increasing for about 10% per year (PLN, 2010). Besides, the vast growing of population that reached 7 billion in the year 2012 (U.S. Census Bureau, 2012) will lead to the increasing of skyscrapers like apartment, school, campus, hotel, mall, etc. that need more electricity uses. The needs of electricity are getting bigger and bigger. Moreover the electricity distribution is limited. Many places in our earth does not get enough electric energy. For example, some areas in developing countries have electricity crisis, like some area of Asia, Africa and some part of Middle East. Sometimes, they do not have 24 hours of electricity supply, and just get 5 hours of supply (Guardian UK, 2012). On the other hand, it is very different with developed countries, they need more electricity and sometimes it is said wasteful of electricity.

Considering the importance of electricity and how hard to generate the power, in this research, we are going to examine and design an alternative source energy to help the main source energy. Here, we use the simple mechanism system dynamo (small generator) that is set inside the stairs as alternative source energy that can

produce electricity. We chose stairs as the generating medium, because stairs are used in our daily life. This research is simple, environmental friendly, low cost, and useful for daily life. Although the energy production is not as huge as power plant, this dynamo stairs is able to produce enough energy to help and support the use of main source energy. We hope in the future this research can be developed and used wisely.

1.2 Objective of the Research

The objective of the research is to find the best way to set a mechanism inside the stairs for producing alternative source of energy. The electricity energy produced by dynamo system is converted into chemical energy using accumulator or battery which can help the main source energy and lower the cost of electricity usage. Dynamo stairs will be set in the public places passed by many people like campus, stadium, railway station, hospital, etc. If one stair is stepped by one adult it can produce energy that can approximately light up one lamp, if there are 20 stairs and there are 100.000 people step that stairs every day there will be huge potency of energy generated from this tool. So it is hoped it can solve the problems we have discussed beforehand.

1.3 Problems

Modernization nowadays emerge technologies which help the human life, so it stimulates us to think efficiently. Everything is run easy, practical, and can be used instantly because of the use of technologies. All of our daily apparatus, for instance home appliances, need electricity. It becomes human basic needs. As the time goes

by, electricity consumption is getting higher. Unfortunately, the energy for generating the electricity is getting lower until it reaches the limit point.

So, we would like to give alternative energy solution which has lower cost and environmentally friendly to overcome those problems. We use the dynamo system sets inside the stairs. Stair is the medium that used to go to higher place. Stairs is available in all multi-storey building. The maximum efficiency of Dynamo Stairs is huge enough. It does not need more energy to press the lever because the human energy for going upstairs is equal to the energy to step the lever. So it can be said the cost that is needed to produce energy is almost zero. Even though the energy production is not as huge as power plant, the energy has enough power to help the main source energy.

CHAPTER II

RESEARCH METHODOLOGY

2.1 Equipment

The equipment we used to build and set the Dynamo Stairs is divided into 4.

They are:

2.1.1 Stairs Construction Equipment

- Wooden board
- Mica/Acrylic
- Nails
- Springs
- Paint
- Rubber pad

2.1.2 System Equipment

- Dynamo
- Loop
- Gear
- Transformer
- Cable
- Electric Switch
- Diode
- Capacitor
- LED
- Battery/Accumulator

2.1.3 Tools

- Hammer
- Pincers
- Drill
- Screwdriver
- Solder
- Tin

2.1.4 Research Equipment

- Oscilloscope
- Volt meter
- Ampere meter

2.2 Design

Dynamo stairs are designed specifically to be suppressed and can return back to normal. As seen in Figure 1, the stairs are inclined about 10 cm high, so when the stairs are stepped on, they will form angle 90° . The stairs are padded with rubber so they are not slippery.

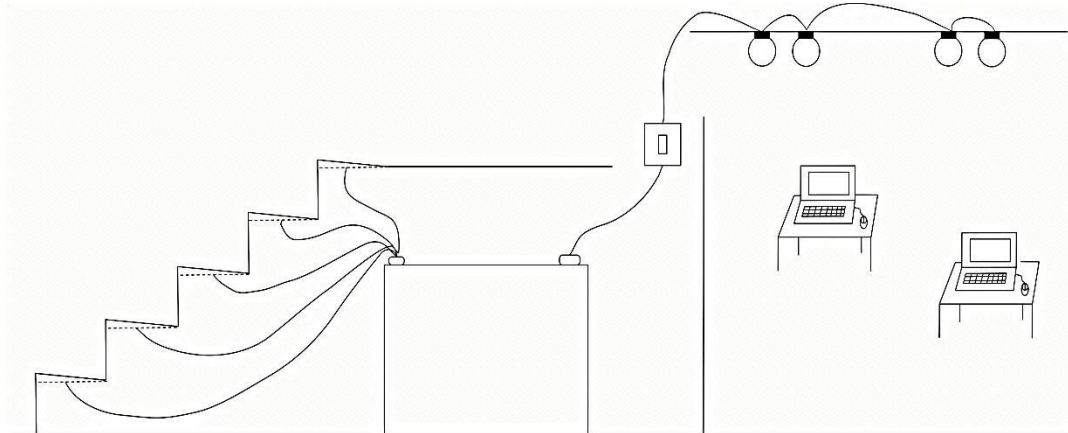


Figure 1. Dynamo Stairs design

Dynamo stairs system can be seen in Figure 2. When people step on the stairs, the lever is lowered and it will spin the gears. Gears spin the dynamo. In dynamo, mechanical energy is converted into electrical energy. The electrical energy that is generated by the dynamo is stepped up in transformer. Then, it will be stepped down by using bridge circuit. The electrical energy that comes out from bridge circuit is stored in the batteries or into the accumulator. Once the accumulator is fully charged, electricity can be used for electricity needs.

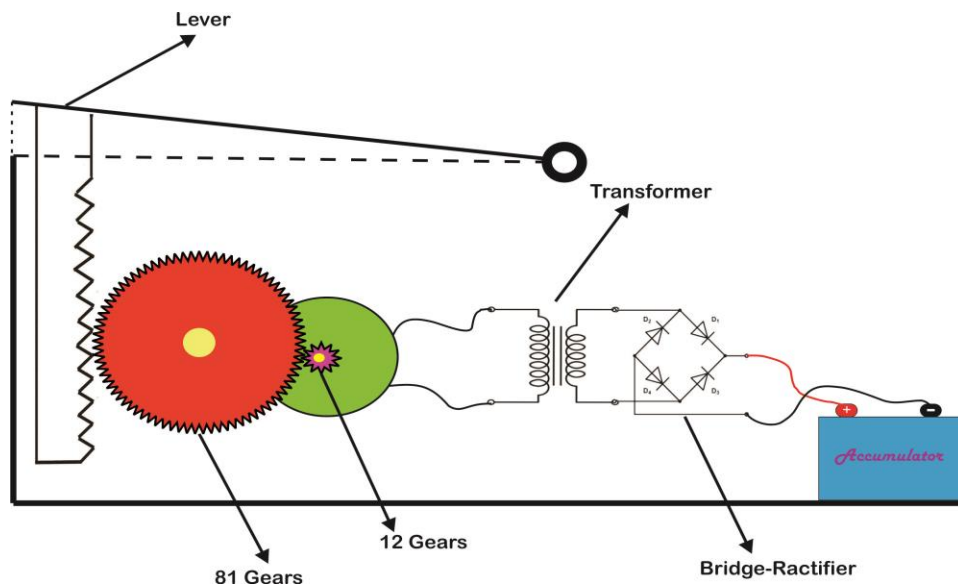


Figure 2. Dynamo Stairs working principle

2.3 Working Principle

1. Press or step on the lever.
2. The lever spins the gear.
3. The spinning gear spins the dynamo.

4. The spinning dynamo produces mechanical energy that will be converted into electrical energy.
5. The electricity is stepped up in transformer.
6. The electricity is stepped down by bridge circuit. Then, bridge circuit converts alternating current into direct current that can charge the battery.
7. Electrical energy is stored in battery.
8. When battery is full enough, it can be used for electricity needs.

The Process of Saving Energy

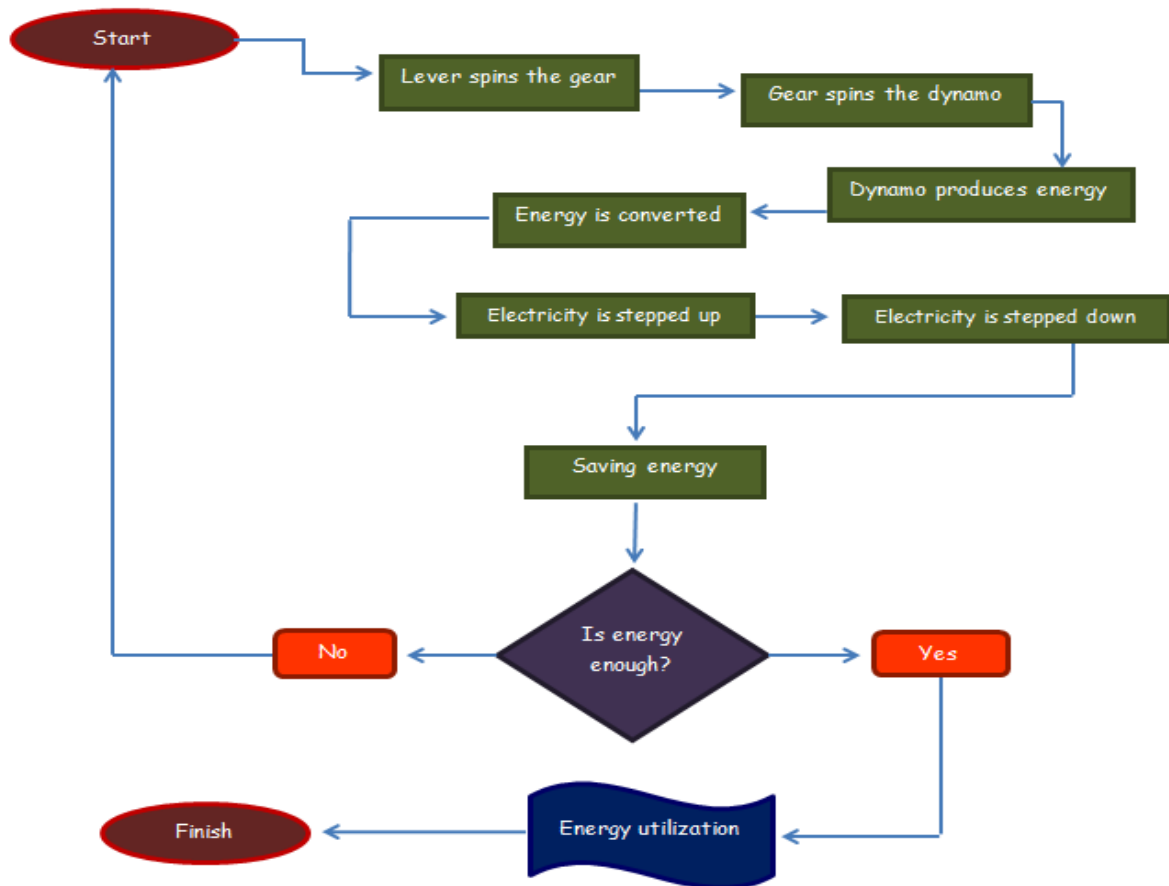


Figure 3. The process of saving energy

The process of the energy storage happens from beginning to end is shown in figure 3. If the energy is not sufficient, then the process will be restarted.

2.4 Efficiency

Engine efficiency is the ratio of output energy to input energy, or output power divided by input power. Practically however, the input energy cannot be totally converted into electrical energy. Some of the input energy is converted into heat energy, sound, and etc. The efficiency can be increased, for example by apply lubricant to the rough surfaces. (Gokhan Aydin and Karaayvaz Osman, 2007).

To calculate the efficiency of the dynamo stairs, the first thing to understand is the energy output. Output energy is the energy that is produced by engine. Energy output can be determined by using a voltage meter, an ampere meter and an oscilloscope. To determine the output energy, we use the formula:

$$\mathbf{P=V \times I} \quad (1)$$

Where:

P : Power (W)

V : Voltage (V)

I : Current (A)

t : Time (s)

Next, calculate the input energy. Input energy is the energy which is required to start an engine. The required components for input energy are the human power to

press the dynamo torch one time by hand, the diameter of the gears, and how many rotations in one press. To calculate the input power we use gear force formula (Kiyokatsu, Sularso, 1978) as shown below:

$$\mathbf{P = f \times v}$$

$$v = \frac{p}{f}$$

$$v = \frac{\pi \times d \times n}{60 \times 10^3}$$

$$\mathbf{kW = \frac{W_t \times \pi \times d \times n}{60 \times 10^3}} \quad (2)$$

Where:

kW : Transferred power (kW)

W_t : Transmission weight (kN)

d : gear diameter (mm)

n : rotation (rpm)

To find the final efficiency, the result of output power is divided by input power then multiplied it with 100 %. As follows:

$$\mathbf{\eta = \frac{E_o}{E_i} \times 100\%} \quad (3)$$

Where:

η : Efficiency

E_o : Output energy or output power

E_i : Input energy or input power

CHAPTER III

RESULT

The Dynamo Stairs system consists of step-up transformer, bridge rectifier, electrical switch, battery, and loads. The order of the system is shown in figure 4.

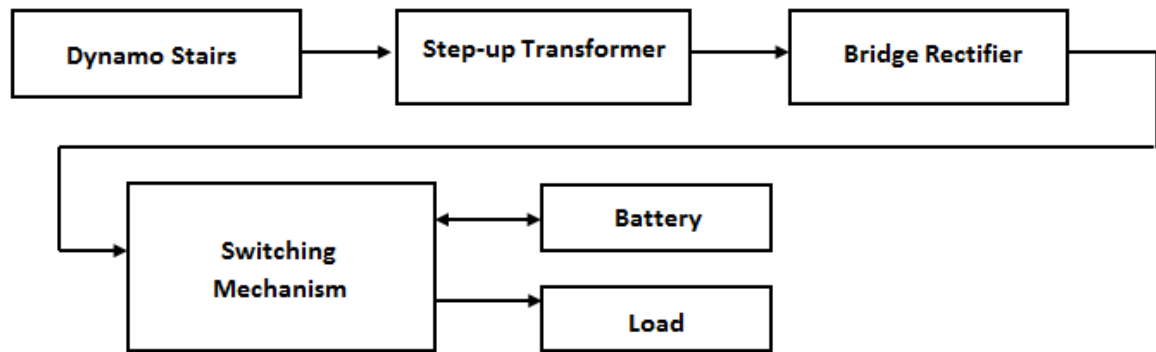
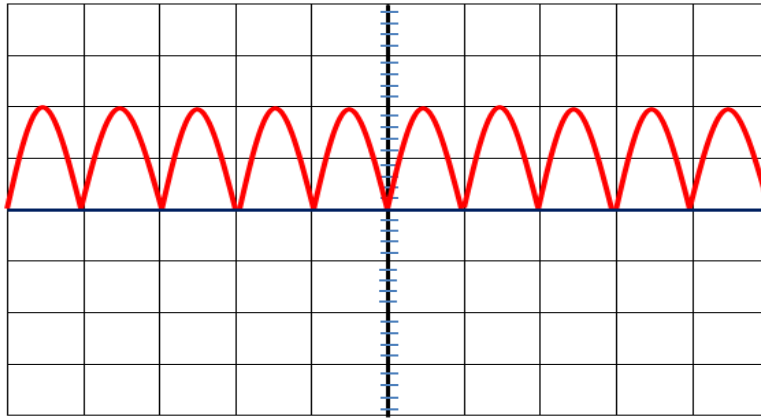


Figure 4. Storage and usage process

In this study, we use an oscilloscope to measure the signal frequency, the power supply voltage and its relation to time, distinguish between AC and DC current, and check the path of a signal (Bernard Grob, 1994). Graph 1 shows the result of research using the oscilloscope before stepped up by the transformer.



Graph 1. Graphic research by using oscilloscope before passing through transformer

On the oscilloscope screen there are 10 divisions from left to right. Each division measured 1 cm. The scope is set to read 2 ms per division, so the time that is required for the total run was 20 ms ($0.02 \times 10 \text{ divisions} = 0.2 \text{ s}$ or 20 ms) and a frequency of 0.5 Hz ($f = \frac{1}{T} = \frac{1}{20 \text{ ms}} = 0.5 \text{ Hz}$). On the other hand, the vertical scale has 8 divisions. Each division has four levels that are 0.2, 0.4, 0.6, and 0.8. The peak of the wave is 2.2 divisions. Therefore, the wave has an average voltage of 2.2 V and the peak of voltage amplitude of 4.84 V ($2.2 \times 2.2 \text{ V} = 4.84 \text{ V}$).

In transformer the voltage is stepped up until it reached voltage about 40 V – 50 V. To find the difference output and input voltage from the transformer we calculate:

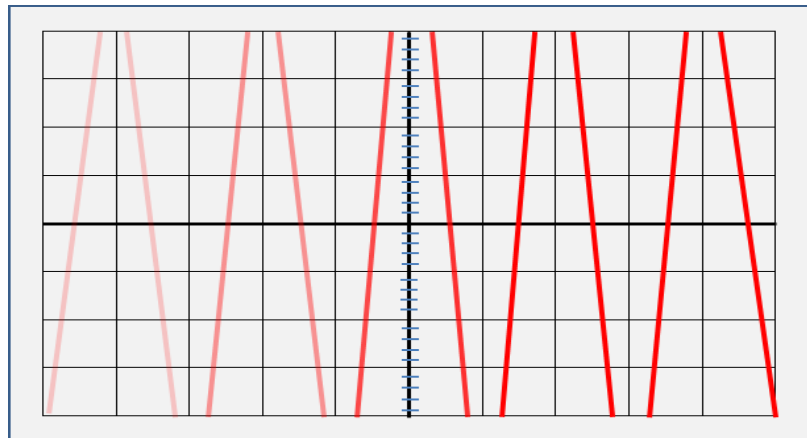
$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{2.2 \text{ V}}{40 \text{ V}} = \frac{12 \text{ V}}{220 \text{ V}}$$

$$18.18 = 18.33$$

The voltage is stepped up 18 times in the transformer.

Graph 2 is the graph experiment by using oscilloscope after passing through the transformer. The peak of the voltage is up to 4 divisions. Each division is set 5 V. The average voltage after passing through a transformer is about 40 V.



Graph 2. Graphic research by using oscilloscope after passing through transformer

Because of the voltage is too high, it is stepped down in bridge rectifier that consists of diode and capacitor as shown in figure 5. The alternating current is changed into direct current, so it can charge the accumulator that has direct current.

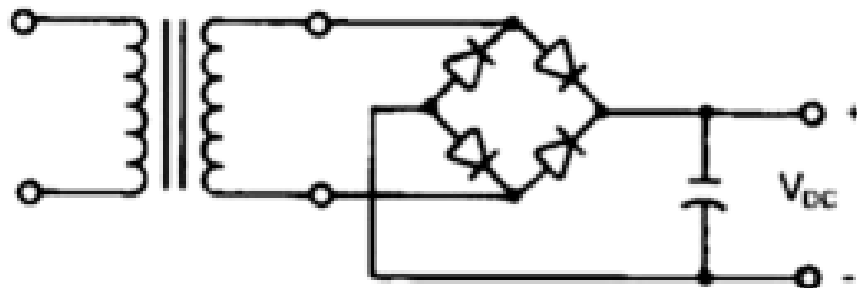
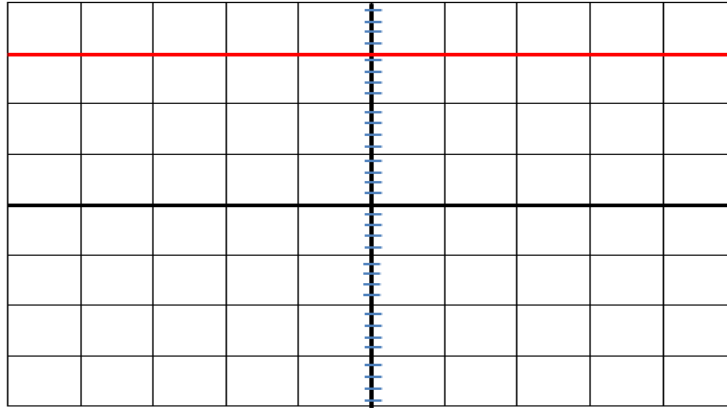


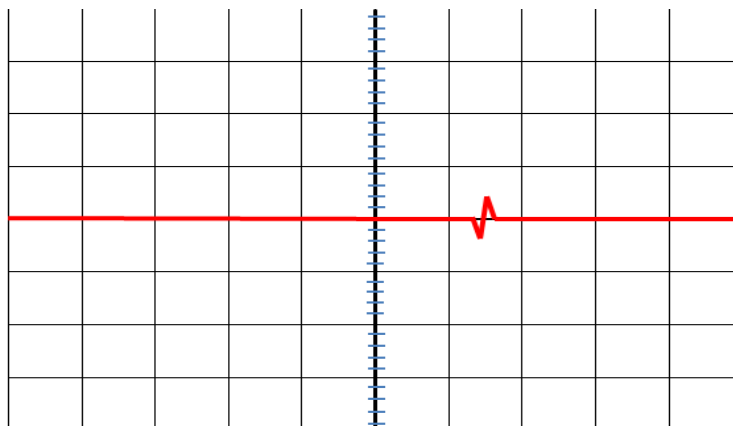
Figure 5. Bridge Rectifie



Graph 3. Graphic research by using oscilloscope after passing through bridge circuit

Graph 3 is the graph observation on bridge circuit. It is proven that after passing through bridge circuit, the alternating current changed into direct current, so it can charge the accumulator. We set 5 V for each division. The peak of the voltage is on division 3. Therefore the average voltage in bridge circuit is 15 V ($3 \text{ division} \times 5 \text{ V} = 15 \text{ V}$). It has enough voltage to charge a 12 V accumulator.

Finally we connect the wire from bridge circuit to the battery. Graph 4 shows that it could charge the accumulator even though the voltage is small.



Graph 4. Graph research by using oscilloscope while charging

CHAPTER IV

DISCUSSION

Before we calculate the input power, we need to calculate how many rotations per minute (rpm). n is the rpm and z is the number of gear. n is inversely proportional to z . n_1 is how many rotation per second on gear 81. We know that one press rotates 0.75 time per second on gear 81. Now we find the rpm of gear 12.

$$\frac{n_1}{n_2} = \frac{z_2}{z_1}$$

$$\frac{0.75/s}{n_2} = \frac{12}{81}$$

$$n_2 = 5.06^{\text{rot}/s}$$

$$5.06^{\text{rot}/s} \times 60s = 303.6^{\text{rot}/\text{min}}$$

According to the experiment, we examine the average force (Wt) by using dynamometer is 1.4 N by hand. d is the gear diameter that spins the dynamo, in this case we measure its diameter by vernier caliper and it is found to be 7 mm. Based on our calculation above, n is known $0.155^{\text{rot}/\text{min}}$. Energy power (kW) can be determined by gear force formula ^[1] as:

$$kW = \frac{Wt \times d \times \pi \times n}{60 \times 10^3}$$

$$\begin{aligned}
&= \frac{1.4N \times 10^{-3} \times 7mm \times 3.14 \times 303.6 \text{ rot}/_{\min}}{60 \times 10^3} \\
&= 1.557 \times 10^{-4} \text{ kW} \\
&= 0.156 \text{ W}
\end{aligned}$$

In this experiment we observe that the average voltage of one press dynamo torch by hand is 2.2 V and the average current is 0.04 A. To calculate the output power we use formula ^[2] as follows:

$$P = V \times I$$

$$P = 2.2 \text{ V} \times 0.04 \text{ A}$$

$$P = 0.088 \text{ W}$$

Next we calculate the efficiency. Efficiency is the output power divided by input power and multiplied by 100% as shown in equation ^[3]. The output energy is known 0.088 W and the input power is 0.156 W. Efficiency can be determined by:

$$\eta = \frac{E_o}{E_i} \times 100\%$$

$$\eta = \frac{0.088 \text{ W}}{0.156 \text{ W}} \times 100\%$$

$$\eta = 56.41 \%$$

CHAPTER V

CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

Dynamo Stairs is alternative source of electrical energy that helps primary energy source by utilizing the dynamo system that is placed on stairs. The stairs are used like regular stairs, but when we step on it, it will rotate the dynamo. The spinning dynamo can generate substantial electrical energy. Based on our observation and experiment, the Dynamo Stairs has an average efficiency of 56.41%. This is a good result because the energy needed to generate electricity is almost zero. This is because the energy used to step a lever and rotate the dynamo is the same.

5.2 Suggestions

We suggest that the Dynamo stairs can be put in crowded places and multistory buildings that are used by a lot of people like campus, station and pedestrian bridges. If more people step on the stairs, more energy is produced. It can generate enough energy to support primary energy source and reduce electrical energy crisis. We hope in the future, the Dynamo Stairs can be improved by increasing the efficiency and built in better designs and constructions.

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