

Implementation of raindrops energy collector board using piezoelectric transducer

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Abstract. Indonesia is a country that has a fairly high rainfall, because it is located in the tropical area. This condition could be a potential for generating electrical energy from raindrops. If the heavy raindrop collide the piezoelectric materials, it can generate electrical energy. The piezoelectric effect was discovered by Jacques and Pierre Curie in 1880. They found that certain materials, when subjected to mechanical strain, suffered an electrical polarization that was proportional to the applied strain. This piezoelectric effect converts mechanical strain into electrical voltage. The molecular structure of piezoelectric materials produces a coupling between electrical and mechanical domains. In this research, raindrops will be exploited to produce electric voltage by piezoelectric transducer. Piezoelectric transducer used in this research is Lead Zirconate Titanate type. Energy conversion processing occurred when raindrop collide the polymer layer of piezoelectric and make an unelastic thrust on its surface. The designed system consists of raindrops collector board and serial connected piezoelectric transducer. From system above, highest voltage, reach is 3.13 VAC for 30 piezoelectric and the average voltage is 2.617 V. This results show us the potential usage of raindrops energy generator using piezoelectric transducer for tropical countries.

1 Introduction

In 2011, the Central BKKBN recorded the population of Indonesia reached 241 million people. The end of 2012 is expected to reach 245 million people. With such a large population, Indonesia's electricity consumption is only 591 KWh per capita based on International Energy Agency (IEA) 2010 data. It is among the lowest in ASEAN and in some parts of the world. This is due to the lack of power plants in Indonesia. To overcome the electricity crisis in Indonesia, distributed generation system using renewable energy is one of the proposed ways. Astronomically, Indonesia lies between 6° LU and 11° LS and is mostly located around the equator so that Indonesia has considerable rainfall especially in western Indonesia, with an average rainfall of 2,000 - 3,000mm / year [1]-[3].

The concept of panning rain energy is the true development of theoretical physics ever coined by world scientists. In this study is used piezoelectric transducer to change the vibration generated by rainwater point. This system can be used for various sizes of raindrops. In addition, based on simulations ever conducted by some researchers [1], with the size of rainwater points ranging from 1 to 5 millimetres produced 12 milliwatts. This energy conversion process occurs when the raindrop points on a polymer surface called lead zirconate titanate (PZT) and produces an inelastic beat above its surface. From the research, it is found that the largest water point

produces the greatest vibration also above PZT, and therefore the electrical energy it produces is also more.

Based on the above, in developing the feasibility of rainwater as an alternative energy source it will be done by putting some piezoelectric under rainwater droplets and will see how much electricity generated from various parameters such as: discharge or falling rainwater volume.

2 Literature study

2.1. Rain

Two thirds of the earth contains water and the rest is land. With the heat of the sun, the water will evaporate into water vapor from all soils, rivers, lakes, ponds, reservoirs, seas, ponds, fields and so on and the process is called evaporation. Evaporation also occurs in all plants called transpiration². Then the water vapors will undergo a condensation or compaction process that eventually becomes a cloud. The clouds will move to different places with the help of wind gusts both vertically and horizontally. Upward vertical wind movement causes clouds to clump. The wind motion causes the clouds to become larger and overlap. Eventually the clouds reach the cooler atmosphere. This is where the grains of water and ice begin to form. Over time, the wind can no longer sustain the weight of the clouds and eventually the clouds that already contain this

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water experience precipitation or the process of falling rainwater hail and so on to the earth.

2.1.1 Rainfall

Rainfall or general precipitation is the event of a liquid drop from the atmosphere to the surface of the earth. The amount of rainfall is the volume of water that falls on a particular area, therefore the amount of rainfall can be expressed in water level that is millimeter (mm) [4]-[5]. The amount of rainfall can be expressed in the equation as follows:

$$R = V/A \tag{1}$$

Description: R = Rainfall (mm)
 V = Water volume (ml)
 A = Area area (cm²)

2.1.2 Rain intensity

Rainfall intensity is the amount of rainfall expressed in rainfall or rainfall volume per unit time, occurring at one concentrated rainwater period [3]. The amount of rainfall intensity varies depending on the duration of the incident rainfall and frequency. High intensity of rainfall generally takes place with a short duration and covers a wide area. According to [4], rain intensity can be classified as table 1 below:

Table 1. Rain intensity.

Intensity (mm/h)	Classification
0 - 5	Very Low
06 - 10	Low
11 - 25	Middle
26 - 50	Quite High
51 - 75	High
> 75	Very High

Rain that covers a large area, rarely with high intensity, but can take a long duration. The combination of high rainfall intensity with long duration is rare, but when it occurs, it means that a large volume of water is shed from the sky [5]. The intensity of rainfall in a rational formula can be calculated by the equation of formula [6]:

$$I = R / t \tag{2}$$

Description: I = rainfall intensity (mm / h)
 R = Rainfall (mm)
 t = Duration of Rainfall (hours)

In the International System, the actual rain intensity should be expressed in units of m / s. However, commonly used today is in mm / hour as above.

2.1.3 Raindrop

Falling rain granules will get air pressure so that it will break smaller, this is why rain grains are generally no more than 7mm in diameter, clear raindrops will affect the falling speed, the bigger the larger the diameter of the raindrop grains the rate of falling grain increases [3]. The diameter of the droplet is the value of the grain size of the rain that is assumed to be in the form of a sphere. Based on the magnitude of the granular diameter can be calculated after the rain intensity is known by using the following equation [7]:

$$Dm = 2,23 (I)^{0,182} \tag{3}$$

Description: I = Rain intensity (mm / h)
 Dm = Diameter of droplet (mm)

2.1.4 Rain falls speed

The speed of falling granules ie the speed of rainfall is the final velocity of the fall rain to the ground. The terminal velocity for water droplets from 19 μm to 7 mm is equivalent to diameter [6]. The falling speed can be calculated by the following equation:

$$v = 0,0561D^3 - 0,912D^2 + 5,03D - 0,25 \tag{4}$$

Description: v = Speed (m / dt)
 D: Diameter (mm)

2.2 Power generation

The process of generating electricity is the process of converting primary energy (fuel or hydropower potential) into mechanical power as electric generator driver and subsequently the electric generator produces electric power. Power generation is done in many ways rotate synchronous generator to get electric current back and forth three phases. The mechanical power used to rotate the electric generator is obtained from an electric generator drive machine or commonly called primer. Electric drive generators are widely used are diesel engines, steam turbines, water turbines, and gas turbines.

3 System design

3.1 Block diagram

In general, systems designed in this study can be seen in Fig.1. The outline of the workflow of the system designed is as follows:

- When it rains, rain will fall on the board under which piezoelectric has been installed.
- The vibrations or pressure generated by the falling rain water onto the board and on the surface of the polymer called lead zirconate titanate (PZT) (piezoelectric material) and resulting in an inelastic hiccup above the surface thus converting mechanical energy from raindrops into electrical energy .

- Electricity that has been produced before will be channeled to the load.

Piezoelectric ceramics used in this study is lead zirconate Titanate Pb (Zr1-yTiy) O3 or commonly called (PZT). Piezoelectric of this type has the following specifications: has dimensions of 20 mm x 0.43 mm, resonance frequency 6.5 ± 0.5 Hz, DC resistance 20 M ohm min, resonance impedance 350 ohm max. The amount of piezoelectric used 50 pieces with the preparation in series to obtain maximum electrical voltage results. The collector board used as a piezoelectric coating is a board made of Polycarbonate [Polycarbonate] or commonly called a canopy. Has a thickness of 6mm with size 60 cm x 130 cm.

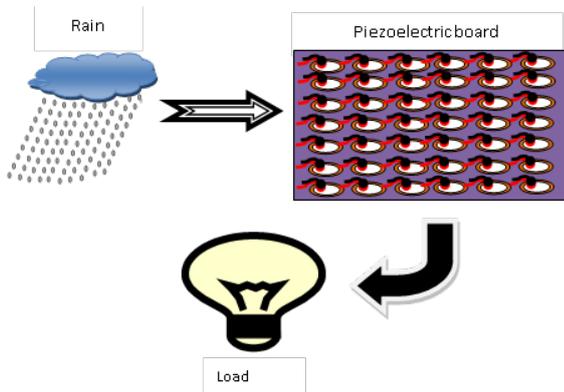


Fig. 1. Block diagram of raindrop generator system.

3.2 System setup

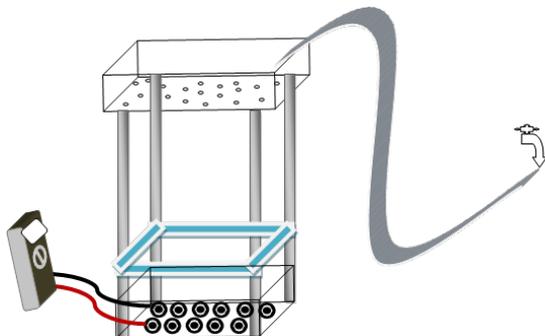


Fig. 2. System for simulation of raindrop generator measurement.

In the picture above, the piezoelectric laying in the open so that the rain drops will directly affect the container where the piezo is placed. Then the electricity generated will be distributed to the DC load. If the resulting voltage cannot ignite the DC load then rainwater pressure must be increased.

4 Results and discussion

Large stress tests generated by piezoelectric rainwater are carried out during rain and simulated rainwater. The constants used are the mass of rainwater type 1000 kg / mm³ and the voltage sensitivity of piezoelectric used is 0.004 V.m / N.

Here are the measurements taken during the rainfall:

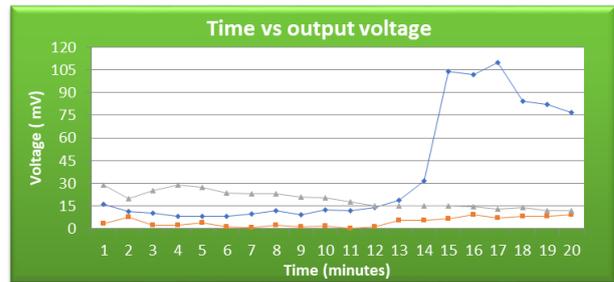


Fig. 3. The result of stress measurement with rainwater for 20 minutes with piezo position under canopy of 50 pieces

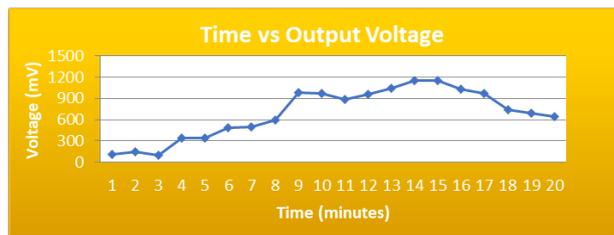


Fig. 4. The result of measuring the voltage with rainwater for 20 minutes with piezo position on the canopy of 45 pieces

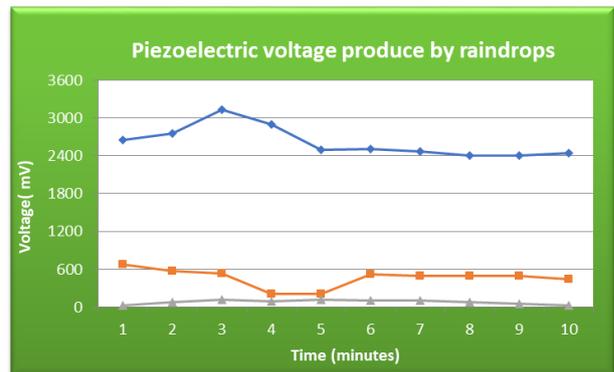


Fig. 5. The result of voltage measurement with rainwater for 10 minutes piezo position above the canopy of 30 pieces

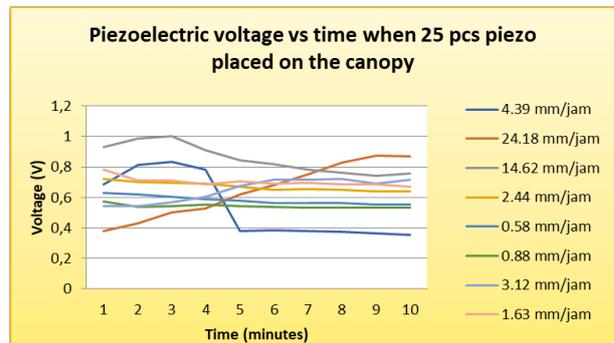


Fig. 6. The result of measuring the voltage with rainwater for 10 minutes piezo position above the canopy of 25 pieces

From Fig.1. to Fig. 6, it was found that the highest piezoelectric voltage produced 104.2 mV when the piezo board position under the canopy and 1.115 V when above the canopy when using 45 piezo, 1.001 V for 25 piezo and 3.13 V for the piezo above the 30 canopy.

5 Conclusions

From the calculation and simulation with piezoelectric installation done in series and parallel that aims to generate optimal electrical energy. The conclusions are from the number of piezoelectric used, it is 5 to 50 pieces, the highest voltage produced is 3.13 V for natural rain with 30 piezoelectric series in series and 0.536 V for rain water simulation with 25 piezoelectric pieces arranged in parallel series. The voltage generated by piezoelectric is related to the amount of rain intensity, which is directly proportional to the pressure. Where is the relationship between rainwater pressures (inversely proportional to the volume of rainwater) with piezoelectric output voltage is linear with the level of closeness of the relationship of both high average. The highest level of accuracy is obtained when the rain is 67.89%. For comparison, a piezoelectric installation with series and parallel arrangement with a weighted press of 6 coins Rp 100 and dropped at the same height. From the test it is concluded that, the piezoelectric number installed does not affect the magnitude of the piezoelectric output voltage but only affects the width of the piezoelectric output signal.

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