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INVESTIGATION OF VARIATION OF FIN LENGTH DIMENSIONS ON PIEZOELECTRIC VOLTAGE GENERATING

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Abstract: Piezoelectric is one of the generators of electrical energy when the material is deflected due to pressure. Research has been done on the potential of the fins on the electric voltage produced by piezoelectric. The research method used is to observe the piezoelectric vibrating due to the flow of air passing through the bluff body resulting in a deflection of the fins to strike the piezoelectric and measuring the electric voltage. Changes in the speed of fins installed with piezoelectric dimensions, namely fin one length 12 cm and width 10 cm, fin two length 12 cm width 10 cm and tip width 12 cm, fin three length 12 cm, width 10 cm and tip width 14 cm. The research was conducted in a mini wind tunnel with wind speeds of 5 m/s, 7 m/s, and 9 m/s with a piezoelectric distance to the rhombus bluff body is 80 mm. The results obtained are fin 1 with a speed of 9 m/s produces an electric voltage of 5.15 volts, fin 3 with a speed of 9 m/s produces an electric voltage of 5.46 volts, and fin 4 with a wind speed of 9 m/s has the highest voltage value, namely 5.58 volts. The airflow as it passes through the end of the bluff body section causes the fin to move up and down. The greater the turbulence that occurs, the greater the air hitting the piezoelectric surface so that the value of the electric voltage becomes high.

Keywords: Piezoelectric, Energy Harvest, Bluff Body, Fin, Deflection

1. INTRODUCTION

Piezoelectric is an energy harvesting material that converts mechanical energy into micro-scale electrical energy (Gamayel, 2019). The piezoelectric layer is subjected to pressure, causing a deflection to produce an electric charge due to receiving vibrations that strike the piezoelectric layer. The electrical energy produced in this energy harvester is relatively tiny, so it cannot be used directly. To be used directly, generally, the energy produced is stored first in a conductor or battery to store electrical energy. Piezoelectric is an environmentally friendly energy source and only requires repeated pressure to produce electrical energy (Sunard & Gamayel, 2018). The development of research on the electrical voltage generated in piezoelectric continues to be improved. One of them is the installation of a piezoelectric with a cantilever mechanism that deflects repeatedly and produces vibrations so that an electric voltage arises. The galloping method is defined as dynamic instability due to turbulent flow affecting the elastic structure. Galloping is used because it can produce large amplitudes at low frequencies when the wind suddenly blows simultaneously.

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Several researchers use cantilever mechanisms and galloping methods such as prism-shaped gallops and produce 50 mW at wind speeds of 11.6 mph (Sirohi & Mahadik, 2012). Beams produce 1.7 W at a wind speed of 15 m/s (Abdelkefi, 2012). A cylindrical bluff body produces 100-3000 microwatts at a wind speed of 2.5 m/s (Weinstein, 2012). The piezoelectric cantilever system with the addition of a bluff body produces a maximum voltage of 0.034 mV at a wind speed of 2 m/s (Gamayel, 2017), and using a triangular cross-section bluff body produces a maximum voltage of 5.21 x 10-3 volts at a wind speed of 3 m/s (Kassum, 2018).

The installation of a bluff body that causes a fluid flow pattern for piezoelectric collisions by adding the fin dimensions of the cantilever system is still rarely studied. Therefore, researchers want to examine the use of fins that will move up and down to pound the piezoelectric due to the fluid flow pattern that hits the fin area on the piezoelectric collision through variations in the dimensions of the fin (fin) will simulate the fluid flow pattern using Ansys software, to determine the area of the fin. A fluid flow pattern that strikes between the fins and the piezoelectric produces the highest electrical voltage. Piezoelectric is installed in an area with the highest fluid flow velocity to produce a maximum electrical voltage. Therefore, research is needed on the dimensions of the fins and variations in wind speed caused by the blower to get the maximum stress. Research sparked research (Gamayel. 2017) regarding piezoelectric in cantilever systems with the addition of a bluff body and (Kasum et al., 2018) regarding piezoelectric cantilever systems with triangular cross-sectional bluff bodies.

2. Material and Method

The research was conducted using two methods, the first was an accurate experimental research method, and the second was a simulation research method. In the actual study, a cross-section of the bluff body was installed to create a fluid flow pattern aimed at pounding the piezoelectric to produce a voltage. The position of the piezoelectric fin is 80 cm from the cross-section of the bluff body. The simulation research method uses the Ansys Academi Student 2021 R2 software. The Ansys simulation in this study serves to determine the pattern of fluid flow in the piezoelectric fin impacting the area and to determine the area with the highest fluid flow velocity to produce a maximum electric voltage with different flow velocities.

In this study, the independent variables in this research and testing are fin shape and speed. The dependent variable in this study is the electric voltage. The piezoelectric material is ceramic, measuring 80 x 30 mm and 0.5 mm thick. At the top of the piezoelectric, a polypropylene fin made of plastic material with a cantilever system aims to make it more impacted on the piezoelectric area. The wind is generated from a 12-inch blower; the materials used to make wind tunnels are wood and acrylic.

The tools, materials, and installations used are the same as those used by previous researchers (Kasum et al., 2018), distinguishing the size variations where the bluff body size is 7 cm, and the length is 25 cm. The piezoelectric position is 80 cm from the cross-section of the rhombus bluff body, and the piezoelectric used is made of ceramic measuring 8 x 3 cm, and the size of fin one is 12 cm long, and 10 wide, fin 3 is 12 cm long, 10 cm wide and 14 cm wide at the tip. , four fins 12 cm long, 10 cm wide and 16 cm thick tip. The size and cross-section of the rhombus-shaped bluff body are shown in Figure 1.

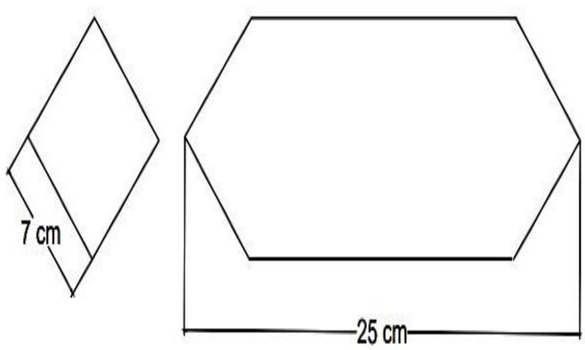

Fig. 1 The cross-sectional size of the rhombus body bluff

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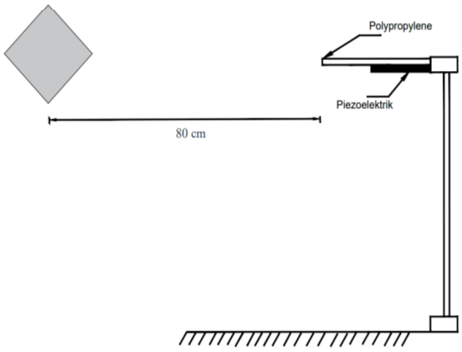
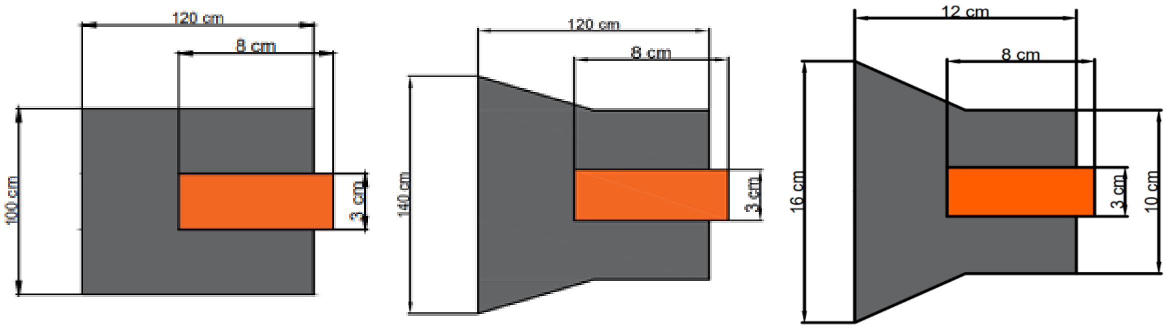


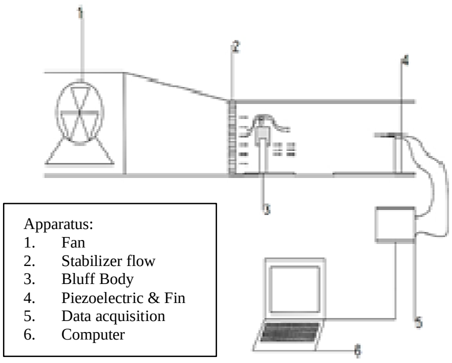
Fig. 2 Distance of testing bluff body with piezoelectric



(a) (b) (c)

Fig. 3 Size details of fin and piezoelectric variations
(a) Fin 1 (b) Fin 2 (c) Fin 3

Electrical voltage measurement uses a data acquisition system, namely DATA-Q. Measurements were carried out for 60 seconds, and 100 data were recorded every second. The collected data is then converted into Microsoft Excel to make graphing easier. The piezoelectric and bluff body is placed in a wind tunnel with a cross-sectional area of 250 x 250 mm, equipped with a flow rectifier and blower with variations in wind speeds of 5 m/s, 7 m/s, and 9 m/s.



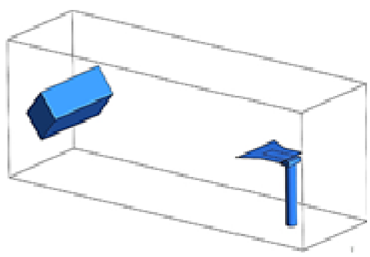


Fig. 4 Research Setup

Fig. 5 Wind Tunnel, Bluff body, and Piezoelectric Fin Unit

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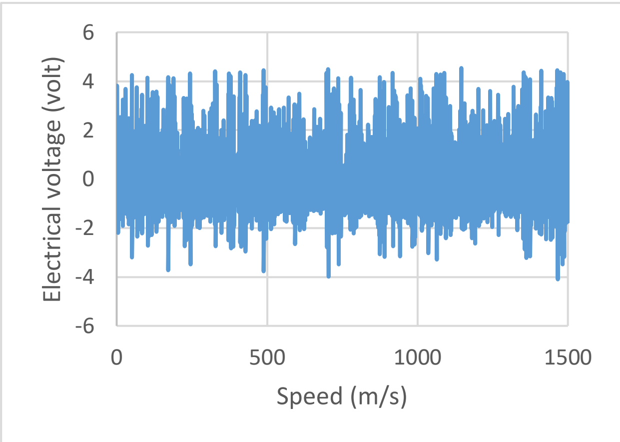
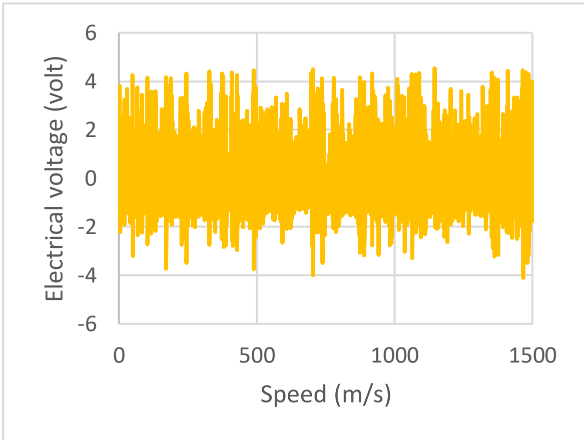
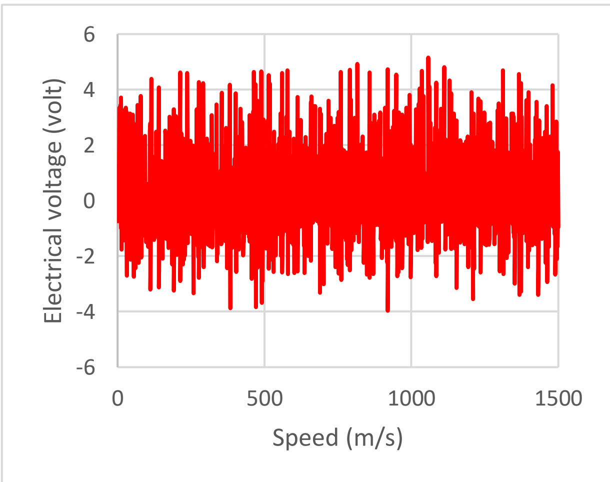
3. RESULT AND DISCUSSIONS

The graph of the relationship between voltage and time with different triangular bluff body sizes is shown in Figure 4. From the three graphs, a 3 cm triangular bluff body produces the smallest voltage. This happens because the size of the bluff body is among the largest among those tested, so it is possible that a lot of wind flow does not strike the piezoelectric. With large dimensions, the wind resistance is large, and when there is turbulence at the end of the triangle, the results of the ripples are slightly on the piezoelectric.





(a) (b)



(c)

Fig. 6 The relationship between electric voltage and time (a) Fin 1 speed 5 m/s, (b) fin 1 speed 7 m/s, (c) fin 1 speed 9 m/s.

Graph of the relationship between speed and electric voltage generated by piezoelectric on fin 1 with variations in the speed of 5 m/s, 7 m/s, and 9 m/s. The experimental results of fin 1 with a speed of 5 m/s produce an electric voltage of 4.53 volts, a speed of 7 m/s produces an electrical voltage of 4.70 volts, and a speed of 9 m/s produces an electrical voltage of 5.15 volts. From the three graphs, it is the fin that produces a high voltage at a speed of 9

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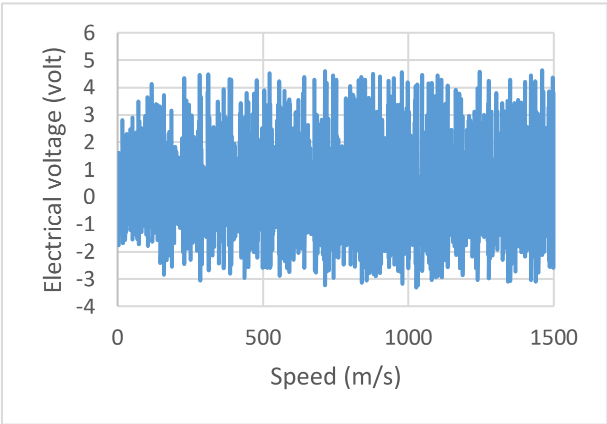
m/s. This happens because the result of the turbulence of the wind flow from the cross-section of the bluff body is greater in the direction of the speed, then the fins will move up and down will be higher.



(a)

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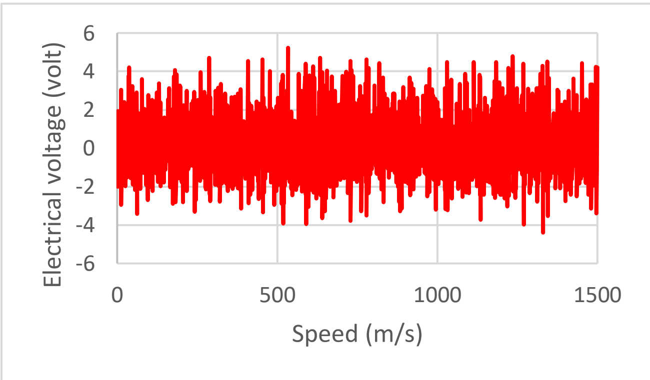
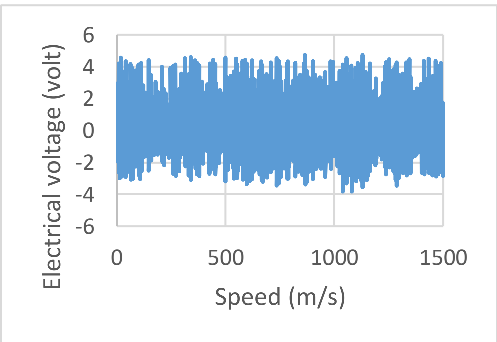


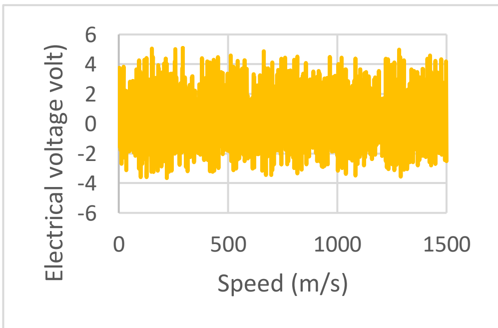
(c)

Fig. 7 The relationship between electrical voltage and time (a) Fin 2 speed 5 m/s, (b) fin 2 speed 7 m/s, (c) fin 2 speed 9 m/s.

The results of the graph of the relationship between speed and electric voltage generated by piezoelectric on fin 2 with variations in the speed of 5 m/s, 7 m/s, and 9 m/s. The experimental results of fin 2 with a speed of 5 m/s produce an electrical voltage of 4.62 volts, a speed of 7 m/s produces an electrical voltage of 4.88 volts, and a speed of 9 m/s produces an electrical voltage of 5.23 volts. From the three graphs, it is the fin that produces a high voltage at a speed of 9 m/s. This happens because the result of the turbulence of the wind flow from the cross-section of the bluff body is greater in the direction of the speed, then the fins will move up and down will be higher.



(a)



(b)

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(c)

Fig. 8 The relationship between electric voltage and time (a) Fin 3 speed 5 m/s, (b) fin 2 speed 7 m/s, (c) fin 2 speed 9 m/s.

The results of the graph of the relationship between speed and electric voltage generated by piezoelectric on fin 3 with variations in the speed of 5 m/s, 7 m/s, and 9 m/s. The experimental results of fin 3 with a speed of 5 m/s produce an electrical voltage of 4.73 volts, a speed of 7 m/s produces an electric voltage of 5.09 volts, and a speed of 9 m/s produces an electrical voltage of 5.46 volts. From the three graphs, it is the fin that produces a high voltage at a speed of 9 m/s. This happens because the result of the turbulence of the wind flow from the cross-section of the bluff body is greater in the direction of the speed, then the fins will move up and down will be higher.

Table 1. Results of Fin Testing Data (fins) 1, 3 and 4.

Fin Shape	**Speed (m/s)**	**Maximum Voltage Yield (volt)**
Fin Shape 1	5	4,53
	7	4,70
	9	5,15
Fin Shape 2	5	4,73
	7	5,09
	9	5,46
Fin Shape 3	5	4,82
	7	5,15
	9	5,58

Based on the results of testing the cross-sectional shape of fin 1, fin 3, and fin 4. The relationship between speed and the electric voltage generated by piezoelectricity, the maximum voltage data for each fin is shown in table 1, and the graphic form is shown in Figure 9.

It can be seen in the graph of the test results of all forms of fins the result of the largest electric voltage is fin 3, starting from a speed of 5 m/s producing a maximum voltage of 4.73 volts, a speed of 7 m/s producing a maximum voltage of 5.09 volts, and a speed of 9 m/s produces a maximum voltage of 5.46 volts. Fin 4 electrical voltage is greater than the other fins; this is because the width of the tip of the fin is larger, then the potential when the wind flow that lifts the fin will produce a larger deflection, which causes the fin to move up and down hitting the piezoelectric surface. The larger the diameter of the fin being tested, the larger the fin will strike the piezoelectric surface so that the effective value will be high.

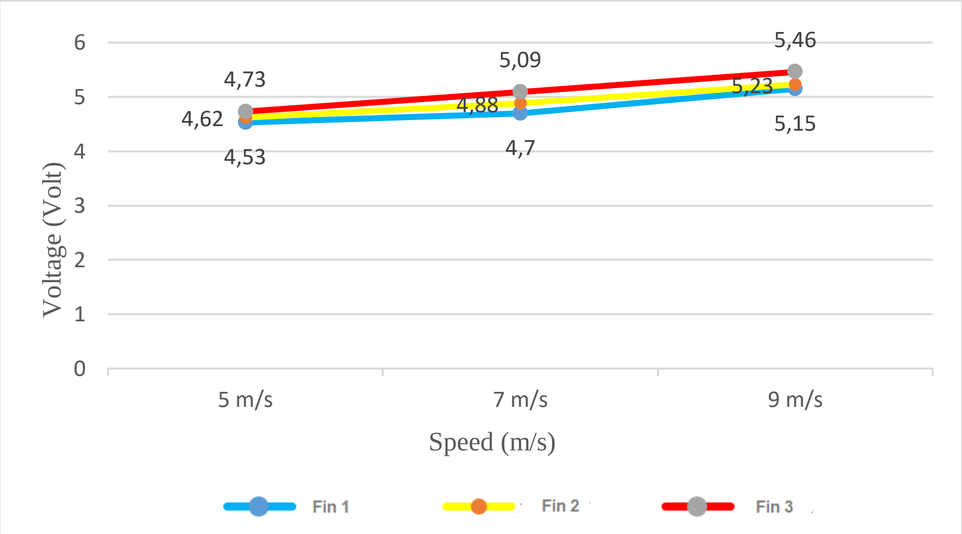

Fig. 9 Graph of test results of all fin shapes

4. CONCLUSION

Based on the results of the research conducted, the following conclusions can be drawn:

1. The results of variations in the shape of fin 1, fin 2, and fin 3 produce the highest electrical voltage, namely fin 3. This occurs because the diameter of the tip fin is larger than the one tested, resulting in a higher piezoelectric fin impacting deflection.
2. The result of the highest electrical voltage from the speed variable used during the test is at a speed of 9 m/s producing an electric voltage of 5.46 volts in the fin 3 test.

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