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Comparative Study of Materials to Improve the Performance of Simple Water Wheels in the Utilization of Hydro Energi

Rabina Amara Yusra[1]; Ade Sylviana Rohendi[1]; Rida Rihadatul Aiys[1]; Fuji Hernawati Kusumah[1]

1. Department of Physics Education, Faculty of Educational Sciences, UIN Syarif Hidayatullah Jakarta, Jl. Ir H. Juanda No.95, Ciputat, Ciputat Tim., Tangerang Selatan, Banten 15412, Indonesia

[*)]Email: rabinaay21@mhs.uinjkt.ac.id

ABSTRACT

Water wheels are one of the examples of renewable energy generators that have been used for a long time. However, the improvement of the performance of simple water wheels still needs further investigation, especially regarding the influence of materials, as there has been limited research on this aspect. This study aims to conduct a comparative study of materials that can enhance the performance of a simple water wheel in harnessing hydro energy. In this research, the performance of water wheels made of wood, aluminum, and plastic was examined. Testing was carried out by measuring the voltage and electric current generated by the water wheels using a multimeter. The water wheels made of wood, aluminum, and plastic produced voltage and electric current values of 2.80 V and 6.90 mA, 2.88 V and 7.82 mA, and 2.93 V and 9.64 mA, respectively. The results of the study indicate that plastic exhibits better performance, as it generates higher voltage and electric current compared to wood and aluminum. The larger the values of voltage and electric current produced by the water wheel, the better its performance. Hence, the materials used in constructing a simple water wheel have an impact on its performance

Keywords: *Hydropower, Wood, Aluminium, Plastic*

ABSTRAK

Kincir air adalah salah satu contoh pembangkit energi listrik terbarukan yang sudah lama digunakan. Namun, peningkatan kinerja kincir air sederhana masih harus diteliti terutama mengenai pengaruh bahan dikarenakan belum banyak yang meneliti. Penelitian ini bertujuan untuk melakukan studi perbandingan bahan yang dapat meningkatkan kinerja kincir air sederhana dalam pemanfaatan energi hidro. Pada penelitian ini, bahan yang diuji kinerjanya adalah kayu, aluminium, dan plastik. Pengujian dilakukan dengan mengukur tegangan dan arus listrik yang dihasilkan oleh kincir dengan menggunakan multimeter. Kincir dengan bahan kayu, aluminium, dan plastik menghasilkan tegangan dan arus listrik berturut-turut sebesar 2,80 V dan 6,90 mA, 2,88 V dan 7,82 mA, dan 2,93 V dan 9,64 mA. Hasil penelitian menunjukkan bahwa plastik lebih baik kinerjanya karena menghasilkan tegangan dan arus listrik lebih besar dibandingkan dengan bahan kayu dan aluminium. Semakin besar nilai tegangan dan arus listrik yang dihasilkan oleh kincir, semakin baik kinerjanya. Therefore, the materials used in the construction of a simple water wheel have an impact on its performance.

Kata kunci: *Energi Hidro, Kayu, Aluminium, Plastik*

1. INTRODUCTION

Energy is an essential resource for every living thing, including humans [1]. Electricity, as a form of energy, plays a crucial role in life [2]. Human activities become more efficient with the presence of electricity. Alongside the growth of the population, the demand for electrical energy in Indonesia continues to rise [3]. Abundant energy assets in Indonesia, such as hydropower, geothermal, natural gas, coal, biomass, biogas, wind, solar, and others, can serve as alternative energy sources, replacing dependence on increasingly limited oil resources [4].

Water represents a renewable and developable energy source for electricity generation [5]. The utilization of water in water wheels acquires kinetic energy. Water wheels utilize water power to generate electrical energy [6]. Its function as an energy converter transforms water energy into kinetic energy, followed by a generator that converts kinetic energy into electrical energy. One of the functions of water wheels is electricity generation. To enhance the efficiency and effectiveness of electricity production, research is required to understand the factors influencing the performance of water wheels.

Research on the performance of water wheels has been conducted, examining factors such as the influence of blade thickness variation , bowl-shaped blades [7], water flow rate [8], turbine blade width, blade angle size [9], fluid flow system, blade quantity variation [10], The Effect Nozzle Angle[11],and blade height. However, there is no discussion yet regarding the comparison of materials in water wheels for enhancing hydro performance. Thus, research is needed on the influence of material variations in water wheels on the performance of a simple water wheel.

In this study, an analysis is conducted to compare various materials that can enhance the performance of a simple water wheel in utilizing hydro energy. The materials considered are wood, aluminum, and plastic. Parameters measured in the simple water wheel involve voltage and current production, where larger values indicate better wheel performance.

2. METHOD

An experiment on a simple water wheel for harnessing hydro energy was conducted. Three different materials for the water wheel, each with the same shape and size, were employed.

2.1. Materials and Components

The materials used to create a water turbine with three different types of components are popsicle sticks, wooden skewers, hot glue, scissors, soldering iron, cutter, water, aluminum cans, styrofoam, tray, DC12V generator dynamo, cables, LED, hose, analog multimeter, and digital multimeter.

2.2. The Process of Making a Simple Water Wheel

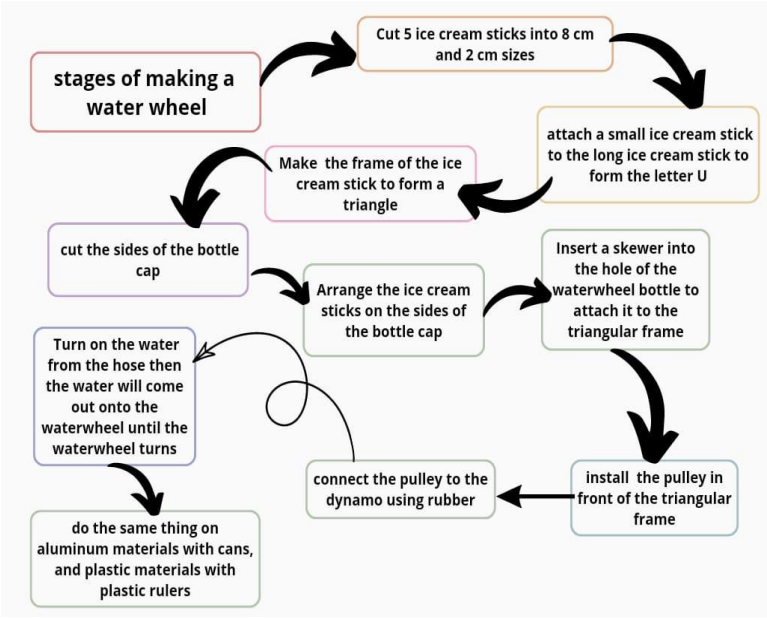

Figure 1. Stages of Making a Water Wheel

The construction of a water wheel using three different materials requires specific tools and materials as depicted in Figure 1. In the first step, we create the water wheel using wood, particularly with ice cream sticks. Cut the ice cream sticks into two sizes: 8 cm (5 pieces) and 2 cm (15 pieces). Next, attach the 2 cm pieces to the 8 cm sticks to form a U shape, serving as a reservoir for collected water. Repeat this process until five blades are formed.

Next, construct a frame using popsicle sticks to create a triangular structure as the base of the water wheel. Cut the sides of 5 bottle caps to serve as the placement for the five water wheel blades made from popsicle sticks. Apply glue to secure them. Make a hole in the center of one of the bottle caps to insert a wooden skewer that will connect to the triangular frame, forming the water wheel. Attach a pulley to the front of the triangular frame on the wooden skewer, and connect the pulley to a dynamo using a rubber band.

Then, turn on the water from the hose, ensuring it falls directly onto the water wheel, causing it to rotate. This rotation powers the dynamo, generating voltage and electric current, indicated by the illumination of an LED. Repeat the same process for aluminum using a can and plastic using a plastic ruler.

2.3. The Data Collection Process on a Simple Water Wheel

In this study, the process unfolds in two stages. The first stage involves crafting three water wheels from different materials and assembling a circuit to generate electricity. The second stage focuses on data recording. The data recording is conducted using repetitive techniques to ensure the accuracy and precision of the acquired data. Each material is tested three times to obtain current and voltage values.

The initial step involves integrating the water wheel with the frame, then connecting it to the electrical circuit using a pulley system. Subsequently, water is released from a similar height to set the simple water wheel in motion, causing the dynamo to rotate and generate electricity, indicated by the illumination of an LED. Furthermore, current and voltage values are measured using a multimeter,

and the measurement results will be compared to assess the effectiveness of different materials in generating voltage and electric current, as depicted in Figure 2.

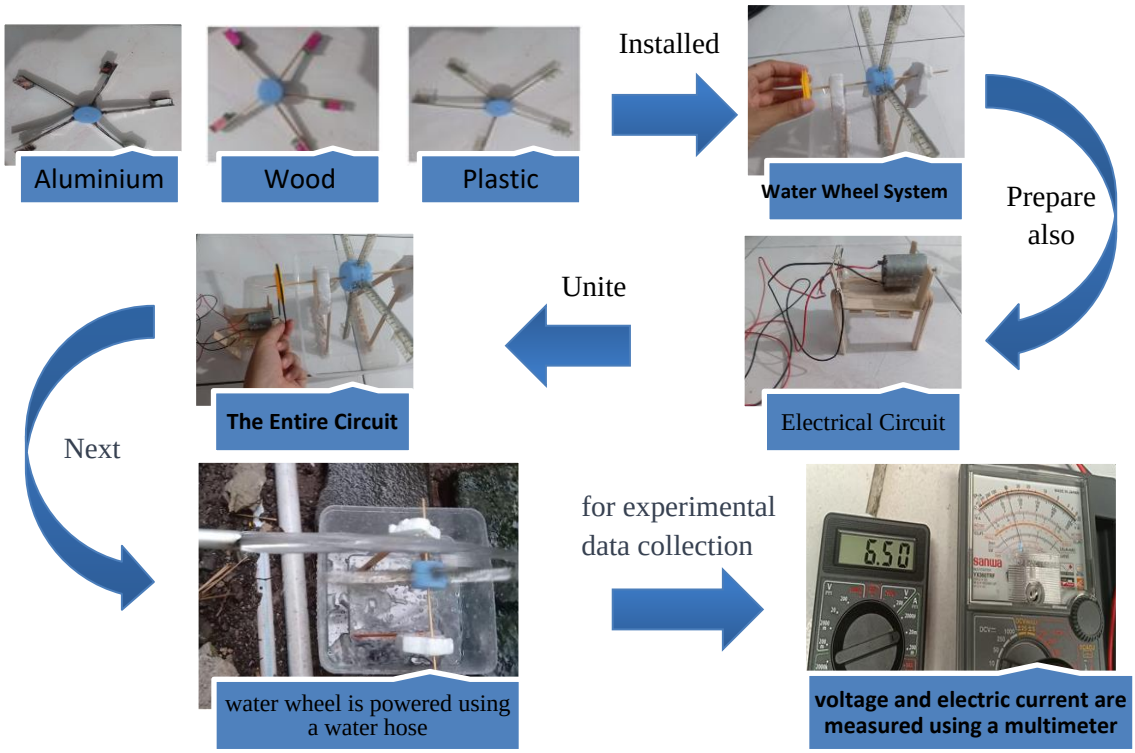

Figure 2. Data Collection Process

3. RESULT AND DISCUSSION

In the experiment of harnessing hydro energy using a water wheel with three different materials wood, aluminum, and plastic the objective is to enhance the water wheel's performance. This experiment aims to analyze and compare various materials that can be utilized to improve the efficiency of a simple water wheel in harnessing hydro energy. Based on this objective, the experiment substantiates its findings by considering the voltage and current measurements as a comparison among the three materials. These measurements gauge the effectiveness of the materials in enhancing the waterwheel's performance, taking into account factors such as water drop height, water volume, and wheel angle, which remain constant throughout the experiment.

Voltage and current measurements are obtained using two types of multimeters digital and analog repeated three times for each material. Refer to Figure 3 for visual representation, where Figure (a) displays the current and voltage values for wood, Figure (b) for aluminum, and Figure (c) for plastic.

(a) The current and voltage magnitudes in wood.

(b) The current and voltage magnitudes in aluminum

(c) The current and voltage magnitudes in plastic materials.

Figure 3. The Magnitudes of Electric Current and Voltage in Wood, Aluminum, and Plastic Materials are Repeated Three Times.

3.1. Electric Current

To determine the most effective material in enhancing the performance of a water turbine, it can be determined by measuring the electric current generated by three types of materials: wood, aluminum, and plastic. The electric current is measured using a digital multimeter, where the results from these materials are analyzed to identify the one producing the highest electric current. This is crucial in determining the type of material that is better suited for improving the water turbine's performance.

In this research, we found differences in the electrical current generated by wood, aluminum, and plastic materials. Based on the results presented in Table 1. Electrical current measurements were conducted through three repetitions for each material. For wood, the electrical current was 6.99 mA in the first repetition, followed by 6.50 mA, 6.99 mA, and 7.47 mA in subsequent repetitions. Aluminum produced an electrical current of 7.82 mA in the first repetition, followed by 7.59 mA, 8.22 mA, and 7.65 mA. Plastic generated an electrical current of 9.64 mA initially, followed by 7.91 mA, 10.85 mA, and 10.17 mA. Based on the magnitude of the electrical current, plastic exhibited a higher current output compared to wood and aluminum.

Tabel 1. Processing of Electric Current in Wood, Aluminum, and Plastic.

Types Of Materials	Electric Current (mA)			The Average Electric Current (mA)
	1	2	3	
Wood	6.5	6.99	7.47	6.99
Aluminum	7.59	8.22	7.65	7.82
Plastic	7.91	10.85	10.17	9.64

3.2. Electric Voltage

This experiment investigates the voltage generated by water wheels using three different materials: aluminum, plastic, and wood. Measurement data reveals variations in voltage values for each material. Table 2. Voltage measurement results with different materials. Firstly, the wooden water wheel produced an average voltage of 2.80 V, with consecutive measurements around 2.84 V, 2.68 V, and 2.88 V. Secondly, the aluminum water wheel yielded an average voltage of approximately 2.88 V, with consecutive measurements of 2.92 V, 2.88 V, and 2.84 V. Lastly, the plastic water wheel exhibited the highest average voltage at 2.93 V, with consecutive measurements around 2.88 V, 2.96 V, and 2.96 V. From the experimental data, it is evident that the plastic water wheel provides a higher average voltage (2.93 V) compared to the wooden (2.8 V) and aluminum (2.88 V) counterparts. This indicates that the plastic water wheel has the potential to generate a greater voltage than wood and aluminum under the given experimental conditions.

It is important to note that these results may be influenced by various factors, such as water wheel design, flow rate, and the characteristics of each material. Variations in values during each experiment repetition should be considered to assess result stability. Thus, from a mathematical data processing perspective, It can be concluded that plastic exhibits better performance in generating voltage in this experiment.

Table 2. Result Of Processing Voltage For Wood, Aluminum, and Plastic

Types Of Materials	Electric Voltage (V)			The Average Electric Voltage(V)
	1	2	3	
Wood	2.84	2.68	2.88	2.80
Aluminum	2.92	2.88	2.84	2.88
Plastic	2.88	2.96	2.96	2.93

3.3. Comparison of Voltage and Electric Current Results

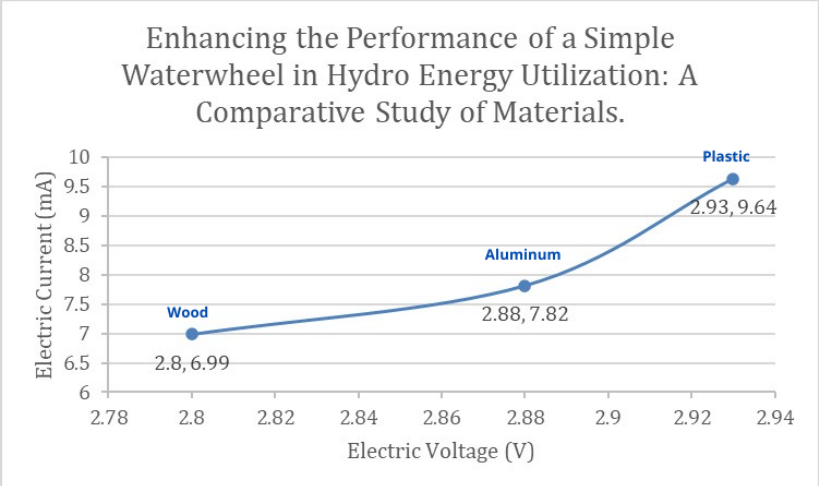

Figure 4. The Graph llustrates a Comparison of the Voltage and Current Produced by a Water Wheel with Three Different Materials.

Figure 4 shows that each material used in the water wheel with different types of bulbs, blade size, as well as the same blade height and water volume, produces different voltage and current for each material. Based on the graph, it can be stated that among the three types of materials, plastic generates higher voltage and current compared to wood and aluminum. A higher voltage leads to a larger obtained current, resulting in better overall performance.

Through the experimental results, it can be analyzed that among the three types of materials, plastic enhances the performance of the water wheel as a power source. This is evident from the magnitude of the generated voltage and electric current; a higher voltage leads to a larger current [12], indicating an increase in the rotational speed of the water wheel [13]. In this context, the selection of materials, such as plastic, becomes a crucial factor in improving the efficiency of the water wheel as a power source, alongside other factors like blade design [14], waterfall height [15] and water volume [8].

4. CONCLUSION AND RECOMMENDATIONS

Based on the research results, it is evident that there are differences in the quality of each material in enhancing the performance of a water wheel. This is observable in the varying voltage and electric current outcomes generated by the three types of materials.

The study indicates that the materials employed in constructing a simple water wheel significantly influence its performance. Among the three materials, plastic demonstrates superior performance, producing a voltage of 2.93 V and a current of 9.64 mA. Aluminum exhibits reasonably good performance, generating a voltage of 2.88 V and a current of 7.82 mA, while wood shows lower performance compared to aluminum and plastic, yielding a voltage of 2.80 V and a current of 6.99 mA. Consequently, it can be concluded that using plastic as the material results in higher voltage and electric current compared to wood and aluminum. The larger the obtained voltage and electric current, the better the performance of the water wheel.

For future research aiming to enhance the performance of a simple water wheel, it is recommended to utilize a water pump capable of generating a substantial water flow. This approach will facilitate the data collection process and contribute to a more comprehensive analysis of the water wheel's efficiency.

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