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The effect of a 120 kg pontoon mass on the wave energy converter device due to heaving

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Abstract: The environment is negatively impacted by the use of fossil fuels as a source of electricity. Using sustainable ocean wave energy is one way to replace fossil fuels and maximize the usage of natural energy. Electrical energy is produced from mechanical energy by ocean waves. An apparatus for converting wave energy from the ocean is needed to absorb it. The wave energy converter uses the up-and-down action of a chain on a pontoon to rotate a generator, producing electrical energy. The mass of the pontoon and the force of the ocean waves that excite it both have an impact on its vertical movement. Thus, the impact of pontoon mass on the wave energy converter is examined in this research. Both a planetary gear system and one without were used in the investigation. The voltage and current obtained at a wave height of 35 cm were 2.28 Volts and 0.160 A, respectively, without the planetary gear and 160.41 Volts and 13.95 A, with the planetary gear. Furthermore, an evaluation of the wave energy converter machine's performance was carried out. Using a planetary gear and a wave height of 13 cm, the second experiment's minimum power production was 212.63 Watts, while the sixth experiment's maximum power output was 2237.72 Watts with a wave height of 35 cm. In the second experiment, the generator without a planetary gear produced 0.0327 watts of power with the same wave height, and in the sixth trial, the generator produced a maximum of 0.3648 watts with a 35 cm wave height. As a result, utilizing a generator with a planetary gear is preferable to using one without one.

Keywords: Converter; ocean waves; pontoon; planetary; non-planetary; generator.

1. INTRODUCTION

All facets of human existence, especially in Indonesia, have a substantial demand for electrical energy due to the ongoing development of industry and technology [1][2]. Mercu Buana University has carried out several experiments on alternative energy, including rotor dynamics, four-stroke gasoline engines, and energy harvesting from vibrations applied to milling machines. There have also been concepts for turbines positioned inside pipe flows. However, because Indonesia is an archipelago with seas covering the majority of its land, the ocean has a lot of potential to be used as a source of new renewable energy that is both environmentally and economically beneficial, particularly when it comes to using ocean waves [3].

Wave Energy Converters (WECs) are machines that use a generator to spin while a chain on a pontoon moves up and down to produce electrical energy [4][5]. The foundation of WEC's operation is the employment of an apparatus that can detect wave motions and transform them into electrical energy with a variety of uses [6]. The impact of pontoon mass on the converter device's performance is an important factor to take into account, particularly in areas with variable sea conditions [7]. Heaving and other variations in the sea state can have an impact on the converter device's functionality [8]. Consequently, knowing the proper pontoon mass to use in wave energy conversion systems is crucial [9]. This study investigates the potential effects of a 120 kg pontoon mass on the heave motion response and power output. This study uses both planetary and non-planetary systems to examine how a 120 kg pontoon mass affects the wave energy converter as a result of heaving action. The ability of the wave energy converter equipment to convert wave energy into electrical energy as effectively as feasible is referred to as its efficiency [10].

To effectively convert the mechanical energy from the waves into electrical energy, components influencing the efficiency of wave energy converter devices must be responsive to wave movements [11]. A floating structure, including ships, that is in heaving motion is moving linearly (up and down) along the vertical Z-axis above the wavy water surface [12].

2. METHOD

This study started with a review of the literature, field testing the wave energy converter device, gathering and analyzing data, and presenting the findings and recommendations from the testing. Figure 1 depicts the research procedure.

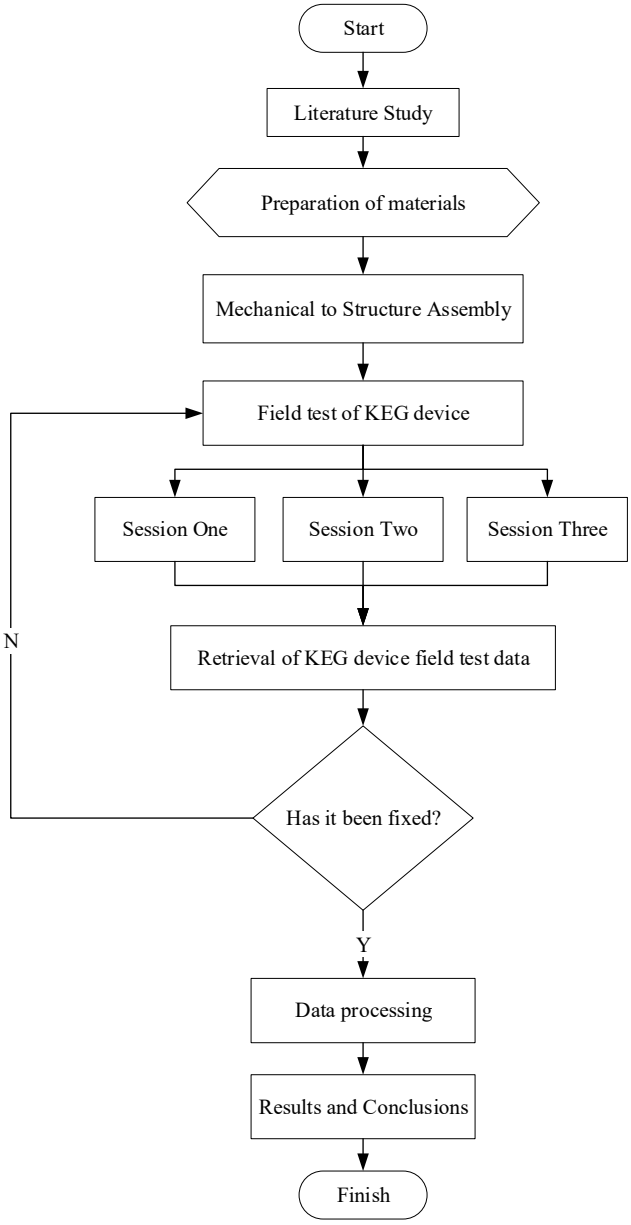

Figure 1. Flow diagram.

This study employed the experimental method, which entails putting the wave energy converter gadget through actual field testing. This study looks at how the tools, materials, time, and place were employed to efficiently gather data on the wave energy's conversion to electrical energy throughout the sea's heaving process. After gathering all the necessary data and deeming it sufficient, Microsoft

Excel was used for data processing to extract the wave energy converter device's output (WEC). The Wave Energy Converter (WEC) apparatus is seen in Figure 2.

Tanjung Pasir Beach in Tangerang was the site of the Wave Energy Converter machine trials, where a 120 KG variation in pontoon mass was used. As seen in Figure 2, this apparatus is made up of several parts that are fixed on the mechanical framework. Among them are springs, which are utilized to lessen the pontoon's impact and shock from the waves of the ocean. Moreover, these springs aid in keeping the pontoon stable on the water. Three springs were employed in this experiment, which involved a 120 KG change in pontoon mass. The gearbox, an essential part of the wave energy converter device, is the following component. The pontoon's back and forth, up and down action drives the gearbox, and this motion is transferred to the gearbox via a mechanical mechanism like gears [13]. The gearbox uses a set of gears with varying sizes to transform reciprocating motion into rotational motion. Smaller gears revolve more quickly than larger gears. There's also the generator part, which is attached to the gearbox shaft. Electrical energy is produced by the generator from mechanical wave energy [14][15]. Two generators—one with a planetary system and the other without—were employed in this study. This was carried out to compare how effectively they could produce electricity. Moreover, the gearbox is mostly driven by the pontoon component due to the up-and-down movement of the chain that connects the two.

Six one-hour experiments were conducted during the heaving process to test the wave energy converter apparatus. Processing of the voltage, current strength, and RPM measurements taken during these trials produced the power numbers.

Figure 2. Wave Energy Converter Machine (WEC).

3. RESULTS AND DISCUSSION

After that, the acquired data were processed by Microsoft Excel computations, which showed a comparison of the data outcomes for generators with and without a planetary system, as seen in Figure 3, and Figure 4.

Analysis of sea experiment data using planetary

Following data processing and analysis with Microsoft Excel, it was possible to observe that the acquired values of voltage, current, and power are highly influenced by the wave height's magnitude. larger wave heights result in larger voltage, current, and power values, as seen in Figure 3, Figure 4 and Figure 5.

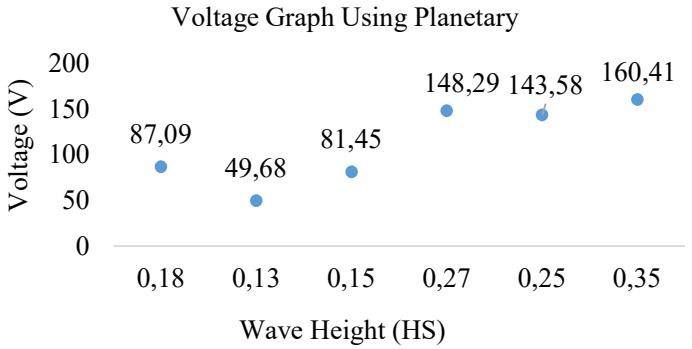

Figure 3. Voltage graph (volt) using planetary.

The voltage data processing graph for the generator employing a planetary system is shown in Figure 3. It demonstrates how the WEC machine's output rises in tandem with the height of the sea waves. An 18-cm wave height results in 87.09 volts of voltage being produced. 49.68 volts are generated at a wave height of 13 cm. The voltage output is 81.45 volts at a wave height of 15 centimeters. A wave height of 27 cm results in an output voltage of 148.29 volts. The voltage output is 143.58 volts at a wave height of 25 centimeters. In the meantime, the voltage output is 160.41 volts at a wave height of 35 cm.

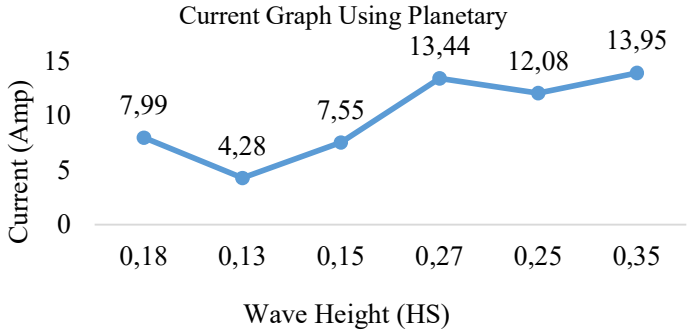

Figure 4. Current graph (ampere) using planetary.

Using a planetary system, Figure 4 shows the current data processing graph for the WEC device generator. It demonstrates that the output generated by the WEC device increases in tandem with the height of the sea waves. The current measured at an 18-cm wave height is 7.99 Amperes. The current measured at a wave height of 13 cm is 4.28 Amperes. The current measured at a wave height of 15 cm is 7.55 Amperes. 13.44 amps is the obtained current at a wave height of 27 centimeters. The current measured at a wave height of 25 cm is 12.08 amps. Meanwhile, the WEC device obtained 13.95 Amperes of current at a wave height of 35 cm.

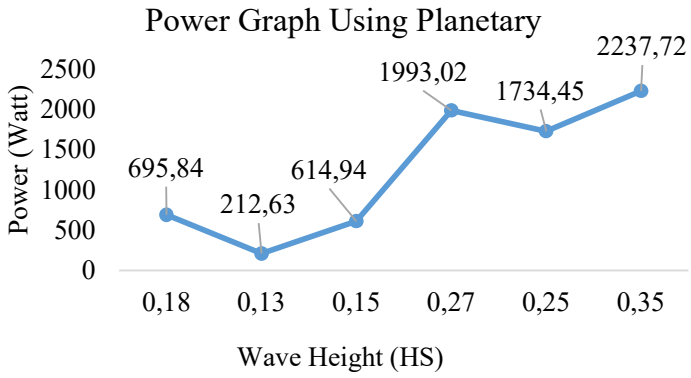

Figure 5. Power graph (watt) using planetary.

The power data processing graph for the WEC device generator employing a planetary system is shown in Figure 5. The WEC device's output power grows in tandem with the height of the sea waves. The power measured at an 18-cm wave height is 695.84 watts. The power measured at a wave height of 13 cm is 212.63 Watts. The power measured at a wave height of 15 cm is 614.94 Watts. The power measured at a wave height of 27 cm is 1993.02 Watts. The power measured at a wave height of 25 cm is 1734.45 Watts. Meanwhile, the WEC device achieves 2237.72 Watts of power at a wave height of 35 cm.

Analysis of sea experiment data without planetary

Following data collection, Microsoft Excel was used for analysis and processing to show how wave height magnitude greatly influences the voltage, current, and power values that are produced. Higher wave heights result in higher voltage, current, and power values, as Figure 5, Figure 6, and Figure 7.

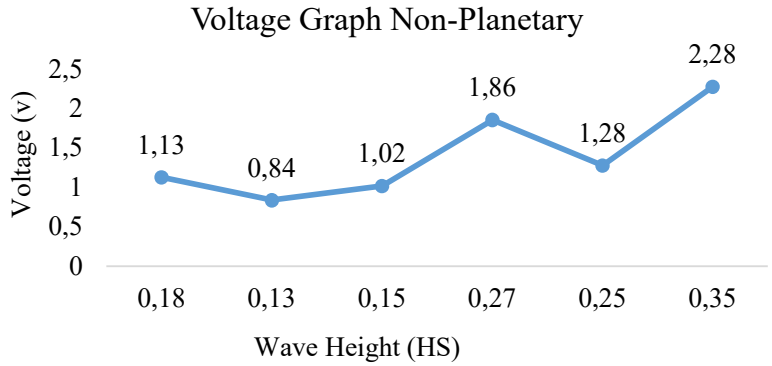

Figure 6. Voltage graph (volt) non-planetary.

The voltage data processing graph for the non-planetary system is depicted in Figure 6, which demonstrates that the output generated by the WEC machine increases in tandem with the height of the sea waves. The voltage generated is 1.13 volts at a wave height of 18 centimeters. There is a 0.84-volt voltage created at a wave height of 13 cm. 1.02 volts is the voltage output at a wave height of 15 cm. 1.86 volts is the voltage output at a wave height of 27 cm. 1.28 volts is the voltage output at a wave height of 25 cm. In the meantime, the voltage output is 2.28 volts at a wave height of 35 cm.

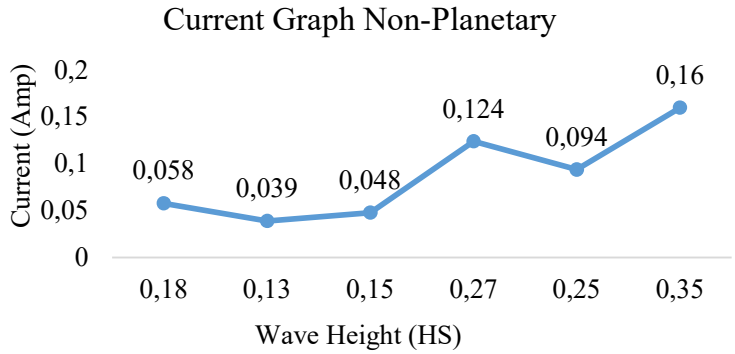

Figure 7. Current graph (ampere) non-planetary.

The current data processing graph for the WEC device's non-planetary generator is shown in Figure 7, which shows that the output generated by the device increases in tandem with the height of the sea waves. The current measured at an 18-cm wave height is 0.058 amps. The current measured at a wave height of 13 cm is 0.039 Amperes. The current measured at a wave height of 15 cm is 0.048 amps. The current measured at a wave height of 27 cm is 0.124 Amperes. The current measured at a

wave height of 25 cm is 0.094 amps. Meanwhile, the WEC device obtained 0.160 Amperes of current at a wave height of 35 cm.

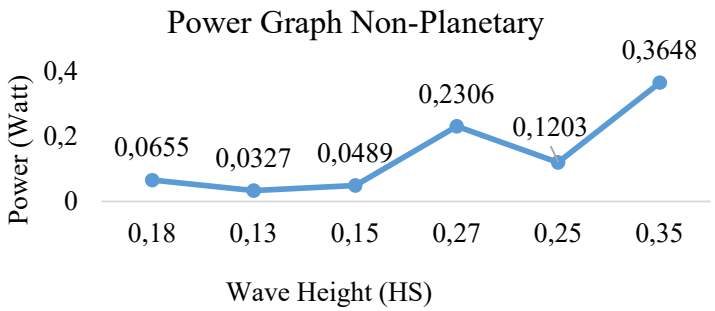

Figure 8. Power graph (watt) non-planetary.

The power data processing graph for the WEC device's non-planetary generator is shown in Figure 8 which indicates that the output power generated by the device increases in tandem with the height of the sea waves.

The power measured at an 18-cm wave height is 0.0655 Watts. The power measured at a wave height of 13 cm is 0.0327 Watts. The power measured at a wave height of 15 cm is 0.0489 Watts. The power measured at a wave height of 27 cm is 0.2306 Watts. The power measured at a wave height of 25 cm is 0.1203 Watts. In the meantime, the WEC device's power output at a wave height of 35 cm is 0.3648 Watts.

Microsoft Excel processing of the sea experiment data analysis produced power output findings for the WEC device. In the tests, the planetary system-equipped WEC device produced a minimum power of 212.63 Watts at a wave height of 13 cm and a maximum power of 2237.72 Watts at a wave height of 35 cm. At the same wave height, the power achieved for the WEC device without a planetary system was 0.3648 Watts and 0.03276 Watts. This indicates that, in comparison to experimental results obtained without a planetary system, the WEC device employing a planetary system exhibits more optimal and promising results. Another important component of this WEC device experiment is the installation of a 120 KG mass. The results of the studies demonstrate that the WEC device can produce the best possible power output for illumination while withstanding a 120 KG mass load.

4. CONCLUSION

The following findings can be made from the Wave Energy Converter (WEC) machine's heaving motion performance trials employing an H-Beam pontoon type and a 120 KG pontoon mass: In the wave energy conversion experiments, power, voltage, and current are generated in proportion to the height of the waves. The minimal voltage, current, and power for experiments without a planetary system are 0.84 volts, 0.039 amperes, and 0.0327 watts at a wave height of 13 cm. The voltage is 49.68 volts, the current is 4.28 amperes, and the power is 212.63 watts at the same wave height as a planetary system. 70.32 rpm is the shaft gear rotation speed. In the meantime, 2.28 volts, 0.160 amperes of current, and 0.3648 watts of power are obtained without the use of a planetary system at the highest wave height of 35 cm. The voltage, current, and power achieved with a planetary system operating at the same wave height are 160.41 volts, 13.95 amperes, and 2237.72 watts, respectively. 83.43 rpm is the gearbox's rotational speed. Consequently, the WEC device may react to wave energy quite optimally by adding a 120 KG pontoon mass. The results of the experiments also suggest that utilizing a planetary system is preferable to not using one.

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