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Study on the effect of pitching on wave energy converter devices due to a spring constant of 980 N/M

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Abstract: Having enough energy is crucial to living a healthy and fulfilling life. Energy is necessary for many of the actions and tasks that individuals carry out regularly. To increase national resilience and enhance the welfare of its citizens, Indonesia is thought to be a good place to use renewable energy through the development of its natural resources. The Wave Energy Converter is one of the energy producers (WEC). The Wave Energy Converter is a machine that uses the up-and-down motion of a chain through a pontoon to drive the rotation of a solenoid in a generator to produce electrical energy. The component that produces energy is the vertical movement of waves. Thus, the impact of the spring constant on ocean waves is examined in this work. Both planetary and non-planetary approaches were used in this study. Based on the research objectives and the experimental results on the pitching motion performance of the Wave Energy Converter machine, it can be concluded that the power without planetary gear in the analysis of potential energy and sea data identification is 0.43 Volts, and the highest is 4.2 Volts. The RPM range is 78.18 RPM at the minimum and 91.45 RPM at the maximum. 0.021 amps is the minimum and 0.043 amps is the maximum current value. The power range for planetary gear potential energy analysis and sea data identification is 58.5 volts to 168.36 volts. The RPM range is 78.18 RPM at the minimum and 91.45 RPM at the maximum. 1.93 amps is the least current value, and 14.01 amps is the maximum.

Keywords: Wave Energy Converter (WEC); pitching; planetary.

1. INTRODUCTION

The need for energy keeps rising in tandem with humanity's expanding requirements [1][2]. Numerous organizations in Indonesia are vying with one another to create new renewable energy sources to combat the depletion of fossil fuels. This includes Mercu Buana University's Department of Mechanical Engineering, which is investigating ways to use water flow in pipes to gather vibration energy. Four forms of energy have been used by society. Utilizing fresh renewable energy sources like solar, wind, water, and ocean waves is one way to find a solution [3][4]. Water energy has enormous potential that has not yet been completely realized.

Sufficient equipment is necessary to acquire wave data from many sources. To find the dominant wave height and wave period, wave height is measured directly with a wave height gauge [5]. Ocean waves are also a feasible renewable energy source because of their enormous potential for use and the fact that moving water is a dense energy carrier due to their high density [6].

Having the right tools is necessary to obtain waveform data from multiple sources. To find the dominating wave height and the next wave period, wave height is directly measured using a wave height gauge [7]. Ocean waves are also a feasible renewable energy source because of their relative availability and the fact that moving water, with its high density, is a dense energy transporter [8]. In this study, the author uses planetary and non-planetary systems to assess an experiment on wave energy arising from pitching motion with a spring constant of 980 N/m. This study uses planetary and non-planetary systems to experiment with wave energy arising from pitching motion with a spring constant of 980 N/m.

An apparatus called the Wave Energy Converter (WEC) is used to transform the kinetic energy of ocean waves into electrical energy [9]. The device that can catch the motion of ocean waves and

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transform it into electrical energy for use in a variety of applications is the foundation of the operating concept of the wave energy converter (WEC) [10]. Three components make up the converter's energy conversion mechanism: the electrical generation system, the pontoon, and the Power Take-Off (PTO) gearbox [11]. Since each component helps produce energy, each component's efficiency should be every researcher's top priority.

When floating on choppy waters, a structure, especially a ship, will pitch, or move vertically up and down [12]. When a floating structure is thrown off balance, it experiences an oscillation known as pitching motion, which has a restoring force [13]. The natural frequency and period of the pitching motion are the result of internal elements that affect the transverse oscillation's frequency and period [14].

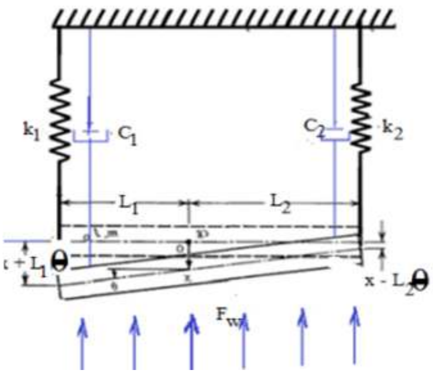

Figure 1. Pitching motion system.

The natural frequency and period of the pitching motion, or the frequency and period of the transverse oscillation caused by internal variables, are depicted in Figure 1. Under the assumption that the rotation angle is modest, the equations of motion in their coordinates, y(x) and y(y), are as follows.

$$ma = \Sigma(forces)m\ddot{x} = \mathrm{c1}(\dot{x} - \mathrm{L1}\theta) - c2\left(\dot{x} + \mathrm{L2}\dot{\theta}\right) - k1(x - L10) - k2(x + L20) + Fw(t)$$

$$Fpto = -\mathrm{c1}\left(\dot{x} - \mathrm{L1}\dot{\theta}\right) - c2\left(\dot{x} + \mathrm{L2}\dot{\theta}\right) - k1(x - L10) - k2(x + L20).$$

$$\mathrm{J}\dot{\theta} = \Sigma(moements)\mathrm{J}\dot{\theta} = \mathrm{c1}\left(\dot{\theta}\right)\mathrm{L1} + \mathrm{c2}\left(\dot{\theta}\right)\mathrm{L2} + \mathrm{kt1}(\mathrm{x} - \mathrm{L1}\theta)\mathrm{L1} + \mathrm{kt2}(\mathrm{x} + \mathrm{L2}\theta)\mathrm{L2} + (\mathrm{L1}\ 2 + \mathrm{L2}\ 2\ \mathrm{L})$$

$$m\dot{x} + kx = F_{(t)} \tag{1}$$

The magnitude of the length change that occurs in a spring when a load is applied is calculated using the spring constant. The amount of the restorative force that the spring produces when it is stretched or compressed by the load is used to compute the spring constant.

$$\mathrm{W} = m\ x\ g \tag{2}$$

$$K = \frac{\mathrm{W}}{\Delta x}$$

Where:

W = Weight [Newton]
m = Mass [kg]
g = Earth's gravity [m/s^2]
Δx = Difference in initial and final length of the spring

The mechanical energy generated by the pontoon, which is also the mechanical output of the Wave Energy Converter, may be expressed as follows since the spring constant per the gearbox is.

$$Ep = \frac{1}{2}kx^2 \tag{3}$$

Where:

k = Spring constant

x = Strain/Compression

The spring constant in this study to obtain the elongation results from the spring can be derived as follows:

$$W = m \, x \, g \tag{4}$$

$$K = \frac{W}{\Delta x}$$

Where:

W = Weight [Newton]
m = Mass [kg]
g = Earth's gravity [m/s^2]
Δx = Difference in initial and final length of the spring

2. METHOD

This study employed an experimental design, which included doing in-person field testing. The procedures utilized in this investigation to confirm the functionality of the tools and supplies, as well as the location and timing of data collection on the Wave Energy Converter machine, were followed. The procedure is shown in the flowchart below, which begins with a review of the literature and continues with the field testing of the WEC machine, data collecting and processing, and presentation of the findings and conclusions of the WEC machine testing. Specifics are displayed in Figure *2*.

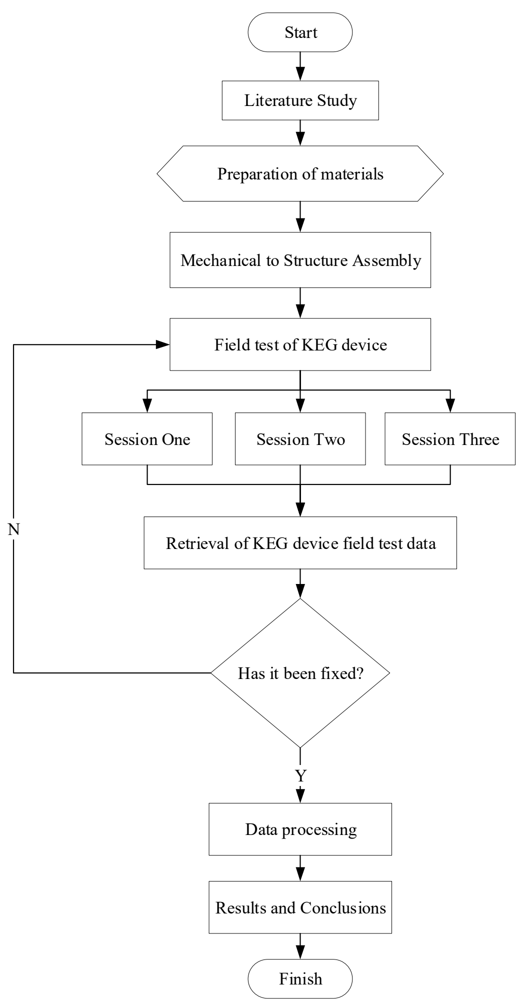

Figure 2. Flow diagram.

Explanation of the flowchart

Below are some explanations regarding the stages of the flowchart Figure 2. 1) The first step before beginning any research is to do a literature review, which entails looking through and analyzing references from books, journals, websites, and prior national and international research. This phase helps comprehend hypotheses or computations associated with the ongoing research. 2) Gathering experimental data and preparing materials for field tests on the wave energy converter machine. 3) Attaching the mechanical parts to the framework. In this phase, the gearbox, generator, pontoon, and multimeter are among the mechanical parts mounted on the construction. 4) The Wave Energy Converter (WEC) machine is field tested. The second field testing session consists of three testing sessions: the Constant Spring Measurement in the first, the Land Testing in the second, and the Sea Testing in the third. The testing will take place on one of the Wave Energy Converter structures. The WEC machine test aims to confirm the machine's pitching motion operation and to monitor voltage and current at Muara Baru Beach during wave height periods. 5) Gathering and processing data from the WEC Machine Field Test. The goal of data collecting is to compile all the information needed for analysis, while data processing is done to provide the study's findings and conclusions. Data processing entails computations using the information gathered from field tests of the wave energy converter device. 5) Findings and Synopsis. Following the wave energy converter machine's field testing, findings and suggestions will be made in the form of a study report based on the data processing and test results.

3. RESULTS AND DISCUSSION

Experiment results of WEC machine performance

These studies aimed to confirm that the WEC machine could operate as intended, based on field tests carried out before data gathering. WEC equipment was supposed to produce results with maximal wave energy [15]. With a prototype WEC machine, testing was done on land and at Tanjung Pasir Beach in Tangerang, where there is a 1.5 Meter sea depth and waves that range in height from 0.10 to 0.35 centimeters. Conversely, 980 N/m was the spring constant employed in this investigation.

Experimental data graphs for planetary system at sea

Following the acquisition of data from the Wave Energy Converter (WEC) apparatus, MATLAB was utilized to perform an analysis, as illustrated in Figure 3, Figure 4 and Figure 5. The Wave Energy Converter (WEC) experimental findings are provided, using a 40 kg pitching motion load and a spring constant of 980 N/m.

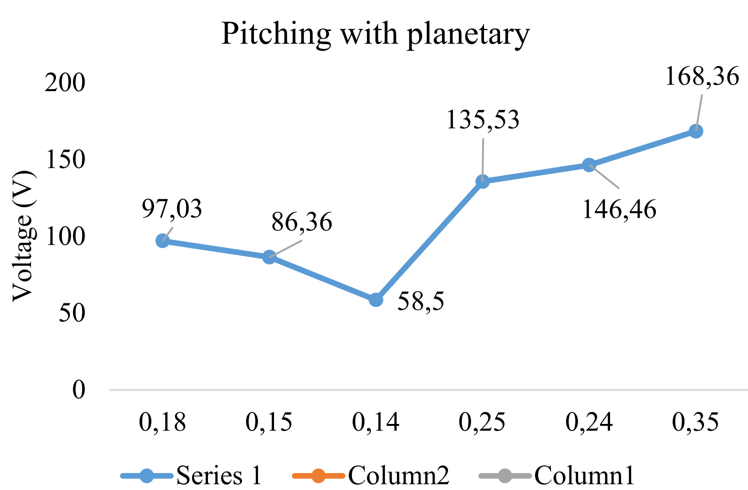

Figure 3. Voltage graph of the planetary system.

Figure 3 illustrates that the lowest voltage value generated at a wave height of 14 cm is 58.5 volts, and the greatest voltage value obtained at a wave height of 35 cm is 168.36 volts.

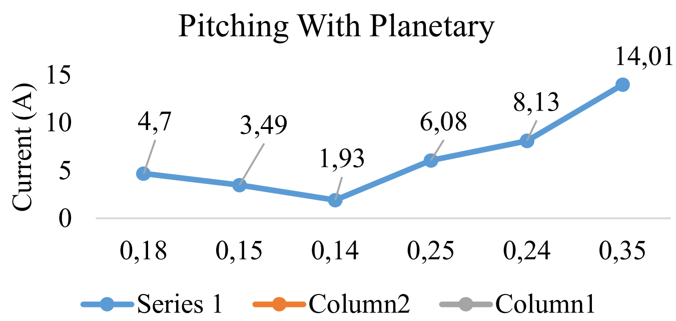

Figure 4. Current graph of the planetary system.

Figure 4 displays the present results. At a wave height of 14 cm, the lowest value of 1.93 Amperes was recorded, while at a wave height of 35 cm, the maximum value of 14.01 Amperes was recorded.

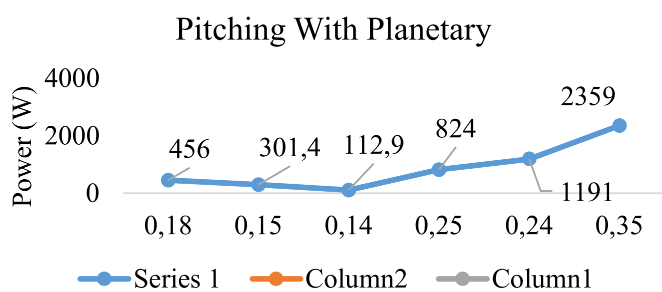

Figure 5. Power data graph of the planetary system.

The power output is shown in Figure 5 where 112.9 Watts is the lowest value recorded at a wave height of 14 cm and 2359 Watts is the maximum value recorded at a wave height of 35 cm. The Wave Energy Converter (WEC) machine's experimental results, with a spring constant of 980 N/m and a load of 40 kg owing to pitching motion using the planetary system, are shown in Figure 3, Figure 4 and Figure 5 The lowest voltage value is 58.5 Volts at a wave height of 14 cm, and the highest voltage value is 168.36 Volts at a wave height of 35 cm. Additionally, at a wave height of 14 cm, the non-planetary system's lowest current value resulting from pitching motion is 1.93 Amperes, and at a wave height of 35 cm, the greatest current value is 14.01 Amperes. Furthermore, with a wave height of 112.9 Watts, the maximum power output, however, is 2359 Watts.

Experimental data graphs for non-planetary systems at sea

As illustrated in Figure 6, Figure 7, and Figure 8 analysis was carried out using the MATLAB application following the acquisition of data from the Wave Energy Converter (WEC) device. Below are the findings from the Wave Energy Converter (WEC) experiment, which used a 40 kg pitching motion load and a spring constant of 980 N/m.

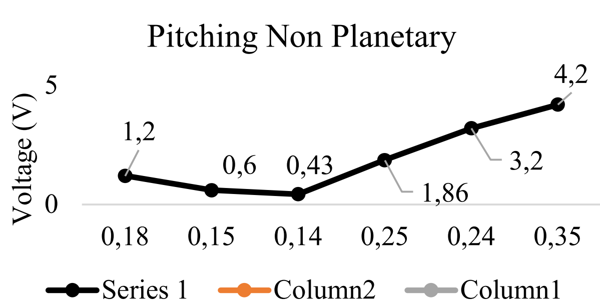

Figure 6. Voltage graph for non-planetary system.

According to Figure 6, at a wave height of 14 cm, the lowest voltage value generated is 0.43 volts, and at a wave height of 35 cm, the greatest voltage value attained is 4.2 volts.

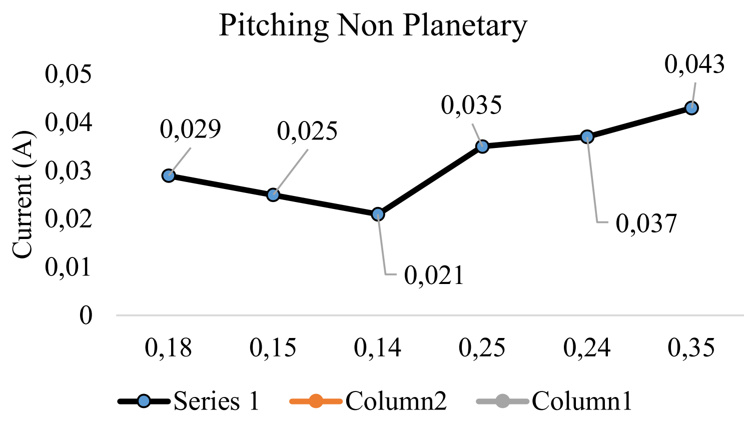

Figure 7. Current strength graph for non-planetary systems.

The results of the non-planetary pitching motion's current strength (in Amperes) are shown in Figure 7. At 14 cm wave height, the lowest current strength measured is 0.021 Ampere, while at 35 cm wave height, the maximum current strength attained is 0.043 Ampere.

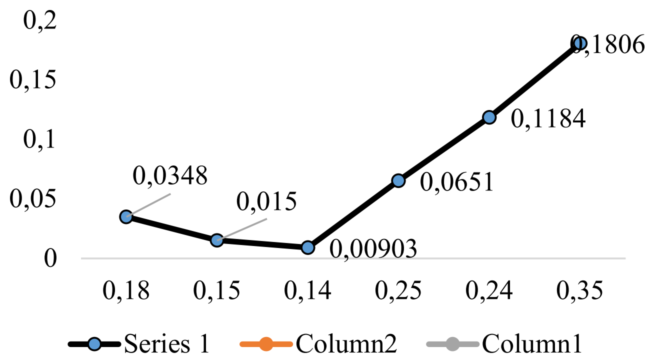

Figure 8. Power graph for non-planetary system.

The maximum power output measured is 0.1806 Watts at a wave height of 35 cm, while the lowest power output, shown in Figure 8, is 0.00903 Watts at a wave height of 14 cm. Figure 6, Figure 7, and Figure 8 illustrate the experimental results of the Wave Energy Converter (WEC) with a non-planetary pitching motion load of 40 kg and a spring constant of 980 N/m. The results show that the power output, voltage, and current strength vary with wave height.

4. CONCLUSION

Based on the research objectives and the experimental results on the pitching motion performance of the Wave Energy Converter machine, it can be deduced that a higher wave height results in a larger voltage and current. According to the experimental results of the Wave Energy Converter (WEC), at a wave height of 35 cm, a voltage of 168.36 Volts, a current of 14.01 Amperes, and a power of 2359 watts were achieved with a spring constant of 980 N/m and a load of 40 kg owing to planetary pitching motion. In the meantime, the findings for non-planetary motion show that at a wave height of 35 cm, there is a voltage of 4.2 volts, a current of 0.043 amps, and a power of 0.1806 watts.

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