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Preliminary design of wave energy utilization model simulation for buoy type seawater pumps

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Abstract. This study aims to obtain a preliminary design of simulation of a wave-powered seawater pump model with a buoy & vertical motion piston. The concept works are the mechanism of pumping seawater through the piston push and the apparent motion of the buoy up and down by the waves. The hypothesis, that the flow rate and pumping head as research variables were strongly influenced by wave height and period (H & T). Also, it was estimated that it was influenced by the weight and dimensions of the buoy (W & A) and the diameter of the piston tube. Preliminary experiments are carried out to see the performance of the test model and select the experimental variable magnitudes that are adjusted to the capacity of the available equipment and the scale of the model for similarity needs to the prototype conditions. This study will use a wave flume of 15 m long, 30 cm wide, and 50 cm effective height. The wave characteristics of the model to be used are the wave period in 3 variations (T1: 1.3 seconds, T2: 1.4 seconds, T3: 1.5 seconds), the range of wave heights in 3 variations (4 cm, 5 cm, and 6 cm) and water depth in 3 variations (d1: 25 cm, d2: 27 cm, d3: 29 cm). From the simulation design of this model, it is expected that the equation of the discharge and the height of the pumping head will be formulated in the form of dimensionless parameter relationships.

2 Introduction

Indonesia is an archipelago that is surrounded by two oceans, namely the Indonesian Ocean and the Pacific Ocean and its position is on the equator so that the conditions of tides, winds, waves, and ocean currents are quite large. The results of tidal height measurements in the Indonesian sea area show that several offshore coastal areas in Indonesia have quite high tides.

Several scientists have developed various alternative energy sources for remote areas such as solar energy, wind power, and micro-hydro. However, these alternative energy sources have advantages such as shallow seas and deep seas. The condition of these waters forms a variety of tidal patterns.

Water energy is a source of energy that is cheap and relatively easy to obtain. Electrical and mechanical energy is a form of utilization of water energy. The energy possessed by water can be utilized and used in the form of mechanical energy and electrical energy. Energy included in the water-energy category is river energy, wave energy, ocean thermal energy (OTEC), tidal energy, and ocean current energy. River hydropower utilizes water energy that moves from high to low levels. The amount of electricity that can be generated depends on the size of the waterfall and the speed of the water flow, the



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small hydro system captures river energy without taking much water from its natural flow, so that the utilization of this energy is environmentally friendly.

This research will simulate a float type wave pump method with vertical motion on a laboratory scale. this model is placed in the middle of a simulated wave pool with a certain frequency and amplitude. Furthermore, the up and down movement of the buoy will move the shaft and will rotate the generator. The amount of movement up and down the float will be determined by the mass of the arm and the length of the arm. With the occurrence of tidal phenomena in the sea, it can be determined by the height of the prototype to the water surface. Some of the previous research that is relevant includes [1-4].

This study aims to obtain a preliminary design of simulation of a wave-powered seawater pump model with a buoy & vertical motion piston. The concept works are the mechanism of pumping seawater through the piston push and the apparent motion of the buoy up and down by the waves. The hypothesis, that the flow rate and pumping head as research variables were strongly influenced by wave height and period (H & T). Also, it was estimated that it was influenced by the weight and dimensions of the buoy (W & A) and the diameter of the piston tube.

4 Methodology plan

This research was conducted at the Hydrodynamics Laboratory of the Department of Civil Engineering, Faculty of Engineering, Hasanuddin University, with a length of research of 6 months.

2.1. Main Equipment Needs

The wave channel is equipped with a wave generator made of steel flume with duct length: 15 m, line width: 0.30 m, and effective line-height: 0.5 m. The wave channel and the side channel view are shown in figure 1 and figure 2.



Figure 1. Wave power plant channels

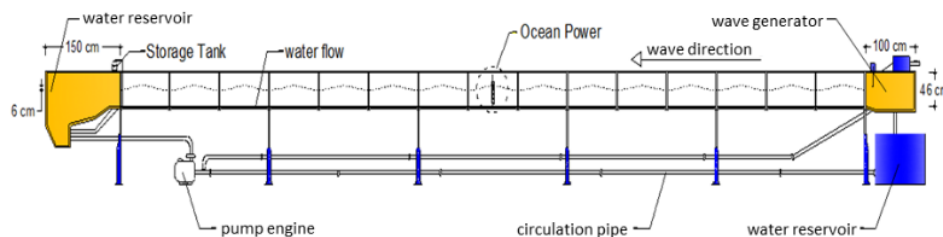


Figure 2. The side channel wave power plant

2.2. Pump Model with Buoy Type

The buoy type pump model studied is made in 3 variants of tube diameter, namely: tube diameter Ø 2.0 cm, tube diameter Ø 2.5 cm, and tube diameter Ø 3.0 cm, a tube made of clear acrylic material with thick 3 mm by using a float outside of the water catcher tube to move the water pressure piston up and

down, the height and length of the wave pump model are adjusted according to the need (adjusting the flume), as in figure 3.




No	Prototipe	Pump Model	Information
1		Model 1	Tube diameter Ø 2.0 cm Tube height 50 cm, Upper lower inlet hole diameter Ø 1.7 cm, Upper bottom outlet hole diameter Ø 0.5 cm, Buoy weight 1.0 kg, Rectangular buoy shape.
2		Model 2	Tube diameter Ø 2.5 cm Tube height 50 cm, Upper bottom inlet hole diameter Ø 2.0 cm, Upper bottom outlet hole diameter Ø 0.5 cm, Buoy weight 1.0 kg, Rectangular buoy shape.
3		Model 3	Tube diameter Ø 3.0 cm Tube height 50 cm, Upper lower inlet hole diameter Ø 2.5 cm, Upper bottom outlet hole diameter Ø 0.5 cm, Buoy weight 1.2 kg, Rectangular buoy shape.

Figure 3. Variation of the float type wave power pump model

2.3. Simulation

Preparation for initial running on the flume (without the wave pump model), to obtain initial data, namely:

- 1) With a stroke/wave generator 6, 7, and 8, to get the Wave Height (H)
- 2) Period (T1) 1.3 = 13 s ; Period (T2) 1.4 = 14 s, Period (T3) 1.5 = 15 s, to get the wavelength (L), every 10 turns = 10 s.
- 3) Start the modeled wave simulation by generating waves by pressing the start button on the control panel. This simulation is carried out to ensure that the wave height and period in the wave flume are by the variations determined in this study.
- 4) Stop the modeler's simulation by pressing the stop button on the control panel.
- 5) Put the test model in the middle of the wave flume.
- 6) Filling water in the wave flume with variations in water depth, d1 : 25 cm, d2: 27, cm, and d3: 29 cm for each model.
- 7) After all the components are ready, the wave simulation starts by generating the waves in the wave flume as in procedure no. 2.
- 8) Measure and record the wave height in front of and behind the test model.
- 9) Measure the water that comes out of the upper and lower outlet holes with a time of 10 seconds for each water withdrawal and is done 3 times to get the discharge.
- 10) Change the water pressure level (Head) at the outlet hole as high as 5 cm and its multiples until the pressure level no longer releases water.
- 11) Repeating procedures 1 to 7 according to the variation in height and wave period for each model type as shown in Table 3 the dimensions of the model and wave parameters are obtained by changing the stroke & variator positions.

The mechanism of action sketches waves power station, shown in figure 4.

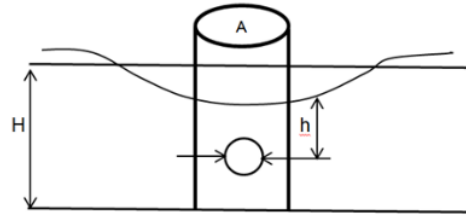


Figure 4. The mechanism of action sketches wave power station

2.4. Research Flowchart

The research implementation with the vertical motion buoy type wave pump model has a research mechanism by the research framework in figure 5.

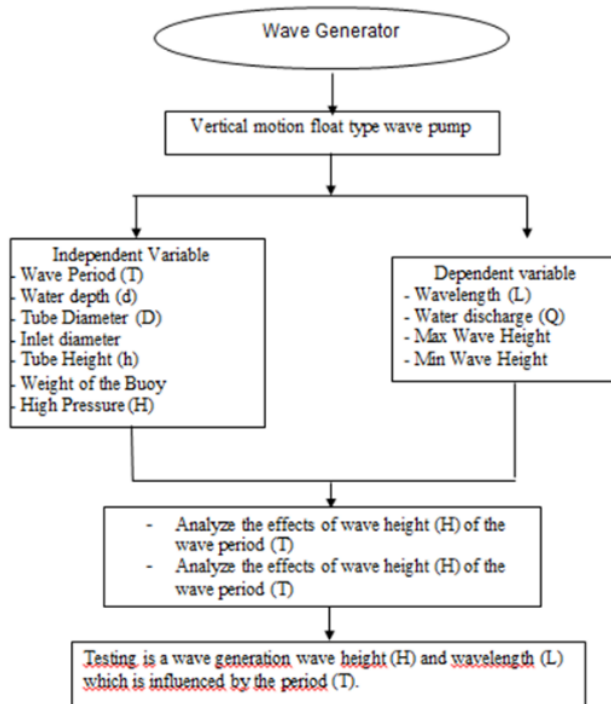


Figure 5. Research flowchart

3. Conclusions

1. The wave characteristics of the model to be used are the wave period in 3 variations (T1: 1.3 seconds, T2: 1.4 seconds, T3: 1.5 seconds), the range of wave heights in 3 variations (4 cm, 5 cm, and 6 cm) and water depth in 3 variations (d1: 25 cm, d2: 27 cm, d3: 29 cm).
2. From the simulation design of this model, it is expected that the equation of the discharge and the height of the pumping head will be formulated in the form of dimensionless parameter relationships.

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