Design and Construction of a Wave Power Plant in the Coastal Region of North Jakarta

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Abstract: The world is experiencing an energy crisis due to depletion of oil reserves sourced from fossil energy, and global problems such as international conflict, increasing demand due to changes in lifestyle. The solution is to switch to renewable energy sources, where Indonesia, with its long coastline, more than 108,000 km, has great potential as an energy source, especially wave-powered electrical energy. Even though Indonesia's coastal energy potential is large, its use is still limited because the technology and investment required is quite large. Further efforts in research and development are needed to optimize utilization. One promising source of renewable energy is wave energy, where a hydraulic float device has been designed to convert wave movement into electrical energy through a gear and generator mechanism. This research proves the success of this device, producing electrical power variations from 10.92 to 35.52 watts.

1 INTRODUCTION

The global issue of energy supply shortages, caused by various factors such as oil depletion, international conflicts, and growth in energy demand due to changes in lifestyle, drives the importance of switching to renewable energy sources. This effort not only addresses the current energy crisis, but also prepares for the future by optimizing available natural resources. Various types of renewable energy such as wind, solar and geothermal energy have great potential without major negative impacts, but technological development and research are needed for sustainable energy generation systems.

Indonesia has great potential in coastal energy through a coastline of 95,181 km and a water area of 58 million square km (71% of the total area), but development requires large efforts and costs. North Jakarta, in DKI Jakarta, offers the potential for energy utilization beach with a coastline of around 60 km and an area of around 5,000 hectares, needs further research (Lilly Aprilya Pregiwati, 2019).

Ocean waves have great potential as a source of renewable energy. Even though Ocean Waves Power Plants ”Pembangkit Listrik Tenaga Ombak” (PLTO) Produces lower power than Solar Power Plants/ “Pembangkit Listrik Tenaga Surya” (PLTS), the author's effort is to utilize this innovative potential to meet electricity needs in the coastal communities of North Jakarta in the future.

The float type PLTO is suitable for the coast of North Jakarta because of its accessibility and avoiding corrosive problems. The hydraulic system converts the float's movement into electrical energy through the push of waves. In this final project, the author will develop this method with the latest models, aiming to increase electrical efficiency through various tool models.

The process for converting wave energy from ocean waves shows variations in peak height, but statistically significant ocean wave heights can still be identified at certain locations. Utilization of ocean current energy has environmental advantages and high kinetic energy. Due to the greater density of seawater, it produces compact ocean current turbines. Utilization of ocean current energy has weaknesses related to sinusoidal wave patterns due to complex tidal fluctuations. At full moon tide, strong currents flow, while at neap tide, the speed decreases. Another challenge is the high cost of device installation and maintenance. The working principle involves collecting ocean wave energy to drive a generator turbine.

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Anaconda Bulge Wave System

The movement of sea waves is used to fill flexible tubes measuring 6-15 meters with a length of 150 meters. As the wave rises, water enters through the valve, the fan with the change of wave, the tube continues to fill and the pressure increases at the back due to the swelling effect. A rear hydraulic system, connected to an electric motor, operates this process according to the height and speed of the wave and the dimensions of the tube. Similar to the peristaltic movement of human digestion.

Oyster Hydraulic Piston System

The hydraulic system is connected to the piston, converting ocean wave energy into piston movement. This movement is used to lift water into the high pressure channel. Water is channeled through the channel to a hydroelectric generator, producing electrical energy. One of the main technologies today is a device called "oyster" by the company Aquamarine Power Ltd. Worldwide, the potential use of hydraulic pistons is estimated to reach around 60 gigawatts (GW).

Pelamis System Attenuator

Oyster Hydraulic Piston System. The hydraulic system is connected to the piston, converting ocean wave energy into piston movement. This movement is used to lift air into the high pressure channel. Air is fed through these channels to a hydroelectric generator, producing electrical energy. One of the main technologies today is a device called "oyster" by the company Aquamarine Power Ltd. Worldwide, the potential use of hydraulic pistons is estimated at around 60 gigawatts (GW).

Pelamis Attenuator System

Attenuators are formed by wave elements floating in parallel, generating energy through the movement of their interactions. This moves hydraulic components in the tube, driving an electric generator like on the Pelamis. The pelamis moves vertically and laterally, consists of at least three segments, 500 meters long, tube diameter 3 meters. Studies show that Pelamis is 180 meters long, 4 meters in diameter, at a depth of 50 meters, producing 750 Kw of electrical energy. The movement of the waves flexes the Pelamis Structure, utilized through a hydraulic take-off system that can lengthen/contract, producing electricity that is channeled through underground cables.

Oscillating Water Column

A Wave Power Plant (PLTO) with a Wave-Wind (OWC) design produces energy from fluctuations in air pressure in a container due to wave movement. These fluctuations drive the wind turbine through compressed air after passing through the control valve. This turbine is connected to a generator and converts movement into electrical energy.

Archimedes Wave Swing System

AWS uses Archimedes' concept to divide objects in water into 3 categories: floating, floating, and sinking. The movement of wave height variations is converted into vertical movement. Inside the tube, there is a stator and rotor. The stator is attached to the seabed, while the rotor connected to the tube moves up and down with the rhythm of the waves. Although it is being tested in Europe and the United States, AWS production costs tend to be higher than other PLTO systems, limiting its widespread use.

Wave Dragon

Wave Dragon operates by collecting sea waves in open water and channeling them into a pool. In the pool, there is a water turbine with a low fall height. The flow of water from the pool drives a water turbine, converting the movement of water into energy. In 2009, the first trial of Wave Dragon was carried out in Nissum Bredning, Denmark, successfully installing Wave Dragon with a capacity of 7 MW (A. Hasnan, et al., 2010).

1.1 Freewheel

It is a sprocket that has a locked direction of rotation, meaning that in a certain direction the shaft and the driver move simultaneously, but if the direction of the drive is opposite, the shaft continues to rotate in the original direction so that it rotates freely.

Figure 1: Freewheel.

The main advantage of freewheels is that they are more economical than freehubs (W. Dian, 2011).

1.2 Chain Transmission

Transmission has an important role in transferring power from one drive axle to the driven axle. Apart from being able to transmit relatively large amounts of power, chain transmissions also have a high service life.

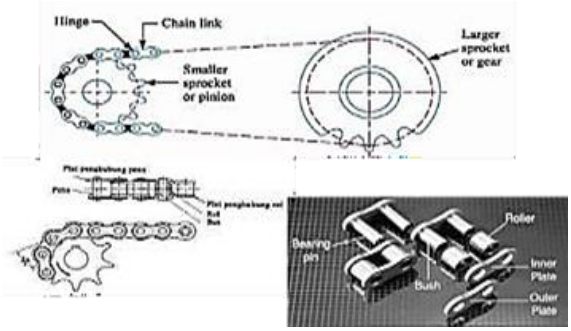


Figure 2: Chain transmission.

Chain transmission allows the flow of strong Pull force. When transferring energy from the rotating shaft, the chain interacts with the sprocket gears. Although suitable for long distance travel, this system is more efficient in transmitting power without losing power due to friction compared to belt and pulley systems. However, it is not ideal for high speeds and can produce significant vibration (K. Sularso & Suga, 1991).

1.3 Generator

A generator is a dynamic machine device that converts mechanical energy into electrical energy. The function of the generator is based on the principle of electromagnetic induction, where the rotating movement of the coil in a magnetic field results in the generation of electrical energy (M. H. Johanda, 2017).

Figure 3: Generator.

2 DESIGN AND BUILD METHODOLOGY

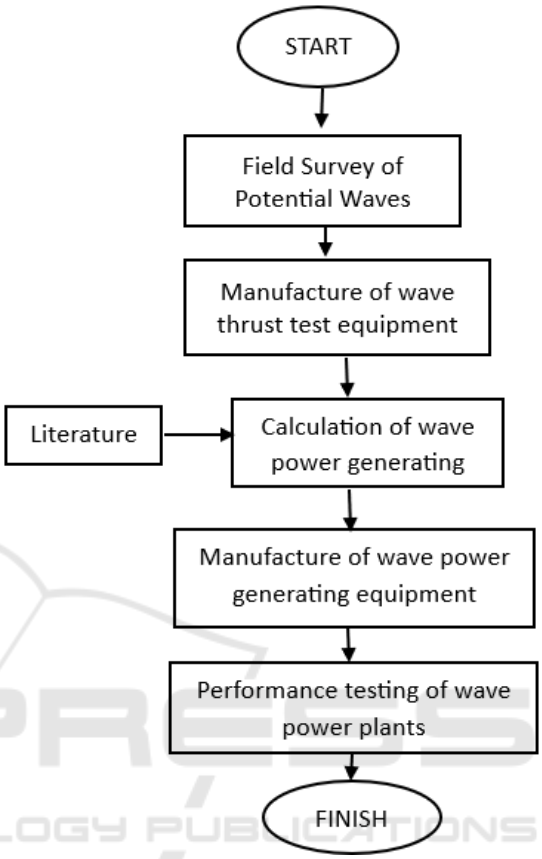


Figure 4: Design process flow.

Basic Theory of Calculation

Pressure: (p)

$$p = \frac{F}{A} \qquad F = p\ x\ A$$

Explanation:

F: Force (N)

A: Area (cm^2)

Torsion (T, $N.m$)

$$T = F\ x\ r$$

Power (N, kW)

$$N = \frac{T\ x\ n}{974.5}$$

Power in electric unit

$$Watt = 0.85\ x\ Ampere\ x\ Volt$$

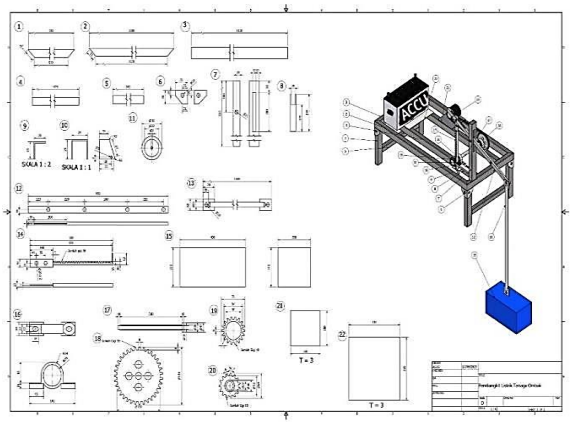
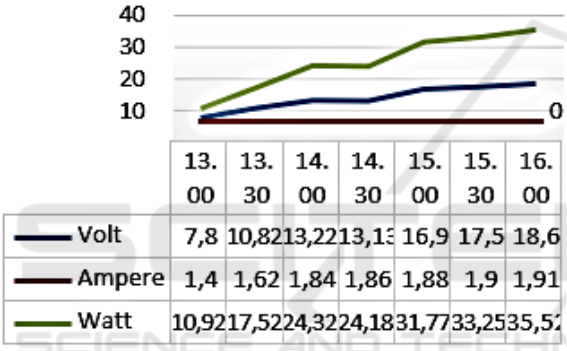


Figure 5: Shop drawing.

3 TEST RESULT



From the test results, it was recorded that the lowest power that could be produced was 10.92 watts at 13.00, while the highest peak power occurred at 16.00 with 35.52 watts. The average power produced was 25.35 watts. At the initial design calculation stage, the average power anticipated to be generated by the device was approximately 42 watts. However, there are several factors that influence the difference *between power* calculations at the design stage and equipment testing results. Some of these factors include float characteristics, swing arm design, drive gear properties, pillow block bearing performance, axle performance, gear and chain efficiency, as well as the influence of natural elements such as wind speed, wave movement and solar radiation.

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