

The Development of Wave Energy Conversion Device to Generate Electricity

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Abstract. The wave energy is one of promising resource for generating electricity in this country. A wave energy conversion system was designed and fabricated; the prototype was tested and its performance was analyzed. The invention herein proposed a system operated by wave resource. This configuration allows the wave resource working to generate electricity. Wave power device operated by the movement of floaters with varying speed connected to the mechanical racks. These mechanical racks move gears and pulleys, which giving forces to the pulley's belts to rotate. This pulley's belts connected to the electric generator that produces the electricity. The final system was tested in the coastal area near to Universiti Malaysia Terengganu (UMT) campus. The measurement results clearly show that the available wave resource could be harness into useful work for electric power generation.

Introduction

The wave energy is one of renewable resources that could been used for generate electricity. The aim of this study is to develop a device for electric generation using the wave resource. The concept of the proposed device differs from the existing designs as considering to the mechanism to capture wave energy. The device was comprised of two joined vessels, an electric generator on top of the vessel, gear pulley, stand, belts, two floaters to drive an electric generator and an anchor to moor the vessel. When the floaters are experiencing the oscillatory motion, the vertical oscillatory movements of floaters will moving the pulley and belt. The belt is connected to the gears to drive an electric generator to generate the electricity. The device can generate electricity even at low wave height. The vessels are provided with piping and ballast tank to adjust the buoyancy of the vessel. The buoyancy is adjusted to achieve the desired water surface level. The location of the device could be adapted either onshore or offshore, by moving the anchors. Through strategically placing the anchors around the edges of the vessel, the vessel can move according to the tide of the sea. Hence, the device can harvest the wave energy regardless of tide level or shoreline.

Methodology

Process of design

The design of wave energy conversion device is showed in Fig. 1. The device consisted of two joined vessels. The vessel, built with steel is provided with float pivoted on an edge of the vessel. A stand is also provided on the similar edge to hold a pulley. The pulley was stringed with belt that connects the floats to the gear. The gear is connected to an electric generator. Waves are providing oscillatory vertical movement to the float, in relative to the vessel. The float is moving the pulley, which drives the gear via belt. The gear then rotating the electric generator. A low rpm generator is utilized to harvest relatively calm and low wave. Two vessels are attached so that it can align itself

to the direction of incoming waves. Two vessels will provide greater stability, experienced by catamaran structured.

The ballast tank and pipes allow the buoyancy of the vessel could be controllable. The ballast tank is provided with porous divider to allow water to pass slowly between ballast tanks to adjust the buoyancy of the vessel, while maintaining the balance of the structure. The device is also provided with a roof and chained to the anchors. Each anchor block is chained loosely to make sure the device has free movement on the water. The location of the device can be adjusted by moving the anchor block either on the coastline or offshore. In this paper, the anchors are labeled as 24A, 24B, 24C and 24D. The first anchor block 24A is chained to two edges of device, on edges opposite of floaters. The second anchor block 24B is chained to an edge of device, on edge adjacent of floater. The third anchor block 24C is chained to second anchor block and placed at the same side of vessel, forming right angle at first anchor block with symmetry line of converter. The fourth anchor block 24D is chained to another edge of device, on the edge adjacent of floater. The fifth anchor block 24E is chained to 24D and placed at the same side vessel, forming right angle of 24A with symmetry line of device. The five anchor blocks, anchor chains and the device are forming an arbitrary W-shape. The anchor block could be constructed by concrete with dimensions of 2 feet by 3 feet or 61cm by 91cm. The 24A, 24C and 24E anchor blocks are placed at onshore, while 24B and 24D anchor blocks were placed on offshore area. The wave direction can align the two joined vessel and floaters to face the wave direction. The anchors chains are loose, hence the device is experiences free movement according to wave height and tide level. The location of the anchor block can be adjusted, when desired, to move the device. This invention is to introduce a wave energy converter device which can adapt to tide and shoreline.

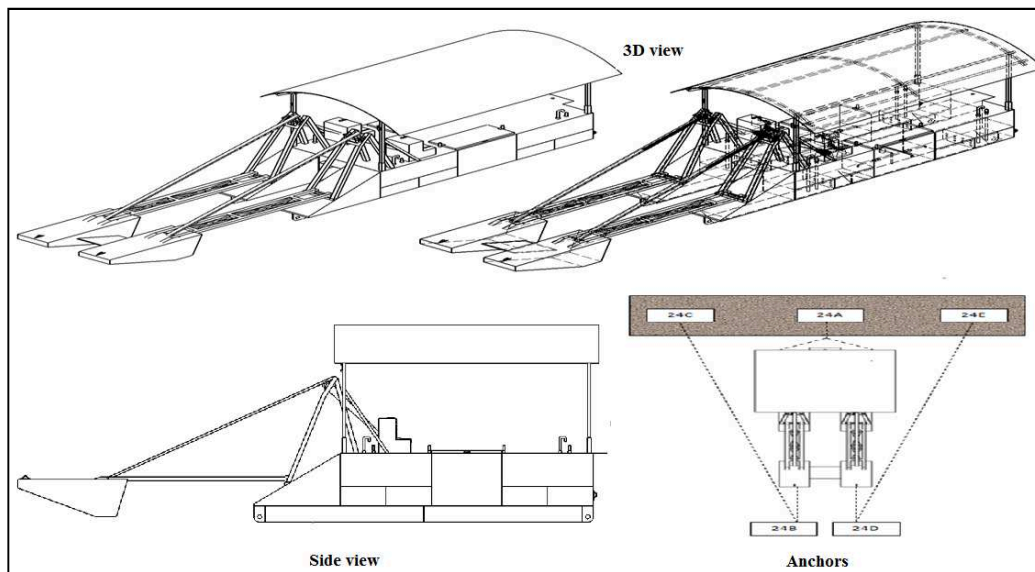


Figure 1: The wave energy conversion device

Process of fabrication

The fabrication process based on the standard criteria that have been presented in a book that published by Carbon Trust in year 2005 [1]. The fabrication process was completed in two months as showed in Fig. 2. The catamaran body sizing is 2 m of length, 1 m of width and 0.5 m of height. The floaters is acted as wave energy converter to capture the waves energy. The other installed components are racks, gears, pulleys, bearing and pulley belttings. The electrical generator with 100 watts rated power is purchased from the existing manufacturer. The last stages of fabrication process include the installation piping systems, roof and mooring system.

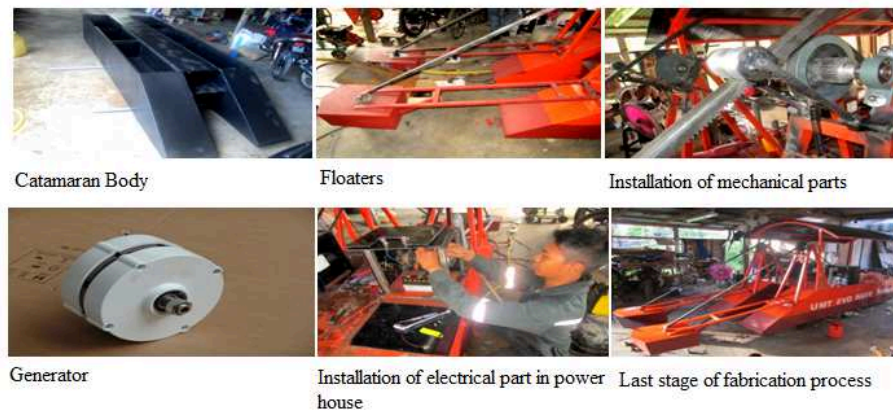


Figure 2 The process of fabrication

The experimental process

The onsite experimental study of wave energy device system was conducted at UMT beach which is near to the UMT renewable energy station (Coordinates: 5°24'37''N, 103°5'16''E). The power output (in watt) and speed of generator (rpm) were measured using the electrical measurement sensors that connected with data logger in the monitoring station. The wave energy device is movable from one location to another because of its mooring systems is using the adjustable anchor as presented in Fig. 3. The onsite wave quality was checked to ensure the wave height would be sufficient to actuate the WEC system while the experiment is conducted [2]. The equipments for experiment was listed in Table 1. The AWAC sensors measures wave height and period using the unique acoustic surface tracking (AST) feature. A short acoustic pulse is transmitted vertically toward the water surface, and the time lag between the transmitted ping and its reflection is used to generate a time series of the surface elevation [3]. The AWAC can transmit raw or processed data to shore if the instrument is connected via cable or a suitable data modem. Data can be displayed using the SeaState software and made publicly available through custom WEB solutions [3]. The manual equipments are also needed during the process of experiments such as multimeter, clamp meter and tachometer. The sensor and data logger recorded the wave height, generator speed, voltage, current and power output automatically. Tachometer measured the speed of generator manually during the maintenance or generator installation session. The data logger was calibrated from manufactured and had a program interface to read the recorded data, set the clock, and set the initial and stop times [2]. The logger was confirm looking at the recorded data on the computer.

Table 1 Measuring equipments

Sensors equipments	Parameter
Nortek Acoustic Wave and Current profiler (AWAC)	Wave height (m)
Power, Current and voltage logger	Power (W), Current (A) and Voltage (V)
Generator speed	Generator speed (rpm)

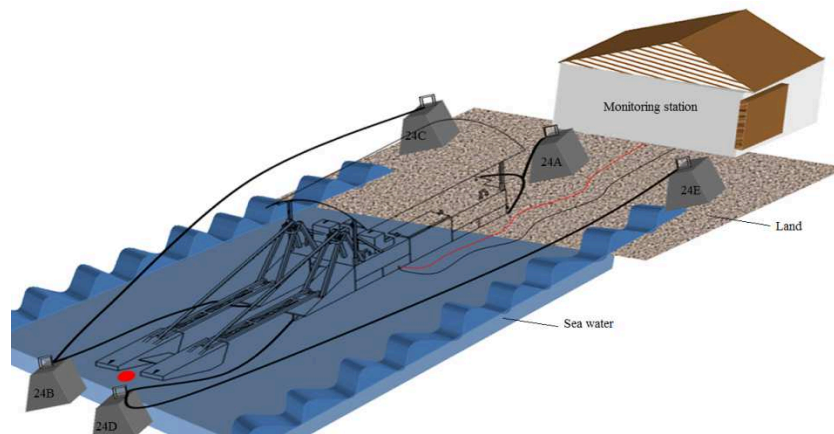


Figure 3: In ocean experimental setup

Results and discussions

The onsite experiment was carried on February 2014 at the coastal area near to Universiti Malaysia Terengganu (UMT) campus. This device was tested for 24 hours in between 1st and 7th February 2014. The 1-week collected data as presented in Fig. 4 is seem showed the same pattern of wave height. During night and early morning, the wave height is highly compared during noon time. The highest wave height recorded is 2.3 m, the lowest is 0.4 m and the average wave height 1.3 m. The selected site is located at east coast of peninsular Malaysia which is experienced the monsoon seasons. The northeast monsoon and the southwest monsoon wind influence the wave condition in Malaysia [4]. During the northeast monsoon season from the months of November to March, the higher average wave height is 1.0 m to 1.5 m was occurred [4]. In the middle of the northeast monsoon period (December and January), the higher wave height is 2.5m to 3.0m [4]. The power output (w) performance depends on the wave height. The increasing of wave height (m) will produce a higher power output. This is because wave energy varies as the square of wave height. Water is being 850 times as dense as air, this result in much higher power production from waves averaged over time [5]. Based on the analysis in Fig. 5, the lower the wave height (m) would create the low generator speed (rpm) and a low power output (w).

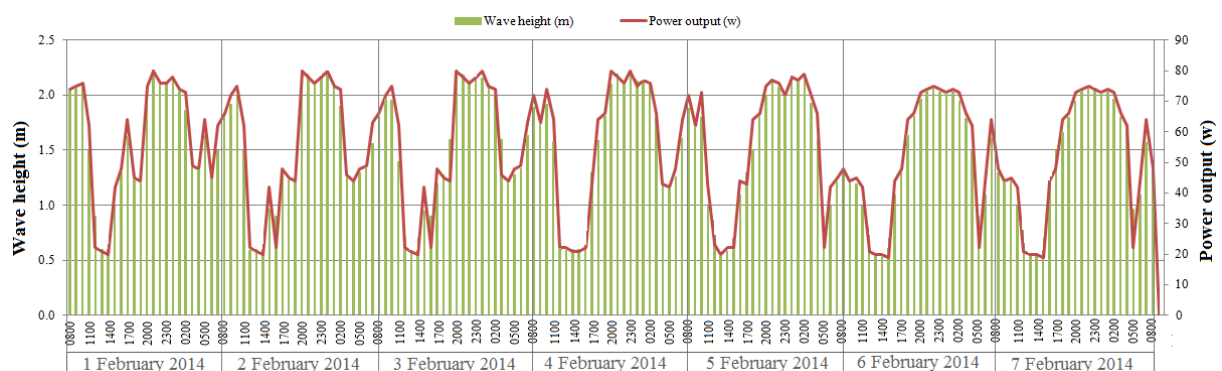


Figure 4: The recorded wave height and generated power in a week

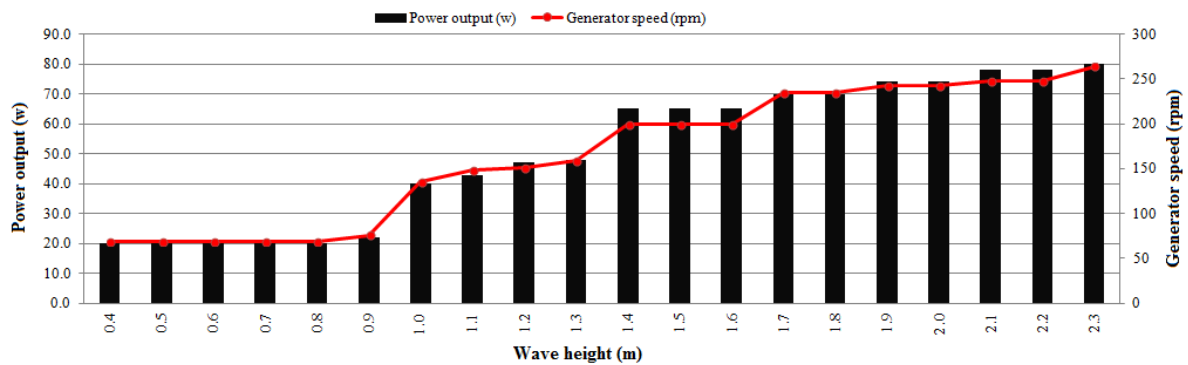


Figure 5: The power output and generator speed at different wave height

Conclusions and future works

The preliminary experiment is showed the proposed wave device is compatible with low wave height quality. The device is design, fabricated, and tested to assure its viability for generate the optimal power output. The uniqueness of this device is movable and can generate electricity at low wave height. In the future, this device will resizing and tested using more larger capacity of generator to generate more power electricity before proceed to the phase of commercialization.

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