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ARTICLE

OSCILLATING WATER COLUMN (OWC) BUILDING PERFORMANCE ANALYSIS AS BEACH ABRASION REDUCING

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ABSTRACT

Ocean waves is a new renewable energy that is rarely explored. It has a great chance to reduce carbon pollution in the world. In spite of that, the ocean waves responsible for the beach abrasion that occurs in some county in the world. Using Oscillating Water Column (OWC) building reducing the impact of waves against abrasion become populer. In this research is to analyze the performance of OWC power conversion as water building for abrasion reducing and as well as electrical energy resource from ocean wave energy conversion. The OWC made in laboratory scale with 4-meter of length, 0.6-meter of width, and 0.6 m height. Wide of chamber in OWC is 0.24-meter square. The OWC has manual wave generator system and breakwater system for reduce wave feedback effect in chamber. High variation wavelength used is 10, 15, and 20 cm for the operation starting time of 0-20 seconds. The results from this study showed that energy conversion has linear relationship to wave characteristic, the higher the wave produced, the higher the power generated by OWC. In the wave height of 10 cm, power generated is 3.5563 watt. While the wave height of 20 cm, power generated is 5.586 watt.

KEY WORDS
Oscillating, water, column, wave, abrasion

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INTRODUCTION

Breakwater designed for reducing the abrasion [1], reduce abrasion, but actually, many cases explained that the breakwater cause fishing vessels become damaged and cause fishermen trouble catching fish, because fishing nets snagged or damaged by the breakwater.

The magnitude of western Java sea waves brings serious problems of abrasion. However, efforts are needed to reduce coastal erosion or abrasion. There are two ways can be implemented. First way is to divide the wave energy into small waves, so the waves did not make coastal erosion or abrasion. The second way is to collect and gathering the wave energy, then convert it into another form of energy. The second way will give the double result. First reducing the abrasion and as well obtain the electrical energy. Ocean in western Java had the high waves and sustainable, provide an opportunity to transform wave energy into electrical energy, thus sea south western Java had the high sea waves and sustainable, provide an opportunity to transform wave energy into electrical energy, thus reducing abrasion [2], whereas the electrical power science believes that energy collecting received in OWC can be used fatherly rotating the turbine and then generate electrical energy.

OWC has a working principle gather to convert ocean wave energy into mechanical energy [3], the mechanical energy in OWC can then be converted into electrical energy [4]. OWC has a working principle gather to convert ocean wave energy into mechanical energy [3]. The mechanical energy can then be converted into electrical energy through a turbine [4].

The waves southern regions of western Java had high waves with a frequency of 0-10% [5], while the potential of ocean waves at Jimbaran of Bali has a potential of between 176 kW – 4 MW [6]. Some researchers believe that the global potential for electrical energy from sea waves at the beach estimated is 1TW [7]. The energy generated by ocean waves is 5 times of what is produced by wind energy at the same rate [8].

Wave Energy Converter (WEC)

There are many concepts of Wave Energy Converter (WEC) and more than 1000 patents on techniques WEC made in Japan, North America and Europe [9]. Despite having varied designs, WEC can be categorized based on the place and type. WEC Type Attenuator (A) by Salter [10], Point absorber and the type of Terminator [11], while according to [9]. WEC operating model can be divided into several, namely: Submerged pressure differential, Oscillating wave surge converter, Oscillating Water Column (OWC) and overtopping devices. According to [6]. OWC is one of the systems and equipment that can transform wave energy into electrical energy using oscillating column (chamber) as Fig 1 below.

The OWC technology concept in Fig. 1, the air pressure of the chamber air pressure to the turbine. The turbine will move the turbines which will produce electrical energy, as in Figure 1. The room's watertight be fixed with the bottom structure is open to the sea. The air pressure in the room's watertight caused by the movement of the rise and fall of the surface of the sea waves. The movement is a movement compresses and decompresses the motion that is on the level of water in the room. This resulted in the movement, generates an alternating high velocity stream *of air. This air flow is driven through a pipe to a turbine generator that is used to generate electricity.*

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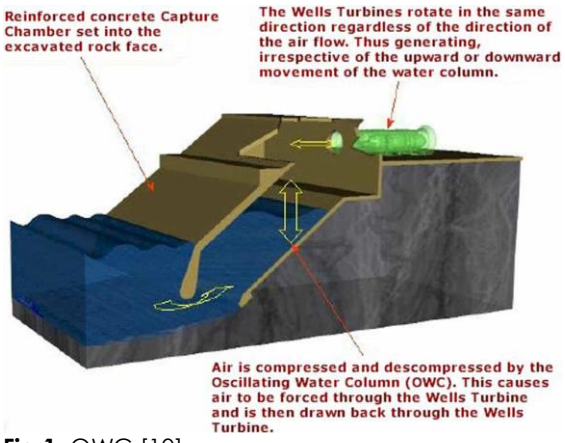

Fig 1. OWC [10]

Wind Effect

Fig 2. Shows the relationships between wave speed and period for various depths (left), and wave length and period (right), for periodic, progressive surface waves [12]. Higher wind speed and deeper the ocean, lower wave period. Note that the term phase velocity is more precise than wave speed.

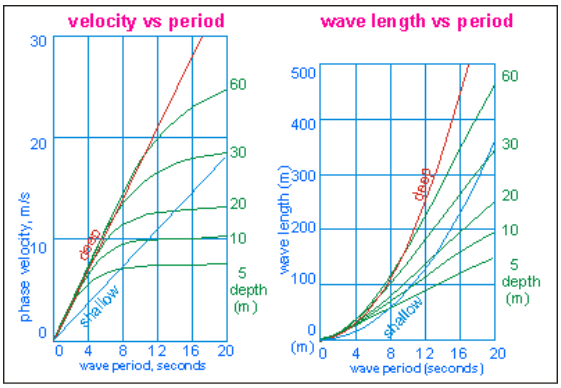

Fig 2. *The spectrum of the wave period for different wind speeds [12]*

Oscillation water column Conversion

Calculation of the wave energy from OWC. The amount of potential energy of ocean waves can be calculated by (1)

$$P.E. = mg\frac{y(x,t)}{2}\ (J) \tag{1}$$

Equestion (1) can be write to the other form that involve densities value as (2).

$$P.E. = w\rho g\frac{y^2}{2}. \tag{2}$$

$$PE = w\rho g\frac{a^2}{2}\ sin^2(kx - \omega t) \tag{3}$$

The magnitude of the potential energy of the wave, it is assumed that the wave is a function of "x" with respect to time, so we get the equation y (x, t) = y (x).

$$dP.E = 0{,}5\ w\rho g a^2\ sin^2(kx - \omega t)\ dx(J) \tag{4}$$

The other form of $k = {}^{2\pi}/_{\lambda}$ and $\omega = {}^{2\pi}/_{T}$, so the simple form of (3) is represented by (5).

$$P.E. = \frac{1}{4}w\rho g a^2\lambda\quad (Joule) \tag{5}$$

The kinetic energy that produce from wave for one period of wave is represented by (6) and total energy of wave (7) is sum of potential energy and kinetic energy.

$$K.E. = \frac{1}{4}w\rho g a^2\lambda \tag{6}$$

$$Ew. = P.E. + K.E. = \frac{1}{2}w\rho g a^2\lambda \tag{7}$$

Substitution from (6) and (7) to find the energy density (EWD) of wave as (8) and energy in electrical (PW) can be find out by (9). The power density (PWD) is power of wave in watt per meter square (10).

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$$E_{WD} = \frac{E_W}{\lambda_W} = \frac{1}{2}\rho g a^2 \quad (J/m^2) \tag{8}$$

$$P_W = \frac{E_W}{T}(Watt) \tag{9}$$

$$P_{WD} = \frac{P_W}{\lambda_W} = \frac{1}{2T}\rho g a^2 \ (Watt/m^2) \tag{10}$$

Where the "ρ" is water density (kg/m3), "w" is wave width in meter (assumed equal to chamber of OWC). "a" is Wave amplitud (h/2), "h" is wave high in meter, "k" is wave constanta $2\pi/\lambda$, "λ" is wave lenght in meter, "ω" is wave frequency in rad/s represented by 2π divide by periode (T).

MATERIALS AND METHODS

In this research, OWC designed in small scale with 4 meters of length, 0.6 meters of high and 0.6 meter width as Fig. 3, While Fig. 4 is chamber of OWC with 0.48 meter of length and 0.5 meter of width, so the chamber is 0.24 m2 of wide. Water wave generated by manual wave generator system. Air speed in chamber measured by mini electrical generator with tubin. This anemometer will sense the air flow through the chamber that representing the speed of electrical generator turbin.

Test of OWC is applied by different In the wave height of 10 cm, 15 cm and 20 cm. Measurment of testing is Wind speed of oscillation in chamber, Wind Power in Chamber, electrical power of turbin. These results will be the conclusion of the OWC performance in reducing the wave energy.

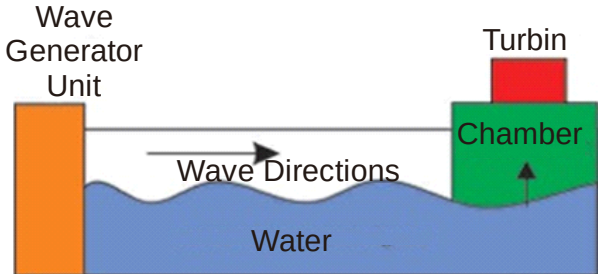

Fig 3. OWC Model with wave small scale

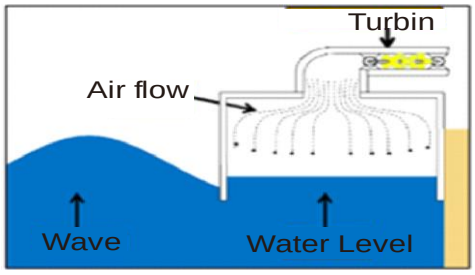

Fig 4. Chamber model with electrical generator system

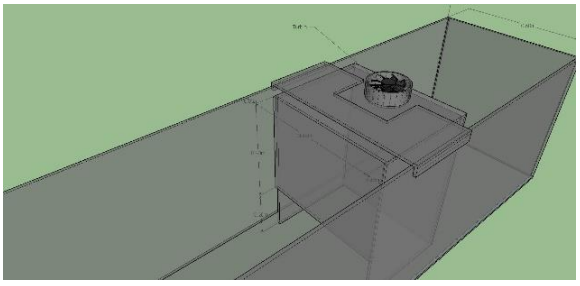

Fig 5. Design of Chamber in OWC system

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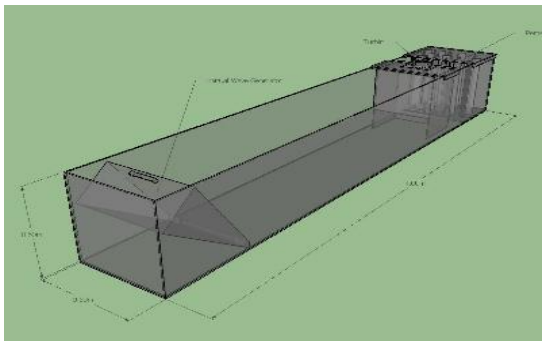

Fig 6. Design of Laboratory scale OWC

RESULTS

Fig 7 shows relation beetwen ascillation of wind speed in chamber at different wave height. The chamber applied with vaious wave high 10 cm, 15 cm and 20 cm. Higher wave applied in OWC, more rapid the frequency of chamber oscillation. Particularly at In the wave height of 10 cm, the wind speed grafic sinusiodal form. The air speed in the chamber on the different wave height, it is known that the waves can be mitigated by changing the wave potential energy into kinetic energy in the turbine and chamber. The speed of the wave height of the water outside the OWC change linearly with the speed of air in the chamber to variations in wave height. The air fluctuations pressure has the ability to rotate the turbine generator. This change has potential reducing or even eliminate the abrasion.

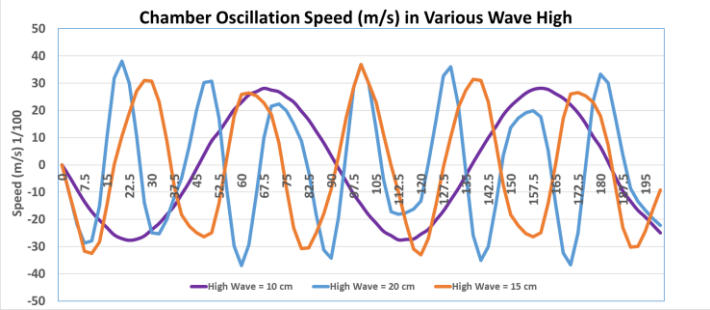

Fig 7. Wind speed oscillation in chamber on different wave height

Fig.7 shows the testing result of wave into wind speed oscillation in chamber. On the 10 cm of wave height produce the wind speed maximum is 0.282 m/s while on the 15 cm of wave height creat the wind speed maximum is 0.3684 m/s and 20 wave height result the maximum wind speed 0.3811 m/s.

Fig. 8 is result energy conversion from wave of OWC into wind power that creat from oscillation in chamber. On the 10 cm of wave height produces the wind power maximum is 13.755 watt, while on the 15 cm of high wave creat the wind speed maximum is 24.029 watt and 20 cm wave height result the maximum wind speed 37.743 watt.

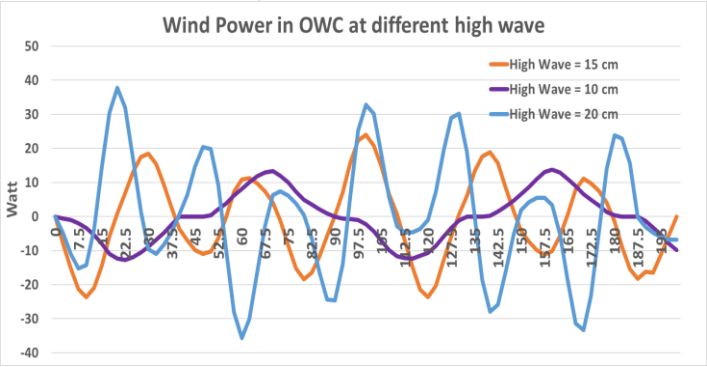

Fig 8. Wind Power of OWC on different wave height

Fig. 9 show the electrical power of OWC on different wave height. 10 cm of wave height produces the electrical power as 2.0357 watt, 15 cm of wave height produce the electrical power as 3.5563 watt, while

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on the 20 cm high wave produce 5.586 watt. From Fig. 8 And Fig. 9 can be concluded that the smaller waves in OWC, the less energy is generated and the slower the frequency of oscillation in the chamber.

From Fig. 8 And Fig. 9 can be concluded that the smaller waves on OWC, the less energy is generated. Otherwise if the higher waves heading to OWC, the energy generated increasingly large. This condition is the advantage of OWC in overcoming the abrasion caused by the ocean waves.

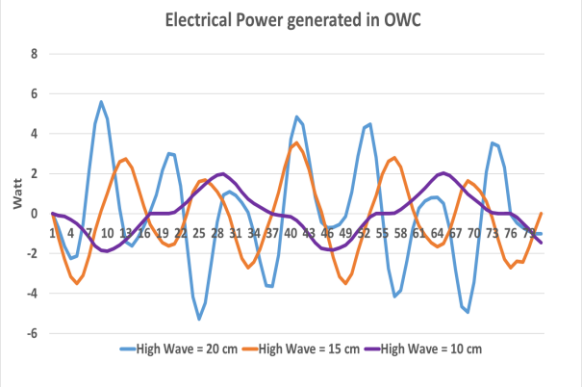

Fig 9. Electrical power generated in owc with on different high wave

CONCLUSION

The conclusion from this research that the oscillation model of water column (OWC) showed the potential for abrasion reducing by conversion the energy of ocean wave into electrical energy. OWC has a dual function, in addition to reducing abrasion and also be used as an alternative energy resources. High waves that heading in OWC has linearity relationship to the electrical energy generated. The higher the ocean waves in OWC, higher electrical energy will be produced. Result of OWC test is by OWC, the 10 cm of high wave produce the electrical power as 2.0357 watt, 15 cm of high wave produce the electrical power as 3.5563 watt, while on the 20-cm high wave produce 5.586 watt

CONFLICT OF INTEREST

All authors have completed the IIOAB uniform disclosure form and stated: all writers have the financial support of KEMENRISTEK-DIKTI for the submitted work; no financial relationships with organizations that may have an interest in the submitted work in the previous three years; there is no relationship or activities that could appear to have influenced the work submitted

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