Research in Marine Sciences
Volume 2, Issue 4, 2017
Pages 188- 193

Designing a rotary converter for absorbing sea wave energy

Reza Babakhani Galangashi[1,*], Ahmad Reza Kohansal[2],
and Seyedeh Safoora Adnani[1]

[1]B. Sc. Marine Engineering Department, Persian Gulf University, Bushehr, Iran

[2]Assistant Professor, Persian Gulf University, Bushehr, Iran

Received: 2017-09-28 *Accepted: 2017-11-31*

Abstract

The energy of waves in sea is renewable. Such resources do not require millions of years to generate and develop and they are endless. Energy production in this way does not have any pollution. These plants can produce the greatest amount of energy during the winter and fortunately at in such times that we need more energy. Small waveforms can be used in remote areas where power transmission is not economical. In this paper, we tried to introduce the idea of converting the energy of sea waves into electricity through a simple generative design, which can be used in any condition of the sea, given that Iran has many coasts and waves' energy can be produced from wind power. Given the fact that the machine is designed to be a turbine, it is aimed even at very low water speeds, it will turn around and the power will be generated. Therefore, this device can be used in the Persian Gulf, which has calm currents. In a wavy or even stormy weather conditions in the Caspian Sea and the rivers with high speed current, faster rotation of the machine and more power generation will be more expedient for this purpose.We also introduce how to make the model and materials used to build the original sample, so that the idea can be realized more than ever.

Keywords: Converter; Coil; Wave energy; Renewable energy; Sea; Electromagnetism.

1. Introduction

Open seas and oceans can be considered as great sources of energy. About 70% of the Earth's surface is covered by the oceans and is therefore a major source of energy storage (Soltani Fard and Kakandi, 2012). The origin of the energy of sea waves is the winds that give their kinetic energy to the sea when they are in contact with the sea level. Sea water stores kinetic energy in the form of potential energy, and after a short time it transforms it into kinetic energy (wave). The amount of energy from the sea waves depends on the transfer of

* Corresponding Author: rezababakhani75@gmail.com

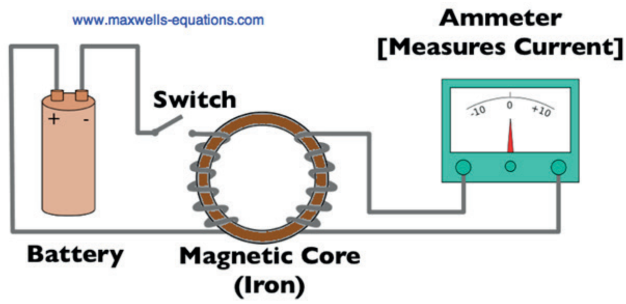

Figure 1. Faraday's Electromagnetic Induction law (www.maxwells-equations.com/faraday/faradays-law.php)

wind energy to the sea (Sarvari, 2016).

Waves' energy is a renewable energy source in comparison to the fossil energy sources that are in use today. Iran has many oil and gas resources, but sooner or later we should seek to find an alternative to it. Recent research on the generation of energy from waves has tended to reduce dependence on non-renewable energies and introduce methods for utilizing renewable energies.

The idea of using the energy of the sea waves has been a matter for many over the past century. The first use of the energy of waves backs to 1799 by Pierre Simon Gerrard and his son (Saif, 2013). But the first wave energy was used to illuminate by Bučaks Prazick's house in 1910 (Sadiku, 2007).

1.1. Statement of the problem

The method of using ocean energy depends very much on the type of energy used. At present, there are many different methods for extracting energy and electricity from existing ocean energy, and there are still many work areas in this field (Clement *et al.*, 2002; Duckers, 2004). The main purpose of this idea is to use the seawater rotational motion and to apply it to force the blades into and out of the rotor. With the arrival of the smallest force, these blades begin to rotate, so even in calm conditions, when there is little sea movement, we have reached our goal of rotation, but the more important goal of this idea is to use this movement in electricity production, which is due to the fact that a generator uses the momentum that derives from the use of fossil fuels, and magnetism rules to generate electricity (Tabee and Torabi Azad, 2007; Mustapa *et al.*, 2017). By turning the magnet inside the high winding coil, we reach this goal, so that the magnet is placed on the rotating shaft attached to the rotary wheel, and located inside a chamber which the coil is laid out around. The electricity is generated when the magnet is rotated in accordance with the Faraday Electromagnetic Induction Law by moving and generating electric charge in the coils in an electric circuit.

1.2. Faraday Electromagnetic Induction Law

According to the law, discovered by Michel Faraday in 1831, a high current charge can be induced by the motion of an electric conductor, such as a wire, which contains electrical charge in the magnetic field, in other words, the electricity is induced by changing the amount of flux passing through a closed circuit of electric propulsion. This motion creates a voltage difference between the two ends of the wire or an electrical conductor, which in turn causes the electric charge to flow and the electric current is generated (Figure 1) [Hayt and Buck, 1981; Popovic *et al*., 2004; Jordan and Balmain, 2006; Sadiku, 2007].

2. Material and methods

The Equation (1) calculates the electromagnetic force, which on the formula φ is the magnetic flux in a circuit, and EMF is an electromagnetic force that is essentially a voltage source. Therefore, the equation shows that the voltage induced in a circuit is opposite of the changing the magnetic flux with time (www.maxwells-equations.com/faraday/faradays-law.php).

$$EMF = -\frac{d\varphi}{dt} \quad (1)$$

As we know the electric current creates a magnetic field and a magnetic field in a loop generates an electric current.

2.1. Governing equations

This system includes blades, shafts, magnet and coil for flow generation. The collision of the waves to the sheets causes them to rotate, and consequently, turning the coil of wire and generating the flow.

2.1.1. Wave equations

Often the sea surface is turbulent and the wave surface profile changes continually and without repetition - the distance between two peaks or two crests frequently changes - these waves are

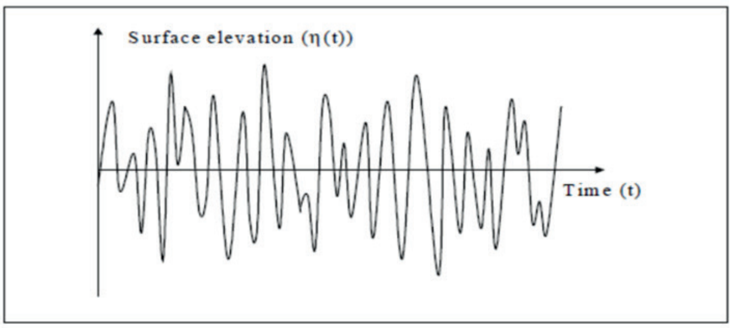

Figure 2. Irregular waves

Table 1. The involved parameters

u	Speed in x direction	φ	Magnetic flux
w	Speed in z direction	B	Magnetic field
m	Mass of each blade	da	Coil area element
h	Calm water depth	θ	Shaft rotation angle
λ	Wavelength	ε	Potential difference
ζ	Wave height	t	Time
K	Kinetic energy	g	Earth's gravity acceleration
r	Blade radius		

irregular waves (Figure 2). Here, we use the regular wave equations to further understand the problem.

The energy of a regular wave is obtained from the following relation (2):

$$K = \int_{volume}^{\square} \frac{1}{2}(u^2 + w^2)dm = \frac{1}{2}\rho \iint_{0\ -h}^{\lambda\ \ \zeta} (u^2 + w^2)\ dz\ dx \tag{2}$$

$$K = \frac{1}{4}\rho g \zeta^2 \lambda \tag{3}$$

2.1.2 Blade equations

The energy of a blade is also derived from the following equation:

$$K = \frac{1}{2}mv_0^2 \tag{4}$$

which is the initial velocity of the blade. When the wave hits the blade, it transmits its energy to the blade. Equation (3) and equation (4) give the value of for the blade as follow:

$$v_0 = \zeta\sqrt{\frac{1}{2}\rho g \lambda} \tag{5}$$

Considering the value of obtained from the equation (5) in the equation (6) can calculate the shaft rotation angle:

$$\theta = \frac{1}{2}r\omega^2\, t^2 + v_0\, t \tag{6}$$

which ω is the angular velocity of the blade.

2.1.3. Coil equations

The flux of the coil is calculated from equation (7):

$$\varphi = \int \vec{B}.\overrightarrow{da} = \int Bda\cos\theta \tag{7}$$

Given the fact that the rotation angle is a function of time, that can obtain the potential difference by equation (1).

$$\varepsilon = \frac{d\varphi}{dt} \tag{8}$$

Initial condition for solving the integral is

$\frac{d\theta}{dt}\Big|_{t=0} = 0.$

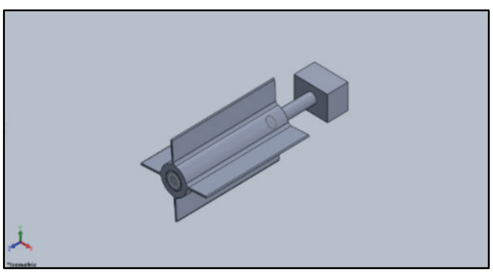

Figure 3. 3D viewer converter

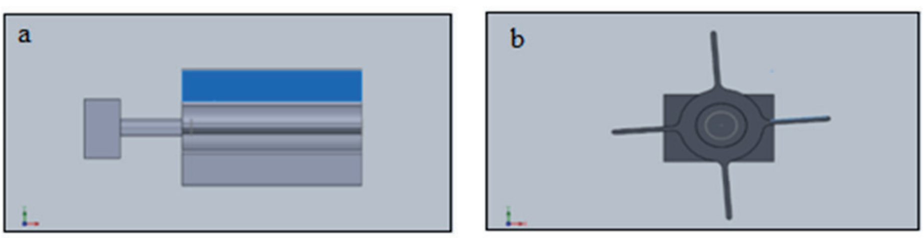

Figure 4. Side view (a) and front view (b) of the converter

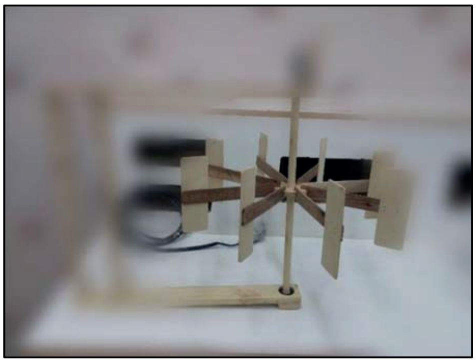

Figure 5. Designed sample

3. Design and construction

The original idea was designed in the AutoCAD software in two-dimensional format and in the Solitaire software in 3D (Figure 3). The designed model was built by the wood, and we used bouldering to move the shaft used to create the rotational motion of the magnet inside the coil. The converter is also shown from different view in Figure 4 (a, b). The model has the blades with 20 cm long and 15 cm wide with a base to the shaft is connected to a length of 50 cm. To lay the device on the bed, the bases can be designed with regard to the depth of water.

The wood is used exclusively for making the model for its practical test (Figure 5). To make a real case, lightweight and resistant blades from aluminum and composite can be used that are resistant to rust and corrosion in the aquatic environment and also have high structural strength. For the shafts, the suitable material can be steel or aluminum. The problem with this device is the way in which the device is placed in water, which may be hard to install at a deeper level, so that it works properly. When placed in water, it must be completely restrained.

Conclusion

Wave energies are one of the largest sources and an intact resource that can be considered as renewable energy. Considering the very rapid growth of the invention of energy conversion devices from waves, this paper attempts to introduce a new electric power converter of sea waves or river flows. The very low cost of making this machine, consisting of just a couple of rotary pieces, a shaft and an electricity box, has made it possible, given the high output that can be utilized when used as a farm, to consider a high-profit device. The design of various parts including the rotating part, the central shaft, the booms used in the Salinder Verks software, and the model was constructed with the wood and in the current at low speed; a rotation test was carried out. Transformation applications also included the coastal cities and coastal roads for lighting using the power output of this device or as a lighthouse entrance power. The model was tested in quite calm conditions in the Persian Gulf at Bushehr coastal area. The amount of power produced at any time was 0.04 V.; of course this voltage will be higher in conditions where the flow is faster.

References

Clement, A., McCullen, P., Falcao, A., Fiorentino, A., Gardner, F., and et al. 2002. Wave energy in Europe: current status and perspectives. Renewable and sustainable energy reviews, 6(5): 405-431.

Duckers, L. 2004. Wave energy. Renewable Energy: Power for a Sustainable Future, 2: 297-340.

Hayt, W.H. and Buck, J.A. 1981. Engineering electromagnetics (Vol. 6). New York: McGraw-Hill.

Jordan, E.C. and Balmain, K.G. 2006. Electromagnetic Waves and Radiating Systems, Prentice-Hall.

Mustapa, M.A., Yakoob, O. B., Ahmad, Y. M., Rheem, C. K., Koh, K.K., and Adnan, F. A. 2017. Wave energy device and breakwater integration: A review, Renewable and Sustainable Energy Reviews, 77: 43-58.

Popovic, M., Popovic, B. D., Popovic, Z., and Bansal, R. 2004. Electromagnetic induction. Handbook of Engineering Electromagnetic, Boston University.

Saif, M. S. 2013. Sea Waves. Iran: Fadak Isatis.

Soltani Fard, A., and Kakandi, N. 2012. Technologies for extracting energy from ocean waves, Wave Energy, 2012: 1-9.

Sadiku, M. N. O. 2007. Elements of Electromagnetic (4th ed.), New York & Oxford: Oxford University Press.

Sarvari, M. 2016. Ocean renewable energy, Research in Marine Sciences, 1(1): 52-60.

Tabee, A. H., and Torabi Azad, M. 2007. Applicable Methods for Wave Energy Extraction, Bandar & Darya, 12: 128-133.

www.maxwells-equations.com/faraday/faradays-law.ph