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Wave Roller Device for Power Generation

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Abstract

The renewable energy is nowadays in growing interest for the developing countries. Sea waves are an important source to produce clean energy. In Lebanon, the application of wave and tidal energy is not yet developed. The aim of this work is to design a high-efficiency system that harvests the sea wave energy to produce electrical power. A novel concept of a mechanical system will be presented in details. This system benefits from the transverse motion of waves and converts it into electrical power. The proposed wave converter consists of a flat plate to which two double acting piston-cylinder assemblies are connected. When submerged under water, the system exploits the drag experienced by the plate to operate the double-acting cylinders and pump water through a hydraulic circuit to a storage tank placed at a higher elevation. After reaching this tank, the water is directed to a hydro turbine generator placed at a lower elevation and electric power is produced. A prototype is built and successfully tested on the Lebanese shore.

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1. Introduction

The renewable energy sources are part of the solution for the global problem of energy. Offshore Renewable Energies (OREs) and especially wind and waves, are amongst the sources with the greatest potential ([1], [2]). However, wave energy is not developed yet. Using waves as a source of renewable energy offers significant

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advantages over other methods of energy generation [3]. It is estimated that the potential worldwide wave power resource is 2 TW [4]. Nowadays, the development of an efficacious and powerful system for electricity generation from waves, is of special interest and constitutes a challenge for both engineers and researchers.

A number of authors studied several types of wave converter ([5], [6], [7]). These studies showed that many wave energy devices are investigated. However, many of these devices are at the R&D stage. Falnes [8] proposed many different types of wave-energy converters of various categories. Kofoed et al. [9] proposed also three projects of wave converters. These converters are Wave Dragon, Wave Star and Seawave Slot-cone Generator. The concept of the Wave Dragon works by waves overtopping a ramp, filling a floating reservoir with water a higher level than the mean sea level. The Wave Star is equipped with a number of floats which are moved by the waves to activate pumps. The Seawave Slot-cone Generator is an overtopping based wave energy converter utilizing a total of three reservoirs placed on top of each other. Other studies are conducted on the wave converters in parallel with another system, forming a hybrid system ([10], [11], [12]).

In this project, a wave power generation system is presented. First, the design of this system is explained. The system components are detailed and the operation process of the system is described. The manufactured system is also presented and tested in a location on the Lebanese coast. The first results of the installed system are shown. These results seem to be promising with respect to the classical systems results.

Nomenclature

WEC	Wave Energy Converter
c_a	Velocity of the wave, m/s
P	Wave energy flux, W
H_{m0}	Significant height of the wave, m
S_{ut}	Ultimate Strength, MPa
S_y	Yield Strength, MPa
E	Tensile Modulus of Elasticity, MPa

2. Wave Converter Design

The concept of the proposed wave converter benefits from the transverse motion of the waves by using pistons. The design is a hinged system where the plate is submerged at the bottom of the sea. The system is moving in both directions forward and backward, in response to the ebb and flow of the surface waves. This device captures the energy directly and oscillates along the fixed axis animated by bearings. Two cylinders are attached to a plate that absorbs this kinetic energy and pump the fluid into a hydraulic circuit as high pressurized water to a storage tank placed at a higher elevation. After reaching this tank, the water is directed to a hydro turbine generator placed at a lower elevation, in order to produce clean electrical power. The design of the wave roller is shown in Fig.1.