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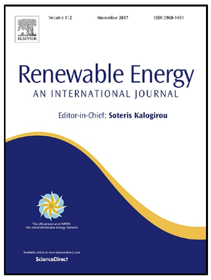

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Alberto Albert, Giovanni Berselli, Luca Bruzzone, Pietro Fanghella

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Research paper

Mechanical Design and Simulation of an Onshore Four-Bar Wave Energy Converter

Alberto Albert, Giovanni Berselli, Luca Bruzzone*, Pietro Fanghella

Department of Mechanical, Energy, Management and Transportation Engineering, University of Genoa
Via all'Opera Pia 15/A - 16145 Genova, Italy;
alberto.albert@fastwebnet.it, luca.bruzzone@unige.it; giovanni.berselli@unige.it; pietro.fanghella@unige.it
* Correspondence: luca.bruzzone@unige.it; Tel.: +39-0103532967

Abstract The paper presents the design of an onshore Wave Energy Converter (WEC) named *ALETTONE* (*At Least Energy Thanks To Neptune*), which is characterized by a low cost mechanical architecture based on a four-bar linkage with mobility in a vertical plane. The lower link is a floating rocker arm moved by the hydrostatic and hydrodynamic forces exerted by the sea water, whereas the upper rocker arm is connected to a rotating electric generator via a transmission composed of either a single or a pair of one-way clutches coupled to a speed multiplier gearbox. Due to its simplicity, this WEC concept seems to be an interesting solution for energy generation in isolated locations. After a description of the overall design, the dynamic model of the system is presented, along with simulation results in case of monochromatic and panchromatic waves.

Keywords: wave energy converter; onshore generation; multibody simulation; four-bar mechanism.

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1. Introduction

Wave energy harvesting potentially represents an important source of renewable energy [1]. As solar energy is converted to wind energy, the power flow is spatially concentrated, and as wind energy is converted to wave energy, a further spatial concentration takes place. The global power potential represented by waves, considering also open ocean, has been estimated in the order of 10^{13} W, whereas the power that hits all coasts worldwide has been estimated to be in the order of 10^{12} W [2]; this portion is evidently the most easy to be harvested. Examples of exploitation of wave energy date back to the thirteenth century, when waves were used to move mills; the first patent was obtained by Girard and son in France [3]; in 1910, Praceique-Bochaux developed a pneumatic-based system capable of producing electricity from wave energy, similar to the Oscillating Water Column principle further investigated by Masuda since 1940 [4]. In the second half of the twentieth century, the research interest about Wave Energy Converters (WECs) and their financing had increasing and decreasing phases, related to the history of oil price. Today, due to the energy crisis and environmental awareness, WECs are unquestionably considered a fundamental research issue.

Over the decades a large variety of WECs has been designed and prototyped [5]; WECs can be classified on the basis of their location [6] (*onshore, nearshore, offshore*), size and orientation with respect to the incoming wave [7], working principle [8] (*pressure differential WECs* [9, 10], *floating WECs* [11, 12], *overtopping WECs* [13], *impact WECs* [14]), power take-off system (*air turbines* [15, 16], *hydraulic systems* [17], *linear generators* [18, 19]).

As regards the power take-off systems, it should be noted that by using direct-drive linear generators the mechanical energy harvested by the WEC is directly transformed into electrical energy, without the interposition of a fluid or a mechanical transmission. In this case, the mechanical layout is rather simple, thus requiring few maintenance. The main drawback of these high-power linear generators is their cost, related to the necessity of large and expensive permanent magnets and to the necessary protection from contact with sea water. Also less expensive linear electromechanical generators, composed of a rotary generator and a ball screw mechanism [20] can perform the same kind of energy conversion, but with higher mechanical complexity and lower reliability.