A Review on the Nonlinear Dynamics of Pendulum Systems for Energy Harvesting from Ocean Waves

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ABSTRACT

The world's wave energy potential is estimated to be around 2.5 – 3 TW [1]. Recent evaluations of the Atlantic coast of South America estimate available wave energy within the order of 200 GW, while for the Pacific coast the assessment arises to 320 GW. Wave energy is currently being used in developed countries. About 55 TWh per year of energy consumption are replaced by energy coming from wave motion in the United States, while in Europe this value corresponds to 280 TWh. Given these trends, it is logical to think that the use of wave energy presents a huge viability in the foreseeable future.

Systems which convert wave energy into rotational kinetic energy of a pendulum, or a set of pendulums, have a great potentiality. Since a pendulum can reach very high rotation speeds, this potentiality is theoretically higher than other systems currently used, such as the oscillating water column, floating moored devices (buoys) or articulated mechanical-hydraulic systems [2]. While this latent advantage is attractive, the development of pendulum and multi-pendulum wave energy systems is still in its embryonic stage [2-3], and there is still no full-scale prototype available. The main reason for this lies in the difficulty of achieving and maintaining rotational motion, under an excitation so irregular such as waves' excitation. To understand the phenomenon a comprehensive analysis of the system's dynamics is required. This dynamics is strongly nonlinear and therefore very complex [4,5].

This article aims to explore the state of knowledge in the field of nonlinear dynamics of pendulum systems, with a view in energy harvesting from ocean waves. There is a significant wealth of analytical, numerical and experimental research which is reviewed in this article. And there are still many unanswered questions that deserve discussion.

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