Optimum use of wave energy using oscillating water column system

March 29 2011

Engineers Modesto Amundarain and Mikel Alberdi have presented the first two PhD theses at the University of the Basque Country (UPV/EHU, Spain) on the use of oscillating water column (OWC) converters for extracting renewable energy from waves. According to these two engineers, the technology of the plant, currently being built in the coastal town of Mutriku in the Basque province of Gipuzkoa, is the most suitable for taking advantage of energy from the waves along the Basque coast.

Both research theses present proposals for enhancing the operation of this kind of plant. Mr Amundarain's thesis (*Control of wave-driven turbo-generators*) puts forward a number of strategies for resolving the problems of control of these installations. Mr Alberdi focused on solving the power problems arising with generators of this nature (and entitled, *Design and development of power plant control strategies for converting wave energy from the sea and for power sags in the electric grid*). The results of this research have been published by the Department of Systems Engineering and Automation at the UPV/EHU, where Mr Amundarain and Mr Alberdi work, in the *IEEE Transactions on Industrial Electronics* journal.

The OWC system

In OWC technology, it is not the waves that move the turbines directly, but a mass of compressed air that is pushed by these waves. It involves a structure usually located in a breakwater, the upper part of which houses an air chamber (thus the compressed mass of air) and its lower part is being submerged under the water. In this way, the turbine takes advantage of the movement caused by waves, both when they come in and when they go out, and the doubly-fed generator (both by its rotor or mobile part and by the stator or fixed part) to which it is coupled feeds energy to the grid.

One of the principal problems described by the two researchers is the loss behaviour of the turbine. The turbine used in these installations is the Wells type and, given its characteristics, on a particularly strong wave hitting it, the turbine can become stuck or rotate much more slowly than normal. It is thus necessary to adapt the speed of the turbine. The research also aimed to identify the maximum power obtainable or to fix a reference power, also related to the control of the turbine.

In the quest for more efficient solutions, Mr Amundarain and Mr Alberdi emulated a whole plant using a computer (including the Wells turbine, which they had to build from scratch, not having any model) and validated their trials experimentally. They managed to establish that the most effective measure was controlling the velocity of the turbine through the doubly-fed generator to which it is coupled. The same generator makes the turbine rotate at the optimum speed to give the maximum power, adapting itself depending on the pressure caused by the waves at each moment. They also combined this measure with the control of the air flow, based on a valve usually found in the reception chamber of these OWC systems, and involving controlling their level of opening according to the air flow.

Losses of grid voltage

These two measures are valid in helping to solve another problem tackled by these two researchers, largely dealt with in Mr Alberdi's thesis: the power sags in the grid which cause imbalances when operational. Mr Alberdi coordinated a series of strategies amongst which are those mentioned above. The researcher also proposes the control of active power (the part that is in fact consumed) and reactive power (not consumed) fed into the grid in a decoupled manner. Also, in order to control electricity generation, whatever the state of the sea, the researcher proposed monitoring the continuity of supply during a power sag and making use of a system of generation of references.

Provided by Elhuyar Fundazioa

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https://phys.org/news/2011-03-optimum-energy-oscillating-column.html