Statement of the work

Latching control of the MBARI's wave-power buoy

The condition for maximum energy extraction of a single-mode oscillating wave energy converter (WEC) in regular waves, is when the body velocity is in phase with the wave excitation force. Several phase-control strategies have been proposed, including for devices in real irregular waves. However, the optimum WEC control for irregular waves is known to be anti-causal, i.e., we must know in advance the excitation force in order to control the floater velocity. Phase control by latching is another well-known technique that may increase the power absorption in point-absorber wave energy converters. It consists in latching the device in a fixed position during certain intervals of the wave cycle so as to achieve approximate optimal phase control. Latching should be regarded as a suboptimal control method. Sub-optimal strategies and algorithms for phase control (including latching) have been proposed without the need to predict the excitation force, with varying success. Latching has been more successful for single-body devices whose resonance frequency is significantly higher than the representative wave frequency. This is typically the case of relatively small bodies (point absorbers). In the case of two-body converters, latching fixes the bodies to each other, but not any of them. In some cases (as is the case under consideration), one of the two bodies is totally submerged and its role is simply that of inertia referential. Naturally, its inertia (mass plus added mass) should preferably be much larger than that of the floating body (whose role is to absorb energy from the waves).

The aim of this work is the development of a latching control algorithm to increase the wave energy conversion of the MBARI's wave-power buoy, and possibly propose modifications to the submerged plate. The work will be divided into two phases.

Phase 1 – Numerical simulation and preliminary conclusions

Using the IDMEC computer codes, the performance of the MBARI WEC will be assessed. To accomplish this, the MBARI group should give the following information:

- floater and plate geometries as well as the hydrodynamic coefficients;
- PTO characteristics and maximum allowable forces;
- experimental data acquired by the sensors, in real-time, that could be used for latching control;
- description of the relevant sea-states at the location where the device will be deployed.

A sensitivity analysis of power absorption with latching in regular waves will be performed in order to assess the potential improvements that can be provided by this technique. This will include the

timing for the latching and the inertia of the submerged plate.

Based on the numerical results, a preliminary conclusion will be drawn about the viability of latching as a way to improve the performance. If the conclusion is negative, then a decision will be made about stopping the investigation or looking for alternative ways of solving the problem. In this case, a report of the performed work will be delivered. Otherwise, we would proceed to phase 2.

The conclusion should be drawn not later than 4 of March 2013 (this date is to be confirmed).

Phase 2 – Causal latching control algorithm

The second phase consists in finding a causal latching control algorithm for irregular waves that improves the efficiency of the MBARI WEC. The task requires additional collaboration with the MBARI research group.

The latching algorithm has the following major constraints:

- During the latched period, the pair floater/plate cannot be kept fixed, unlike in the case of a single body reacting against a fixed reference (sea bottom, breakwater, etc.). This situation would be expected to significantly improve if the inertia of the second body (plate mass plus added mass) is made substantially larger than the inertia of the floater.
- The calculation of the latched period has to be performed in real-time, as function of the current sea wave conditions.

Additional data from the Inertial Measurement Unit (IMU) and floater draft sensor may be used in the latching control algorithm if data is available in real-time with enough accuracy.

At the end of phase 2, a report will be delivered with the numerical results, latching control algorithm and recommendations for other ways of increasing the amount of produced energy. The latching control algorithm should be delivered not later than 25 of March and the report by the end of April.

Additional collaboration

The work should end with one or more joint papers, to be written after relevant field data have been collected by the MBARI group. The paper(s) will report numerical results and comparisons with experimental data in a form that is acceptable to the MBARI group.

The IDMEC group is available to analyse sets of experimental data acquired by the IMU sensor during sea tests to compute the floater motion, with the aid of a numerical code that has been developed in-house for two years.