Modelling and Dynamics of a Compressible Cylindrical Variable-shape Wave Energy Converter

Master thesis proposal at the Marine Offshore Renewable Energy Lab

Department of Mechanical and Aerospace Engineering

Politecnico di Torino

International collaboration: **Iowa State University (USA)**

Recommended profile:
Mechanical engineering, Aerospace engineering, Mechatronic engineering

Topics involved:
Mechanical modelling, Hydrodynamics, Dynamical analysis, Renewable energy, Soft materials

Proposal description

Wave energy conversion is an evolving field, with recent advances focused on devices that adapt their shape to maximise energy capture. Conventional wave energy converters (WECs) generally maintain a fixed geometry, which can limit efficiency due to suboptimal interaction with varying wave conditions. Variable-shape WECs present a promising alternative, dynamically altering their form to better align with the forces of the surrounding fluid and increase power production. This approach mitigates the need for complex reactive power systems, which can be costly and reduce overall efficiency. The dynamics of flexible WECs have been previously investigated, with studies indicating significant improvements in power capture by leveraging shape adaptability. Such devices often utilise flexible hulls that interact with ocean waves through complex hydrodynamic interactions. Prior research includes the development of mathematical models that describe the forces on and the movement of these adaptable structures. This project (made in collaboration with Iowa State University, USA) aims to extend these concepts to a variable-shape WEC that can change shape via internal hydraulic actuation.

This master's thesis project will focus on developing an analytical and numerical model of a compressible variable-shape WEC with a flexible cylindrical hull, capable of shape transformation through hydraulic actuation. The hull, constructed from a polymeric or soft plastic material, will allow for vertical shape modifications, effectively varying the height of the cylinder. The candidate will employ MATLAB/Simulink for this model, developing an analytical approach for the device's dynamics while using numerical methods to approximate the hydrodynamic interactions. The research will explore how ocean waves and the device's actuation compress and decompress the hull, affecting its hydrodynamic properties.

The project will involve an initial training phase at the Marine Offshore Renewable Energy (MOREnergy) Lab, followed by a research period at Iowa State University. There, the candidate will develop and refine the model, perform dynamic analyses, and assess the device's energy conversion performance. Through this collaborative effort, the project aims to advance the understanding and application of variable-shape WECs in the field of renewable ocean energy.

Objectives

- Development of a mathematical model aimed at describing the dynamics of the compressible variable-shape wave energy converter.
- Dynamical analysis.
- Operative conditions simulations.

Contact references:
Dr. Fabio Carapellese (fabio.carapellese@polito.it)
Dr. Edoardo Pasta (edoardo.pasta@polito.it)