Experimental and Numerical investigation of a Very Promising Technology for Marine Current Exploitation: the Kobold Turbine

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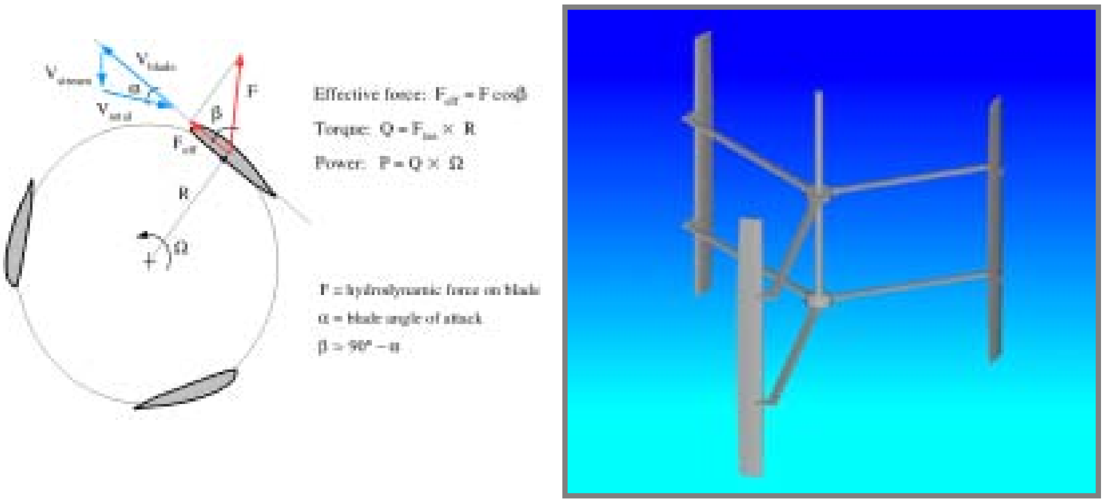
ABSTRACT

Marine currents represent large renewable energy resources and have the potential to give a significant contribution to fulfill the worldwide energy demand.
The possibility to extract power from both air and water currents is well known to the human beings since thousands of years, and modern technology makes the exploitation of this type or renewable energy more and more reliable, safe and cost-effective. A very promising new technology for marine current exploitation based on the *Kobold turbine* concept is addressed here. Basically the Kobold Turbine is a vertical-axis multi-bladed rotor that is fully submerged under a floating moored buoy and which is subject to an incoming flow originated by a tidal sea current. This kind of turbine has several advantages compared to the horizontal axis ones: designing and building simplicity, sense of rotation independent from the current direction, a very high starting torque and a high efficiency. A prototype has been realized and it is now successfully operating in the Messina Strait in Italy since 2001, producing, for the first time in the whole world, electricity from marine currents delivered to a local electricity grid.

In this paper we describe the activity in the framework of a research project. Aims of the project are to achieve a better understanding of hydrodynamics aspects involved in the Kobold turbine operation and to develop prediction tools to assist design of high-performance Kobold turbines. The primary role of hydrodynamics studies stems from the fact that the successful design of a Kobold power generation plant is necessarily related to maximizing the energy transfer from water to the shaft through the turbine blades. In the present work, both experimental techniques and theoretical/computational models have been used to address such aspects.
In order to determine strategies to optimise the turbine's design we have tested different models of Kobold turbine at the INSEAN towing tank, simulating the marine current with the turbine towed by the carriage. Measuring torque and angular velocity for each current speed and for different number of blades, we have defined the overall hydrodynamic performances in terms of the delivered power on the shaft. These experimental results on the model have been compared with data available for the full scale prototype recorded along its operational life on the sea-site.
From a theoretical and computational perspective, a fully three-dimensional unsteady hydrodynamic model has been developed based on a Boundary Element Method. This methodology allows to include in the performance analysis the unsteady effects of the vortical wake shed by each turbine blade and to understand the influence of the blade-wake interaction on the torque generated by the turbine.
The theoretical model has been implemented into a hydrodynamic performance prediction software that has a low computational cost and thus represents a practical design-oriented tool. As a matter of fact one of the major problems with such a kind of turbine is that it has to be site-tailored according to the different marine current conditions which, albeit largely available worldwide in coastal regions, can greatly differ both in intensity and in time duration from one site to another one.
In the final paper, the experimental methodologies as well as the theoretical models used in the project will be described. Turbine performance measurements from towing tank tests will be analysed. Next, numerical predictions by the proposed computational tool will be presented and validated through comparisons with experimental data.

The Kobold turbine



Sketch of a three-bladed Kobold turbine