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EXPERIMENTAL TEST BENCH IN A WAVE FLUME FOR THE DEVELOPMENT OF A NEW MINI MORPHABLE WELLS TURBINE

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1 INTRODUCTION

The aim of this research study is to perform experimental tests on a new morphable mini Wells turbine designed to operate in presence of waves with limited energy content which presents a high frequency of occurrence along the Mediterranean coasts (Corsini et al., 2010). The strengths of these mini Wells turbines are: i) extremely light rotor; ii) no need of actuators to morph the rotor blades; iii) low construction and maintenance costs; iv) capability to produce energy starting from low wave heights in the order of a few decimetres. Furthermore, the small size and low investment costs of the turbine make it particularly suitable to be installed either in existing structures, such as anti-reflective perforated caissons (often used in the Mediterranean harbors), or in devices for coastal defense from erosive phenomena located on shallow water conditions. The need to carry out experimental tests derives from the difficulty of handling in a virtual Computational Fluid Dynamics environment the huge difference in the time scale of the turbine, which spins at 1500-3000 rpm, and the wave periods, in the order of some seconds (Corsini et al., 2012; Barnabei et al., 2020). Properly designed lab tests, executed in controlled conditions with irregular sea states, are therefore mandatory to fully characterize the behavior of morphable Wells turbines to be employed in the Mediterranean Sea, and in particular to assess their self-start capability.

2 THE MINI WELLS TURBINE AND THE LABORATORY FACILITIES

The mini Wells turbine investigated by means of experimental tests is protected by a patent held by Eng. Francesco La Spada. As an example, Figure 1 shows some images of the new turbine already installed in Marina Corta (Aeolian Islands - Italy), where it was installed above a perforated caisson used to reduce quay reflection. Waves characterized by less than 0.5 m height made it possible to generate an amount of energy suitable for illuminating the harbor breakwater.

Though the potentiality of the turbine is fully recognized, it has never been tested under fully controlled conditions, such as those obtainable with laboratory tests, suitable to reproducing both the real environmental conditions (characteristics of the incident waves, bathymetry, etc.) and the apparatus features (power energy and performance). Furthermore, the laboratory tests constitute a benchmark for the validation and calibration of the numerical model.

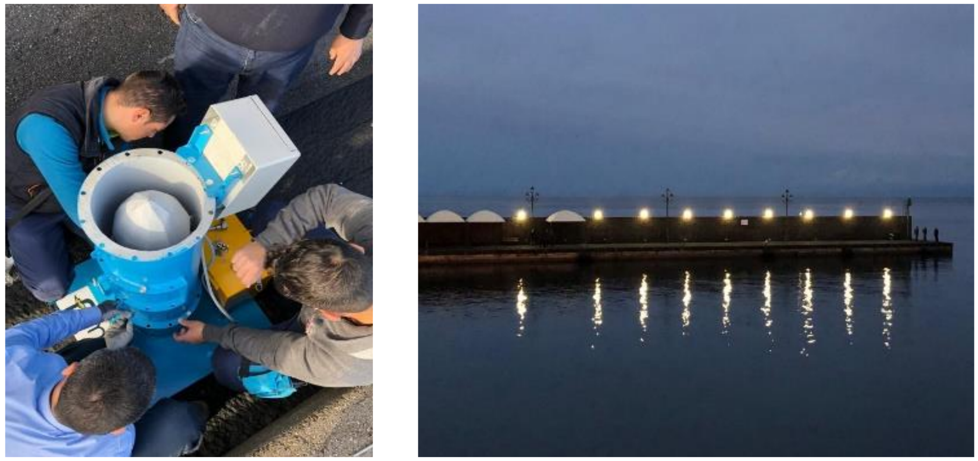

Figure 1. Prototype scale tests carried out in Marina Corta on the Lipari Island (Aeolian Islands - Italy).

The experimental tests are carried out in the wave flume of DICEA, Sapienza University of Rome. The wave flume is characterized by a length of 15.0 m and a cross-section of 0.60 m by 0.60 m (see Figure 2). The structure is made of steel and glass, allowing the use of high-resolution cameras for image analysis. The generation of waves in the flume is accomplished by using a piston wavemaker whose movement is electromechanically induced. The characteristics of a generic sea state are synthesized using AwaSys software, developed by the Danish University of Aalborg (Andersen et al., 2014).

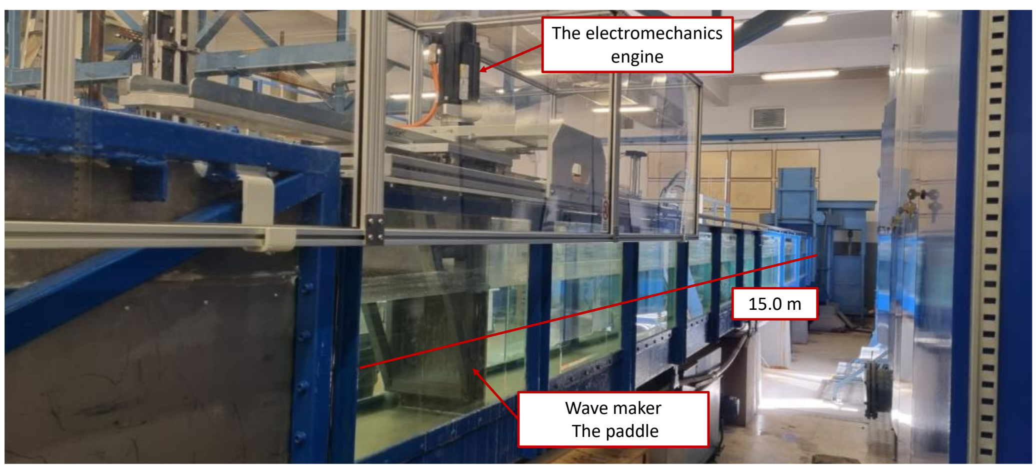

Figure 2. Wave flume in the Laboratory of DICEA Sapienza University of Rome.

The experimental test will mimic the sea features near the Port of Messina (Italy) where a prototype will be installed. The site has been characterized by a meteo-oceanographic study which provides the basis for the design of the turbine to be tested in the laboratory. To characterize the Wells turbine performance the following time-resolved quantities will be measured on the test-rig: i) water level in the OWC chamber; ii) static pressure in the OWC chamber and downstream of the Wells turbine; iii) mechanical torque on the Wells turbine axis; iv) mass flow rate in the turbine; v) rotor deformation.

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