Experimental validation of a RANS-VOF numerical model of the wave generation, propagation and dissipation in a 2D wave flume

Lander Galera*, Urko Izquierdo*, Gustavo A. Esteban*, Jesús M. Blanco* and Iñigo Albaina*

*School of Engineering of Bilbao, Department of Nuclear Engineering and Fluid Mechanics
University of the Basque Country (UPV/EHU)
Plaza Ingeniero Torres Quevedo 1, 48013 Bilbao, Spain
Email: galera.lander@gmail.com, Web page: www.ehu.eus

ABSTRACT

Nowadays, there is an increasing interest for developing efficient wave energy converters (WEC). The usual strategy to analyse the viability of the new designs is to test reduced scale WEC models before the construction and testing of the full-scale prototypes, because it is more cost-effective. Hence, there is a need to replicate wave propagation conditions on a reduced scale in a wave flume and to study the interaction of the waves with the WEC models under those conditions, both experimentally and numerically [1]. The experimental approach may be used both to study the physical behaviour full-scale prototype and to validate a numerical model that can be applied to study the full-scale prototype before open sea experiments characteristic of high TRL designs.

With this objective, a numerical model based on Reynolds Averaged Navier Stokes (RANS) equations to represent the turbulence and Eulerian Volume of Fluid (VOF) unsteady approach has been developed in STAR-CCM+ CFD code to track the evolution of the free surface.

The experimental campaign has been performed in a wave flume of 12.5 x 0.6 x 0.7 m (length x width ·x height), with a wide range of depths, wave heights, wavelengths and periods. This new facility installed at the Laboratory of Fluid Mechanics at the Faculty of Engineering in Bilbao, has the capacity of producing a wide range of monochromatic and panchromatic waves by a piston-type wavemaker driven by a linear induction motor, and of capturing the wave propagation by several ultrasonic wave probes located along the test length far from the generation and extinction regions at each end of the flume. A parabolic solid beach, 1.5 m long and with adjustable height and sloping angle, has been selected as extinction passive method to minimize the wave reflection.

The flume has been designed to be able to reproduce the wave swell characteristics of the most representative research facilities in the Basque Country: BiMEP (Biscay Marine Energy Platform, located off the coast at Armintza) and the Mutriku Wave Energy Plant where wave energy converters and power take-off (PTO) systems designed for Oscillating Water Column (OWC) technology can be tested for harnessing the energy of the waves. This piece of research contains the most important steps of the flume building process as well as the properties of the materials and equipment that have been incorporated, together with the development of the CFD model and its validation.

The numerical and experimental campaigns focus on the description of the basic hydrodynamic processes of wave generation, propagation and dissipation, giving as a result the definition of the configuration of the wavemaker (amplitude, period and time-dependent stroke function) and the extinction parabola to produce a certain required wave. The results are analysed together with the analytical solution coming from the potential flow theory, and taking the validity limits of different wave theories as a reference in the Le Méhauté chart. The experiments carried out in the present work establish the operational limits of the wave flume in terms of wave generation, propagation and extinction, defining the operational range of future experimental and computational campaigns where wave interaction with floating structures, wave energy converters and mooring systems will be studied.

REFERENCES

[1] I. López, B. Pereiras, F. Castro, G. Iglesias, “Optimisation of turbine-induced damping for an OWC wave energy converter using a RANS-VOF numerical model”, *Appl. Energ.*, Vol. 127, pp. 105-114, (2014).