Abstract

The objective of the thesis is to investigate the hydrodynamic performance of oscillating water column (OWC) wave energy devices in the presence of different types of bottom profiles viz. stepped, sloped and curved bottom. The main focus is to numerically build a wave tank and OWC device using computational fluid dynamics (CFD) and analyze the hydrodynamic efficiency under the influence of various sea bottom profiles. Both fixed and floating type OWC are modeled for the purpose of analysis. The free surface waves are generated using the volume of fluid (VOF) method in the computational domain. The power take off (PTO) unit is modeled as a porous region in the computational domain to replicate the pressure jump versus flow characteristics of an air turbine. The 6-DOF dynamic meshing technique is used to capture the motions of the floating OWC structure. The mooring lines are molded as spring elements having certain stiffness value. The efficacy of CFD models are tested by validation with experimental and analytical studies. In addition to hydrodynamic efficiency, the fluid flow characteristics and free surface oscillations within and around the OWC chamber are studied in detail. The effect of wave steepness and wave length on the hydrodynamic efficiency is also analyzed. PTO unit of the device is analyzed for optimal performance of the OWC device. Along with CFD, a boundary integral equation method (BIEM) based model was also developed to study the hydrodynamic performance of the OWC device. In the BIEM method, the boundary value problem is solved in two-dimensional Cartesian coordinates using the linear water wave theory. There is a general agreement between CFD and BIEM results in terms of resonating behavior of the device for flat bottom case. The peak efficiency and variation of efficiency over a range of frequencies for CFD and BIEM method are quite different for modified bottom geometries.

Key Words: Oscillating Water Column (OWC), Computational Fluid Dynamics (CFD), Volume of Fluid (VOF), Power take Off (PTO), hydrodynamic efficiency, Boundary Integral Equation Method (BIEM).