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Comparative analysis of turbulence models in hydraulic jumps

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Abstract. A numerical simulation of the incompressible multiphase hydraulic jump flow was performed to compare the interface prediction through the use of the three RANS turbulence models: k–ε, RNGk– ε and SST k–ω. A three dimensional no submerged hydraulic jump and a two dimensional submerged hydraulic jump were modeled. Both the geometry and the mesh were created using the open source Gmsh code. The project's geometry consists of a rectangular channel with length and height differences between the two dimensional and three dimensional simulations. Uniform hexahedral cells were used for the mesh. Three refining meshes were constructed to allow to verify simulation convergence. The Volume of Fluid (abbr. VOF) method was used for treatment of the air-water surface. The turbulence models were evaluated in three distinct set up configurations to provide a greater accuracy in the flow representation. In the two-dimensional analysis of a submerged hydraulic jump simulation, the turbulence model RNG RNG k– ε provided a better interface adjust with the experimental results than the model k– ε and SST k–ω. In the three-dimensional simulation of a no-submerged hydraulic jump the k–# showed better results than the SST k–ω and RNG k– ε capturing the height and length of the ledge with a better fit with the experimental results.

Keywords: fluid-flow interface; turbulence model; hydraulic jump; multiphase flow

1. Introduction

Hydraulic jumps occur due to the rapid transition from supercritical to subcritical flow, associated with a sudden elevation of water level, surface waves and air bubble entrainment. Analytical solutions of the hydraulic jump were presented by McCarthy O'Leary (1978), who implemented an analysis of the study of the propagation of the jump in a channel of uniform width and variable length.In particular, they derived a differential equation and determined how the height varies with the wave propagation. Thus, they established criteria for the wave to grow, decay or to propagate with constant amplitude. Three years later, Hirt and Nichol (1981) introduced the famous Volume of Fluid method. This method has been shown to be more flexible

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