3D numerical simulations of the impingement of a turbulent swirling jet against a solid wall*

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ABSTRACT

Most industrial applications of impinging swirling jets are in areas such as paper and fabric drying, local cooling of turbine blades and high-power electronics, material coating, metal solidification, and some others [1]. However, the numerical study in the present work has been motivated by yet another industrial application of impinging swirling jets such as the seabed excavation process: a swirling jet, generated by a special nozzle, impinges against a sand bed located at a known distance H downstream from the nozzle exit, making a footprint on it.

In particular, we have previously characterized experimentally the footprint made by a known swirling jet, whose velocity profile at the nozzle exit had been experimentally measured by means of a LDA system, on several types of sand beds. The aim of this study is then to try to explain the swirling jet performance on the sand bed by means of 3D numerical simulations. To that end we use the commercial code Fluent©to simulate the 3D turbulent swirling jet impinging against a solid non-deformable wall. The experimentally measured profiles of the circumferential and axial velocity components were used as the boundary condition at the nozzle exit, and the resulting wall shear stresses exerted by the fluid on the wall were computed. We then explain the experimentally measured pattern of the footprint made by the swirling jet in terms of the computed structure of the turbulent jet and the resulting shear stresses on the wall.

We first selected the best turbulent model and the optimum mesh grid in the computations, validating both with previously reported data on the impingement of a swirling turbulent jet [2,3]. The Reynolds number in the computations, based on the flow rate and the jet diameter D, ranged between 7000 and 20000, as in the experiments. Several non-dimensional nozzle-to-plate distances H/D, and several velocity profiles at the nozzle exit, were considered. The computations showed a variety of swirling jet structures for the different configurations, with qualitatively different distributions of the shear stresses on the impinging plate. These variety of distributions explained the different patterns of the footprints on the sand bed found experimentally, showing the main trends to be followed in the swirling nozzle design to optimize several aspects of the seabed excavation process.

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