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Simulation of Velocity Distribution for Water Flow in a Vortex-Chamber-Type Sediment Extractor

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A vortex-chamber-type sediment extractor (VCTSE) system, consisting of a cylindrical chamber, an inflow system, a bottom orifice outflow and an overflow weir, has been used to separate sediment from sediment-laden water flow. A tangential inflow is introduced into a cylindrical chamber with a bottom orifice; thus, a strong vortex flow is produced there. Under actions of gravity and centrifugal force, heavier sediment particles are forced to move towards the bottom orifice, and relatively clear water flows over through the top overflow weir. The efficiency of sediment extraction by a VCTSE is significant dependent on the flow characteristics in the device. The vortex flow in a VCTSE is complicate and it is very difficult if not impossible to measure its velocity distribution by using a direct measurement. This study tries to numerically assess the velocity distribution in a VCTSE by a commercial software named as FLOW-3D under a clear water condition. The VCTSE used in this study has a cylinder of 100 cm in diameter and 30 cm in height. The elevation of the overflow weir is 15 cm above the cylinder bottom. Firstly, the surface lines at the water surface obtained by the simulation of FLOW-3D were compared with the observation in a physical experiment. The comparison shows that the simulated results are quite close to the experimental results, and this confirms that FLOW-3D can be used to simulate the flow characteristics in a VCTSE. The simulated velocity distributions of at the depths of Z = 6.3 cm (the distance from the bottom), 10.3 cm, and 14.3 cm (near the surface layer) were analyzed. The characteristics of tangential velocity (Vt), radial velocity (Vr), and axial velocity (Vz) at these three depths were discussed. The effects of inflow discharge as well as the installation of horizontal deflectors on the velocity distributions are also discussed. Except the velocity distributions, the formation of an air core in the central part of vortex flow was also simulated and compared with the experimental one. Overall, the results show that the value of tangential velocity is the highest among the three velocity components. As for the stability of the velocity distribution, it is more stable at deeper depth compared with the swallower's depth. The result indicated that VCTSE air-core with horizontal deflector apparently has less extent of stirring.