SPH numerical investigation of oscillating characteristics of hydraulic jumps at an abrupt drop

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Abstract: This paper shows the results of the SPH modelling of the transition from supercritical to subcritical flow at an abrupt drop based on the laboratory experiments by Mossa et al. [1]. At an abrupt drop the transition from supercritical to subcritical flow is characterised by several flow patterns depending upon the inflow and tailwater flow conditions. SPH simulations are obtained by a pseudo-compressible XSPH scheme with pressure smoothing; turbulent stresses are represented either by an algebraic mixing- length model, or by a two-equation $k-\varepsilon$ model. The numerical model is applied to analyze the occurrence of oscillatory flow conditions between two different jump types characterised by quasi-periodic oscillation, and the results are compared with experiments performed at the hydraulics laboratory of Bari Technical University. Figure 1 shows an example of an oscillation cycle between a B-type jump (a,c) and a wave jump (b,d). The purpose of this paper is to obtain a deeper understanding of the physical features of a flow which is in general difficult to be reproduced numerically, owing to its unstable character. In particular, relying on previous SPH analyses of vorticity-dominated flows [2], vorticity fields, velocity, water depth and pressure spectra downstream of the jump (fig. 2), and velocity and pressure cross-correlations can be computed and analysed.

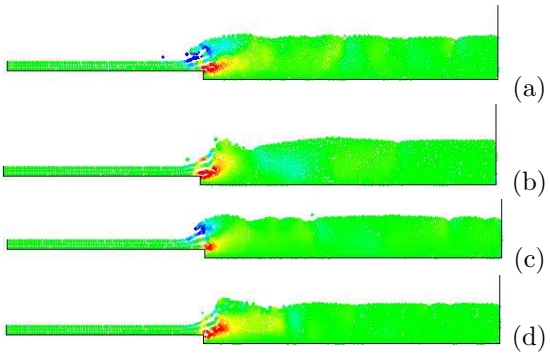

Figure 1: Instantaneous vorticity fields in the SPH simulation: a) $t = 15$ s; b) $t = 21$ s; c) $t = 26$ s; d) $t = 30$ s.

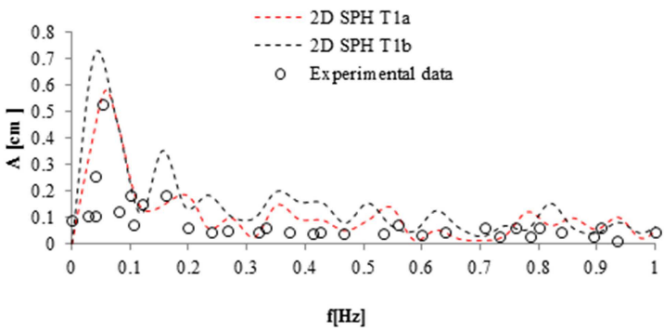

Figure 2: Amplitude spectra of pressure fluctuations under the jump for SPH simulations with ML turbulence model (T1a), with $k-\varepsilon$ model (T1b) and experiments

References

[1] Michele Mossa, Antonio Petrillo, and Hubert Chanson. Tailwater level effects on flow conditions at an abrupt drop. *Journal of Hydraulic Research*, 41(1):39–51, 2003.

[2] Diana De Padova, Michele Mossa, and Stefano Sibilla. Sph numerical investigation of the velocity field and vorticity generation within a hydrofoil-induced spilling breaker. *Environmental Fluid Mechanics*, 16(1):267–287, 2016.