Numerical and Analytical Solutions for Air Cavity Formation in Ducts

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ABSTRACT

Intrusion of air cavities into filled ducts is a physical event which often occurs in sewer systems during a storm. Analytical solutions of this motion in horizontal ducts can be obtained for simplified configurations, including a weir situated at the end of the duct [1]. Nevertheless full analytical solution for inclined ducts is not available, mainly due to gravity effects in the cavity formation and propagation (see e.g. [2]). We derive extended semi–analytical integral solutions for horizontal and inclined configurations along the lines of Baines [2], for a wide range of slopes and weir positions. We compare analytical simplified calculations with detailed numerical simulations of the experiments by a open source finite volume approach [4].

Otherwise, formation and propagation of cavities imply very different interface configurations and demands for the numerical algorithm. We adapt interface-capturing methods to this problem, by introducing a volume of fluid–continuous 2D finite element model, integrating a non–oscillatory finite element correction for the phase function ([3]) with an efficient characteristic based split FEM for incompressible flows. Experiments illustrate the suitability of the model for stringent tests, with particular emphasis on simulation of air–cavities propagation in ducts during pressurization.

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