Polytropic models for critical two-phase flow in the layer of spherical particles

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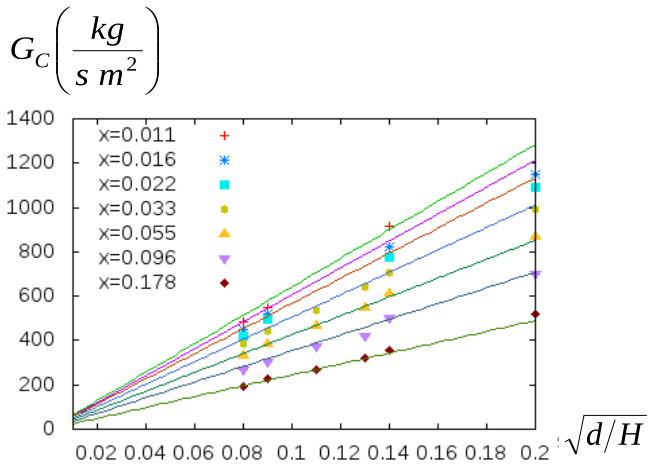
Abstract: Two-phase gas-liquid flows are widely used for heat removing from any kind of heat exchanger surfaces, including apparatus with immovable layer of solid particles. In this kind of flow, the mass velocity, G, is limited by the critical flow phenomenon. There are many publications about critical flow in short and long a pipe, washers, and nozzles, but for the gas-liquid flow through the solid particles layers the study is lacking. The purpose of this study is to develop a method to predict critical mass velocity, G_c, for such flow. The vapour-water flow through the H=50-355 mm thick layer of solid spherical particles with diameter, d, of 2, 3 and 4 mm was studied experimentally. The inlet flow quality ranged from x_1=0.011 to 0.178, and the inlet pressure, P_1, was adjusted at the levels of 0.3, 0.6, 0.9 and 1.2 MPa. The outlet pressure was gradually decreased and the mass flux was estimated by measured the time needed to fill the control volume, until the critical velocity is obtained. We used the theoretical model of nonlinear filtration of two-phase flow with different velocities of gas and liquid phase. The polytropic index, void fraction and slip ratio were estimated by iteratively adjusting theoretical and experimental mass velocity. The developed method gives polytropic approximation for isenthalpic process of the flow expansion with phase-transition, and provides 5% accurate prediction of the critical mass velocity.



Critical mass velocity. Lines corresponds to theoretical model, markers – to experiment