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On closure strategy for 1D thermohydraulics models and closure relationships of two-phase flows in simple and subchannel geometry for NPP accident conditions

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One-dimensional mathematical models are extensively used in thermohydraulics assessment of Nuclear Power Plant (NPP) transients and accidents, because specifically 1D system of the conservation laws allows to reduce computing time and required memory, especially in "best estimate" code calculations. There, for example in the case of drift flux model, we need to provide the closure strategy of 1D models of conservation laws accompanied by the closure relationships for NPP two-phase thermohydraulics. This closure strategy is necessary for development and verification of the best estimate codes.

This work is generalization of the well-known Zuber-Findley and Hancox-Nicoll methods for two-phase flow distribution parameters C_S taking into account the non-monotonous void fraction distribution in the transverse direction in terms of two superimposed monotonous profiles. The method is very useful in evaluating the saddle-shape void fraction profile effects. In this work two-phase flow distribution parameters C_S were developed for simple circular and rectangular pipes, and subchannel geometry in a rod bundle. Basic assumptions were power-mode approximations for describing the profiles of local volume flux density, phase velocity and temperature. The general analytical (quadrature) relationships for C_S were obtained and their 3D illustrations are proposed.

Also, we propose generalized formulation and simple approach to construct friction factor, heat and mass transfer coefficients within the gradient hypothesis and boundary layer assumptions. The contribution of momentum, heat and mass transfer as well as their sources and sinks in the channel cross-section are taken into account. In the same way, the friction factor, heat and mass transfer coefficients with the transversal and azimuthal variations being taken into account are proposed for subchannel geometry as well.