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Three Dimensional Computational Fluid Dynamics Simulation of Wall Condensation inside Inclined Tubes

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Abstract : The current PhD project comprises CFD-modeling and simulation of condensation and heat transfer inside horizontal pipes. Condensation plays an important role in emergency cooling systems of reactors. The emergency cooling system consists of inclined horizontal pipes which are immersed in a tank of subcooled water. In the case of an accident the water level in the core is decreasing, steam comes in the emergency pipes, and due to the subcooled water around the pipe, this steam will start to condense. These horizontal pipes act as a strong heat sink which is responsible for a quick depressurization of the reactor core when any accident happens. This project is defined in order to model all these processes which happening in the emergency cooling systems. The most focus of the project is on detection of different morphologies such as annular flow, stratified flow, slug flow and plug flow. This project is an ongoing project which has been started 1 year ago in Helmholtz Zentrum Dresden Rossendorf (HZDR), Fluid Dynamics department. In HZDR most in cooperation with ANSYS different models are developed for modeling multiphase flows. Inhomogeneous MUSIG model considers the bubble size distribution and is used for modeling small-scaled dispersed gas phase. AIAD (Algebraic Interfacial Area Density Model) is developed for detection of the local morphology and corresponding switch between them. The recent model is GENTOP combines both concepts. GENTOP is able to simulate co-existing large-scaled (continuous) and small-scaled (polydispersed) structures. All these models are validated for adiabatic cases without any phase change. Therefore, the start point of the current PhD project is using the available models and trying to integrate phase transition and wall condensing models into them. In order to simplify the idea of condensation inside horizontal tubes, 3 steps have been defined. The first step is the investigation of condensation inside a horizontal tube by considering only direct contact condensation (DCC) and neglect wall condensation. Therefore, the inlet of the pipe is considered to be annular flow. In this step, AIAD model is used in order to detect the interface. The second step is the extension of the model to consider wall condensation as well which is closer to the reality. In this step, the inlet is pure steam, and due to the wall condensation, a liquid film occurs near the wall which leads to annular flow. The last step will be modeling of different morphologies which are occurring inside the tube during the condensation via using GENTOP model. By using GENTOP, the dispersed phase is able to be considered and simulated. Finally, the results of the simulations will be validated by experimental data which will be available also in HZDR.

Keywords : wall condensation, direct contact condensation, AIAD model, morphology detection
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