

Title	Development and Validation of Effective Models for Simulation of Stratification and Mixing Phenomena in a Pool of Water
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Abstract This work pertains to the research program on Containment Thermal-Hydraulics at KTH. The objective is to evaluate and improve performance of methods, which are used to analyze thermal-hydraulics of steam suppression pools in a BWR plant under different abnormal transient and accident conditions. The pressure suppression pool was designed to have the capability as a heat sink to cool and condense steam released from the core vessel and/or main steam line during loss of coolant accident (LOCA) or opening of safety relief valve in normal operation of BWRs. For the case of small flow rates of steam influx, thermal stratification could develop on the part above the blowdown pipe exit and significantly impede the pool's pressure suppression capacity. Once steam flow rate increases significantly, momentum introduced by the steam injection and/or periodic expansion and collapse of large steam bubbles due to direct contact condensation can destroy stratified layers and lead to mixing of the pool water. We use CFD-like model of the general purpose thermal-hydraulic code GOTHIC for addressing the issues of stratification and mixing in the pool. In the previous works we have demonstrated that accurate and computationally efficient prediction of the pool thermal-hydraulics in the scenarios with transition between thermal stratification and mixing, presents a computational challenge. The reason is that direct contact condensation phenomena, which drive oscillatory motion of the water in the blowdown pipes, are difficult to simulate with original GOTHIC models because of appearance of artificial oscillations due to numerical disturbances. To resolve this problem we propose to model the effect of steam injection on the mixing and stratification with the Effective Heat Source (EHS) model and the Effective Momentum Source (EMS) model. We use POOLEX/PPOOLEX experiment (Lappeenranta University of Technology in Finland), in order to (a) quantify errors due to GOTHIC's physical models and numerical schemes, (b) propose necessary improvements in GOTHIC sub-grid scale modeling, and (c) to validate proposed models. Results obtained with the EHS model shows that GOTHIC can predict development of thermal stratification in the pool if adequate grid resolution is provided. An equation for the effective momentum is proposed based on feasibility studies of the EMS model and analysis of the measured data in the test with chugging regime of steam injection. An experiment with higher resolution in space and time of oscillatory flow inside the blowdown pipe is highly desirable to uniquely determine model coefficients. Implementation of EHS/EMS model in GOTHIC and their validation against new PPOOLEX experiment is underway.

Key words BWR pressure suppression pool, thermal stratification, mixing, effective models, GOTHIC