NTech Lehrstuhl für Nukleartechnik

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Implementing Different Boiling Models in the Development of FLUBOX–3D Code.

INTRODUCTION

FLUBOX-3D is a computational fluid dynamics simulation tool for the accurate description of two-phase-flow conditions inside the reactor pressure vessel.
It simulates multi-dimensional two- phase-flow of water and steam on basis of a two-fluid-model.

The subject of the present work is the implementation of multidimensional modeling of vertical upward subcooled boiling flow in FLUBOX-3D code using a two fluid approach and calculation of two phase flow void fraction.

SUBCOOLED BOILING MODELS

The subcooled boiling is considered as a **combination of evaporation near wall and condensation in the bulk**, see Fig. 1

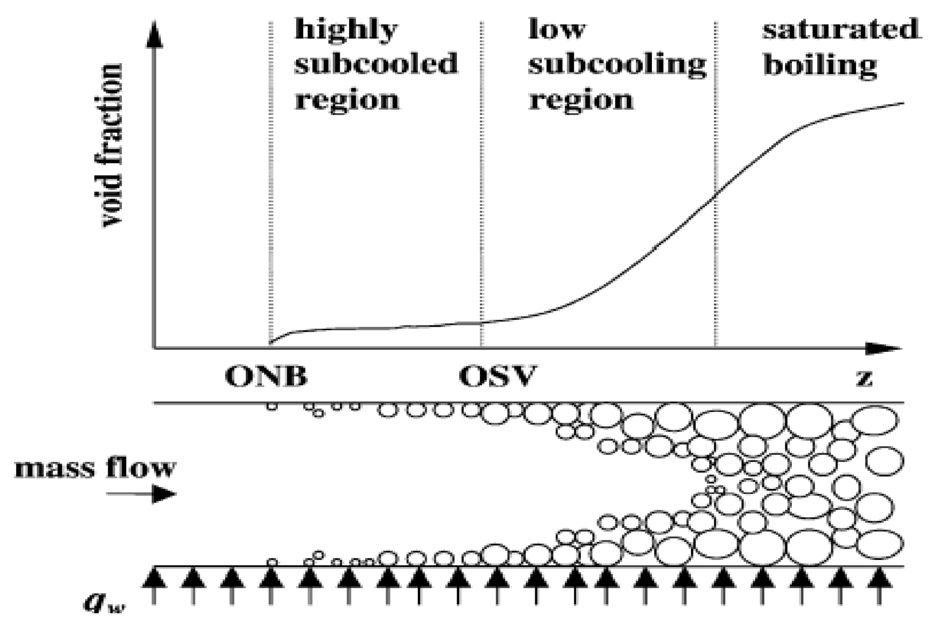

Figure 1 schematic description of the axial void fraction profile in the subcooled **boiling** regions for upward vertical flow

A set of two models for wall evaporation and another set of condensation models in the bulk were adopted to be implemented in the FLUBOX code

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- Evaporation Models
  - **lahey mechanistic** model
  - **Kurul and Podowski** model
- Condensation Models
  - **Ranz_Marshall** Nusselt number,
  - **Hughmark** correlation.
  - The modified **Unal–Lahey** correlation.

So for simplicity and to easily understand the figures of work validation, the models are divided in three main models, as follow:

- **Model 1**: Hughmark for condensation, and Kurul-Podowski for evaporation.
- **Model 2**: Unal-Lahey for condensation, and lahey mechanistic for evaporation.
- **Model 3**: Ranz-Marshal for condensation, and lahey mechanistic for evaporation.

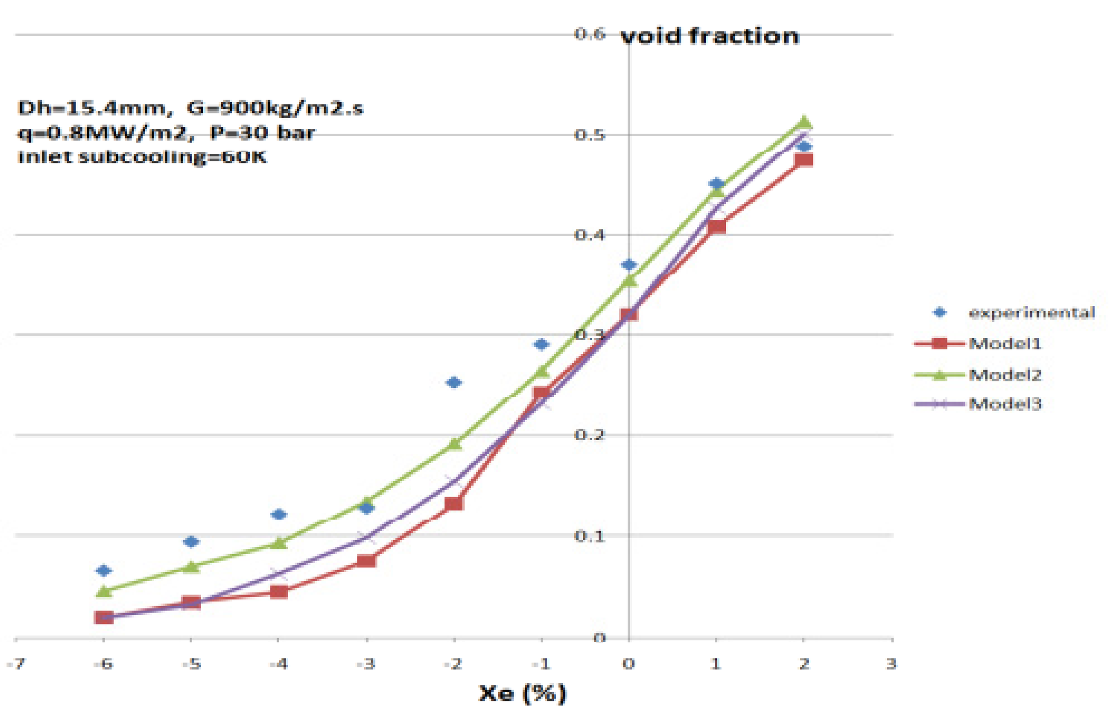

Figure 2 Thermodynamic quality versus void fraction**. P=30 bar**, **q=0.8MW/m²**, Dh = 15.4mm

VALIDATION OF THE MODELS

Bartolomej Experiment:
The Bartolomej experiment was performed in 2m long heated tube with an inner diameter of 15.4mm, a water pressure of 30 and 45 bar, heat flux (0.38; 0,8) MW/m² and mass flow velocity 900 Kg/m²s. The inlet temperature subcooling condition varied between 20 ˚C and 160 ˚C.

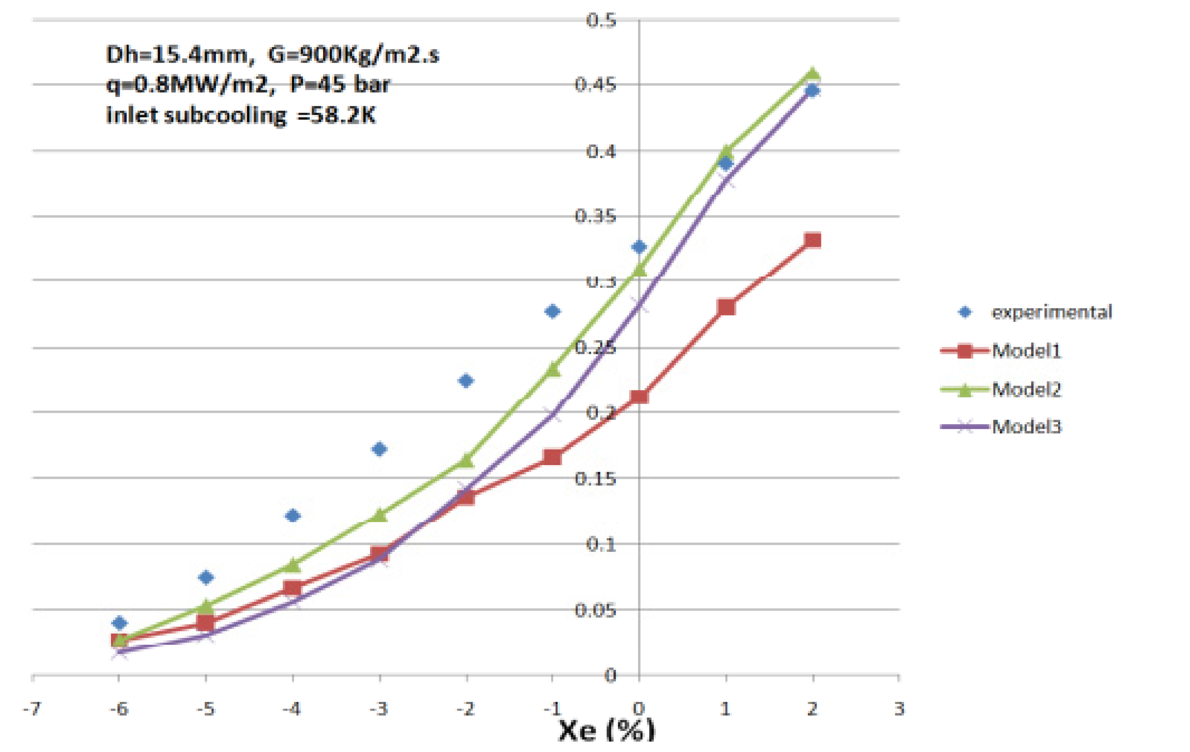

Figure 3 Thermodynamic quality versus void fraction. **P=45 bar, q=0.8MW/m²**, Dh = 15.4 mm

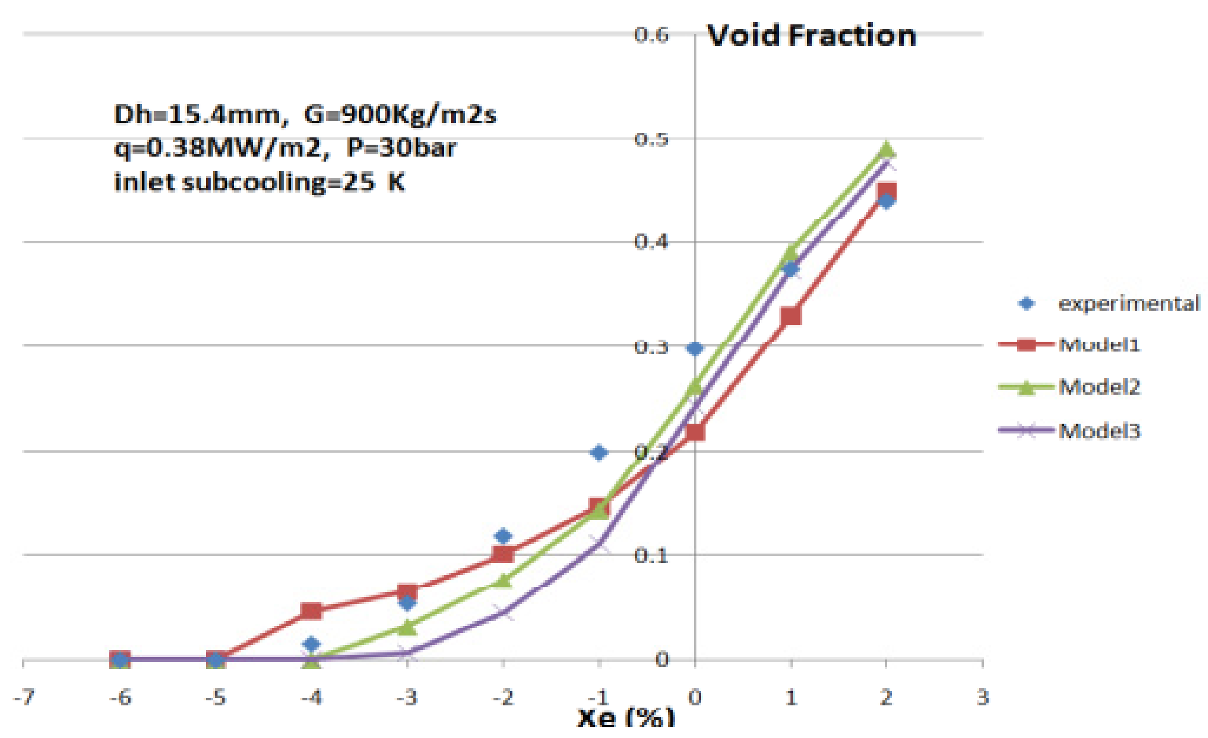

Figure 4 Thermodynamic quality versus void fraction**. P=30 bar**, **q=0.38MW/m²**, Dh = 15.4 mm

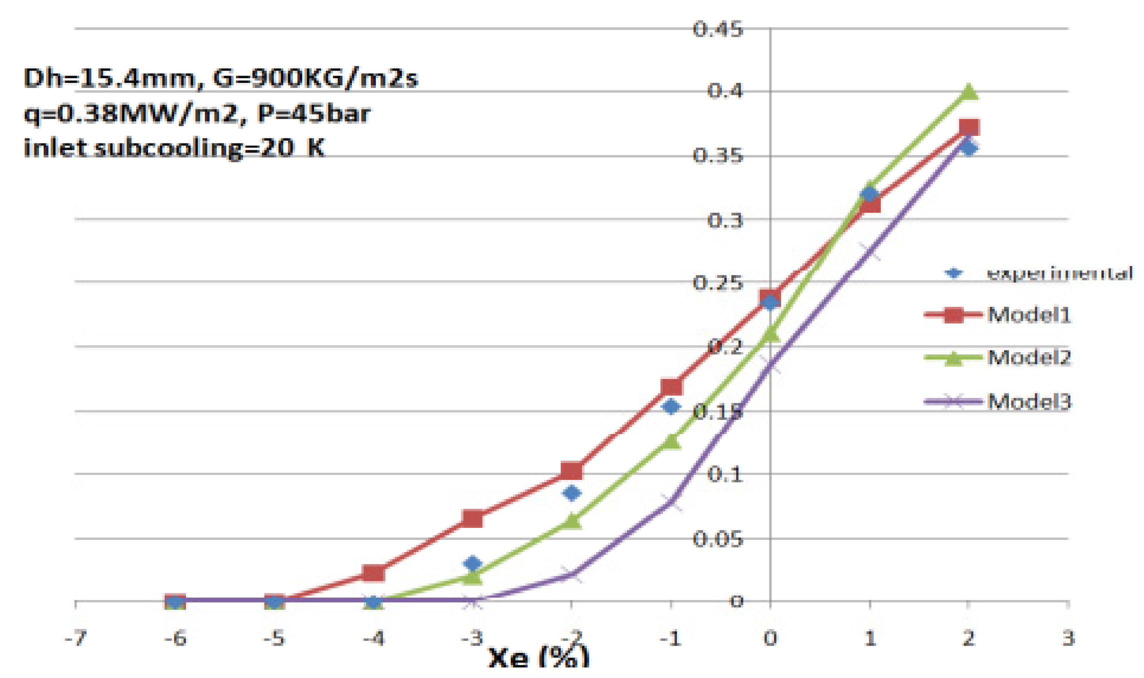

Figure 5 Thermodynamic quality versus void fraction**. P=45 bar**, **q=0.38MW/m²**, Dh = 15.4 mm

CONCLUSION

The results of the simulation indicate that the implemented **Model 2** which is a combination of modified **Unal-Lahey** model for condensation and **Lahey mechanistic** model for evaporation resulted in better void fraction prediction.

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