PROCESSNET
EINE INITIATIVE VON DECHEMA UND VDI-GVC

Jahrestreffen der ProcessNet-Fachausschüsse Computational Fluid Dynamics und Wärme- und Stoffübertragung

8. - 10. März 2010

Kurzfassungen

www.processnet.org/cfd_wsue

Prediction of polydisperse steam bubble condensation in sub-cooled water using the inhomogeneous MUSIG model

C. Lifante, T. Frank, A.D. Burns, ANSYS Germany Gmbh, Otterfing (Germany);
D. Lucas, E. Krepper, Institute of Safety Research, Forschungszentrum Dresden-Rossendorf (Germany),

The aim of this paper is to present the validation of a new methodology implemented in ANSYS CFX (ANSYS Inc., 2009), that extends the standard capabilities of the inhomogenous Multiple-size group model (MUSIG) by additionally accounting for bubble size changes due to heat and mass transfer. Bubble condensation plays an important role in sub-cooled boiling or steam injection into pools among many other applications. Since the mass transfer rate between phases is proportional to the interfacial area density, a polydisperse modeling approach considering different bubble sizes is of main importance. Therefore, an accurate prediction of the bubble diameter distribution is required.

The standard MUSIG approach is an inhomogeneous one, which combines the size classes into different velocity groups to precisely capture the different behavior of the bubbles depending on their size. In the framework of a collaboration between ANSYS and the FZ Dresden-Rossendorf (FZD) an extension of the MUSIG model was developed, which allows to take mass transfer due to evaporation and condensation into account in addition to breakup and coalescence effects.

After the successful model verification, the next step was the validation of the new developed model against experimental data. For this purpose a testcase was chosen, which was investigated in detail at the TOPFLOW test facility at FZD. It consists of a steam bubble condensation case in sub-cooled water at a large diameter (DN200) vertical pipe. Sub-cooled water flows into the 195.3 mm wide and 8 m height pipe, were steam is injected at z=0.0m and is recondensing. The experimental results are published in (Lucas & Prasser, 2006). Using a wire-mesh sensor technique the main characteristics of the two-phase flow were measured, i.e. radial steam volume fraction distribution and bubble diameter distribution at different heights and measurement cross-sections. The main physical parameters of the testcase are: 2 MPa pressure at the end of the pipe, an inlet superficial velocity of 1 m/s for the water and 0.54 m/s for the steam and 3.9 K of water sub-cooling. Due to the high amount of injected steam of up to local volume fraction of about 30% this case represents a challenge for a CFD computation.

ANSYS CFX 12.0 was used for the numerical prediction. A 60 degrees pipe sector was modeled in order to save computational time, discretized into a mesh containing 260.000 elements refined towards the pipe wall and towards the location of the steam injection nozzles. Interfacial forces due to drag, lift, turbulent dispersion and wall lubrication force were considered.

The numerical results were compared to the experimental data. The agreement is highly satisfactory, proving the capability of the new MUSIG model extension to accurately predict such complex two-phase flow, as it can be seen in the Figures [1, 2].

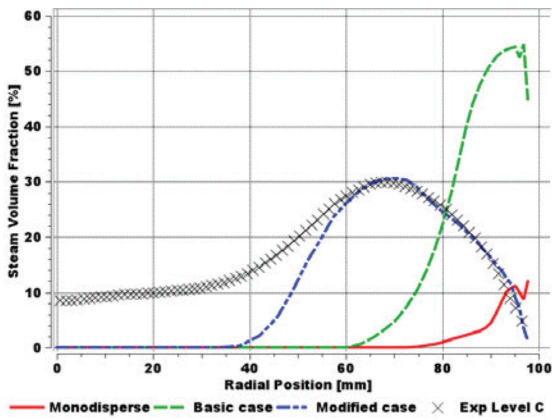

Fig. 1: Radial Steam Volume Fraction Distribution at Level C

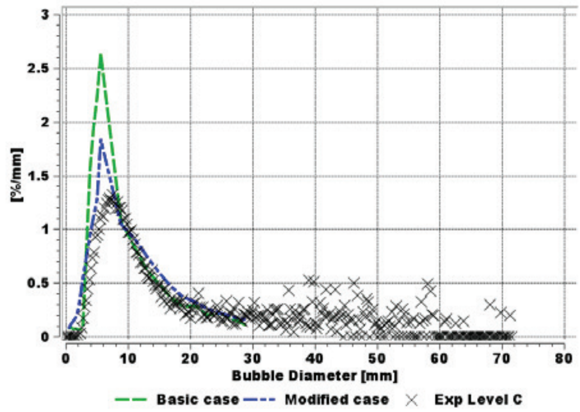

Fig. 2: Bubble Size Distribution (dr_α/dD_B)at Level C

References

ANSYS Inc., ANSYS CFX 12: Users Manual, 2009

Lucas D. and Prasser H-M., Steam bubble condensation in sub-cooled water in case of co-current vertical pipe flow, Nuclear Engineering and Design, Vol. 237, Issue 5, pp. 497-508, 2007