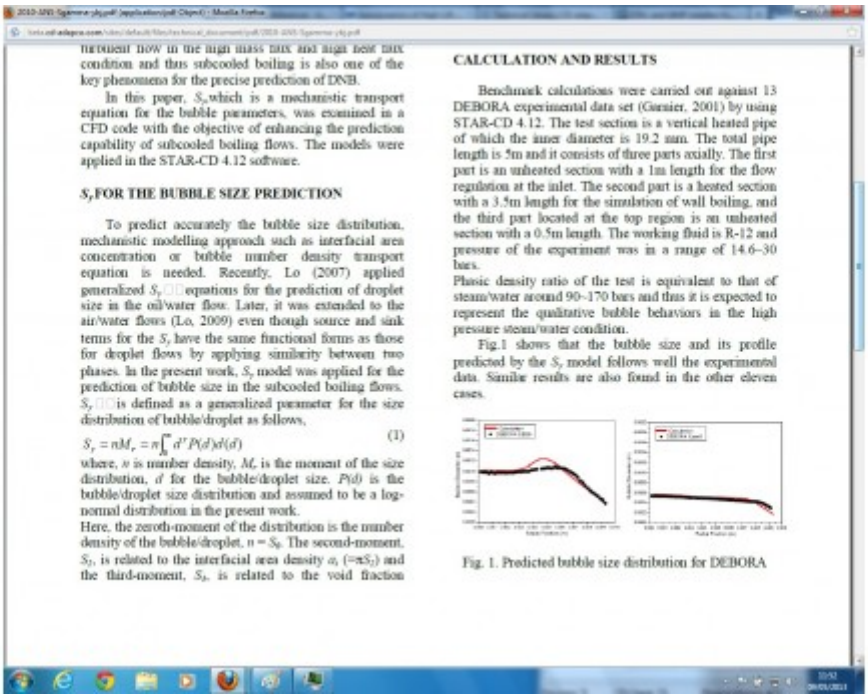
# Application of Sgamma Model with CFD Code to Predict Subcooled Boiling Flow



fluent flow in the high mass flux and high heat flux condition and thus subcooled boiling is also one of the key phenomena for the precise prediction of DNB.

In this paper, $S_\gamma$ which is a mechanistic transport equation for the bubble parameters, was examined in a CFD code with the objective of enhancing the prediction capability of subcooled boiling flows. The models were applied in the STAR-CD 4.12 software.

**$S_\gamma$ FOR THE BUBBLE SIZE PREDICTION**

To predict accurately the bubble size distribution, mechanistic modelling approach such as interfacial area concentration or bubble number density transport equation is needed. Recently, Lo (2007) applied generalized $S_\gamma$ equations for the prediction of droplet size in the oil/water flow. Later, it was extended to the air/water flows (Lo, 2009) even though source and sink terms for the $S_\gamma$ have the same functional forms as those for droplet flows by applying similarity between two phases. In the present work, $S_\gamma$ model was applied for the prediction of bubble size in the subcooled boiling flows. $S_\gamma$ is defined as a generalized parameter for the size distribution of bubble/droplet as follows,

$$S_\gamma = nM_\gamma = n\int_0^\infty d^\gamma P(d)n(d) \quad (1)$$

where, $n$ is number density, $M_\gamma$ is the moment of the size distribution, $d$ for the bubble/droplet size. $P(d)$ is the bubble/droplet size distribution and assumed to be a log-normal distribution in the present work.

Here, the zeroth-moment of the distribution is the number density of the bubble/droplet, $n = S_0$. The second-moment, $S_2$, is related to the interfacial area density $a_i$ ($=\pi S_2$) and the third-moment, $S_3$, is related to the void fraction

**CALCULATION AND RESULTS**

Benchmark calculations were carried out against 13 DEBORA experimental data set (Garnier, 2001) by using STAR-CD 4.12. The test section is a vertical heated pipe of which the inner diameter is 19.2 mm. The total pipe length is 5m and it consists of three parts axially. The first part is an unheated section with a 1m length for the flow regulation at the inlet. The second part is a heated section with a 3.5m length for the simulation of wall boiling, and the third part located at the top region is an unheated section with a 0.5m length. The working fluid is R-12 and pressure of the experiment was in a range of 14.6–30 bars.

Phasic density ratio of the test is equivalent to that of steam/water around 90~170 bars and thus it is expected to represent the qualitative bubble behaviors in the high pressure steam/water condition.

Fig.1 shows that the bubble size and its profile predicted by the $S_\gamma$ model follows well the experimental data. Similar results are also found in the other eleven cases.

Fig. 1. Predicted bubble size distribution for DEBORA

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**Abstract:**

Accurate simulation of subcooled boiling flow is essential for the operation and safety of nuclear power plants (NPP). In recent years, the use of computational fluid dynamics (CFD) codes has been extended to the analysis of multi-dimensional two-phase flow for the NPP. Among the applications of CFD code for the NPP analysis, the first target was selected as a mechanistic prediction of DNB (Departure from Nucleate Boiling) in PWR (Bestion et al, 2006). In DNB-type CHF (Critical Heat Flux), the expected flow regime is bubbly or churn turbulent flow in the high mass flux and high heat flux
condition and thus subcooled boiling is also one of the key phenomena for the precise prediction of DNB.In this paper, S?,which is a mechanistic transport equation for the bubble parameters, was examined in a CFD code with the objective of enhancing the prediction capability of subcooled boiling flows. The models were applied in the STAR-CD 4.12 software.

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