§37. Fundamental Study on Thermofluid Characteristics of Liquid Wall in Laser Fusion Reactor

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To protect from high energy/particle fluxes caused by nuclear fusion reaction to a first wall of a laser-fusion reactor such as the "KOYO" reactor [1], a "cascade type" falling liquid film flow is proposed as a "liquid wall" concept which is one of the reactor chamber cooling and wall protection schemes. In this "cascade-type liquid wall" concept, the first wall of the chamber consists of the saw-shaped wall modules in order to prevent the concentration of the evaporation steam from the liquid surface to the reactor core center.

In the previous study [2, 3], the proof-of-principle experiments and the numerical simulations were conducted to investigate the behavior of the droplets and liquid film on the ceiling wall regarding the wettability effects of the wall surface. It was understood that if the liquid film is formed on the wall surface, the liquid never falls away from the ceiling wall of the reactor chamber as long as the vapor is supplied. In addition, the measurements of the liquid-film thickness formed on the inclined wall surface were taken by using the confocal laser scanning microscopy. Since all the previous experiments done by authors were used water as a working fluid, it is necessary whether the condensation behavior of the liquid metal (PbLi) is similar to the water as a simulant coolant or not. Therefore, the fundamental study on thermofluid characteristics of liquid lead-lithium will have to focus on.

In order to compare the evaporation/condensation characteristics between PbLi and water, the numerical procedure to calculate these behaviors will be developed, and the fundamental thermofluid properties of PbLi regarding the gas-absorption/desorption will be measured and also be considered its mechanism in this study.

At first, it focuses on the clarification of the heat transfer characteristics of the subcooled pool boiling, the discussion on its mechanism, and the establishment of a boiling and condensation model for direct numerical simulation on the subcooled pool boiling phenomena. In this paper, three dimensional numerical simulations based on the MARS (Multi-interface Advection and Reconstruction Solver) [4] with a boiling and condensation model which consisted of the improved phase-change model and the relaxation time based on the quasi-thermal equilibrium state have been conducted for the bubble growth process in the subcooled pool boiling. The numerical results regarding the bubble growth process of the subcooled pool boiling show in good agreement with the experimental observation results and the existing analytical equations among Rayleigh [5], Plesset et al [6] and Mikic et al [7] as shown in Fig. 1. It was found that the improved boiling and condensation model with the relaxation time consideration can predict the bubble growth process of the subcooled pool boiling phenomena.

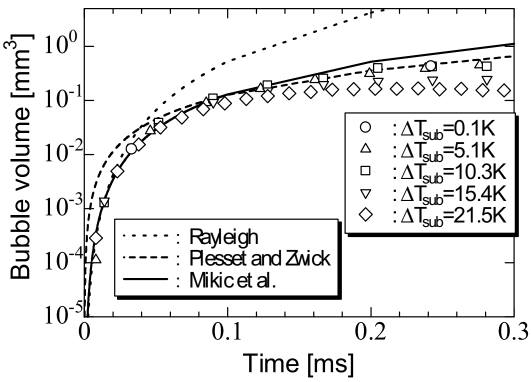

Fig. 1 Comparison between three theoretical correlations and experiment for various degree of subcooling

The bubble departure process is also important for this study. Figure2 shows the comparison between the experiment and numerical simulation for the bubble departure process in case of the degree of subcooling 10.3K. The numerical simulation is successfully simulated the bubble departure process. This also shows the present phase-change model is appropriate one.

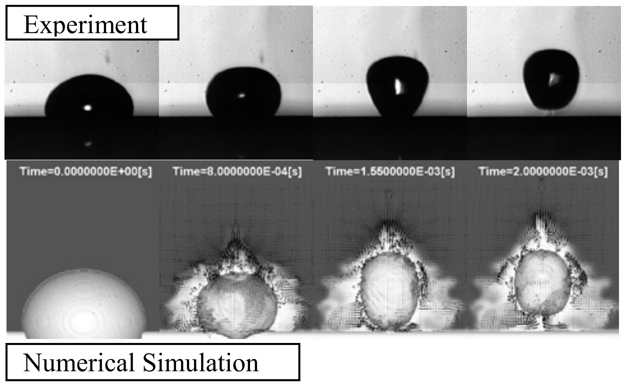

Fig. 2 Comparison of bubble departing behavior between experiment and numerical simulation in case of the degree of subcooling 10.3 K

Another objective of this study is to grasp the characteristics of suction and release of the environmental gases from/to the PbLi at various temperature conditions. In this year, the experimental apparatus was built and has been preconditioning. He, Ar and Xe gases will be tested in this experiment because the radius of these gas molecules is largely different. It will be expected the effect of the size of gas molecules can be observed.

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