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Film Boiling Heat Transfer on an Oscillating Surface

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1. Introduction

Film boiling occurs when the wall temperature is so high that the vapor layer exists between the heating wall and the liquid. Various works have been made to investigate the film boiling heat transfer [1-6]. However, they are limited to the stationary heating wall.

Recently, a marine reactor receives a great attention [7]. Figure 1 shows a ship equipped with a nuclear reactor. The ship may show six-degree-of freedom motions in response to external conditions such as ocean waves. Of six motions, the heaving linear oscillation and the rolling rotational oscillation are relatively important in terms of length scale.

The objective of this study is to investigate the effect of the wall oscillation on the heat transfer. Toward this end, we performed volume-of-fluid simulations.

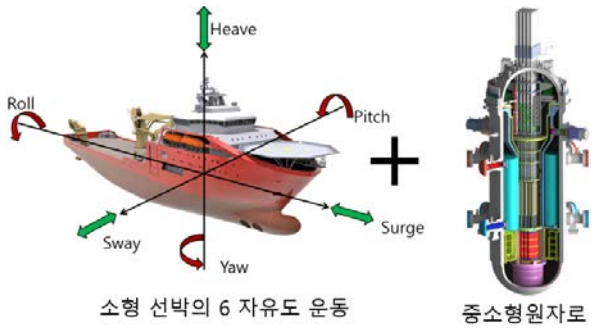

Fig. 1. A ship equipped with a nuclear reactor

2. Numerical method

Figure 2 shows two-dimensional film boiling on an oscillating plate. The heating plate may oscillate linearly or rotationally.

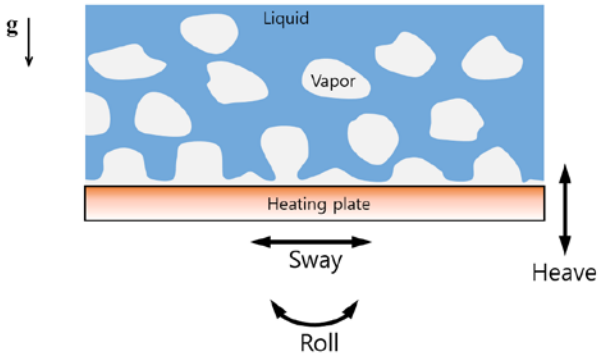

Fig. 2. Film boiling on an oscillating plate

There are two choices in the simulation approaches. The first approach is to adopt the moving grid system for the heating surface in the absolute coordinate. The second approach is to perform simulation in the moving coordinate. The latter approach is preferred owing to simplicity.

The momentum equation in the moving coordinate is given as follows:

$$\begin{aligned}&\frac{\partial}{\partial t}(\rho\mathbf{u})+\nabla\cdot(\rho\mathbf{uu})\\&=-\nabla p+\nabla\cdot[\mu(\nabla\mathbf{u}+(\nabla\mathbf{u})^T]+\rho\mathbf{g}+\sigma\kappa\mathbf{n}\delta_s\\&-\rho\ddot{\mathbf{R}}-\rho\dot{\boldsymbol{\Omega}}\times\mathbf{r}-2\rho\boldsymbol{\Omega}\times\mathbf{u}-\rho\boldsymbol{\Omega}\times(\boldsymbol{\Omega}\times\mathbf{r})\end{aligned}\qquad(1)$$

where $\ddot{\mathbf{R}}$ is the linear acceleration of the heating wall when viewed from the absolute coordinate, $\boldsymbol{\Omega}$ is the rotation vector of the moving coordinate, $\mathbf{r}$ is the position vector in the moving coordinate. The term $\sigma\kappa\mathbf{n}\delta_s$ accounts for the surface tension force, which appears only in the gas-liquid interface region.

ANSYS FLUENT was used to perform numerical simulation in the moving coordinate. To do this, the last four terms in Eq. (1) were implemented into the software through user-defined function (UDF).

For the first step, we considered the linear oscillation the heating wall. The simulation is underway.

3. Summary

This study seems the first in the film boiling on a moving surface. The effect of the oscillation on the film boiling heat transfer will be investigated numerically. The result will be presented in the conference.

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REFERENCES

1.Tomar, G., et al., *Numerical simulation of bubble growth in film boiling using a coupled level-set and volume-of-fluid method.* Physics of Fluids, 2005. **17**(11): p. 112103.

2. Tomar, G., et al., *Multimode analysis of bubble growth in saturated film boiling.* Physics of Fluids, 2008. **20**(9): p. 092101.
3. Berenson, P.J., *Film-Boiling Heat Transfer From a Horizontal Surface.* Journal of Heat Transfer, 1961. **83**(3): p. 351-356.
4. Banerjee, D. and V.K. Dhir, *Study of Subcooled Film Boiling on a Horizontal Disc: Part 1 - Analysis.* Journal of Heat Transfer, 2000. **123**(2): p. 271-284.
5. Son, G. and V.K. Dhir, *Numerical Simulation of Saturated Film Boiling on a Horizontal Surface.* Journal of Heat Transfer, 1997. **119**(3): p. 525-533.
6. Esmaeeli, A. and G. Tryggvason, *Computations of film boiling: Part 2 multi-mode film boiling.* International Journal of Heat and Mass Transfer, 2004. **47**(25): p. 5463-5476.
7. 해양-원자력 공동위원회, "해양원자력시스템 사업화 방안: 비즈니스 모델을 중심으로", 2015.