§32. Investigation of Cascade-typed Falling Liquid Film Flow along First Wall of 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], the authors concluded that the cascade type falling liquid film was able to be realized based on the flow visualization experiment and the numerical calculation by using the commercial code (STREAM: unsteady three-dimensional general purpose thermofluid code).

In this study, proof-of-principal experiments and numerical calculations were conducted for the liquid film formation on the saw-shaped wall structure. Both flow visualization experiments and numerical simulations were conducted in order to examine whether a liquid film can cover the corner part of the triangle shaped coolant channel of the first wall. Figure 1 shows the liquid film flows at 30° and 90° corners by the flow visualization experiments. Figure 2 shows the surface contour of volume of fluid at each corner in the numerical simulations.

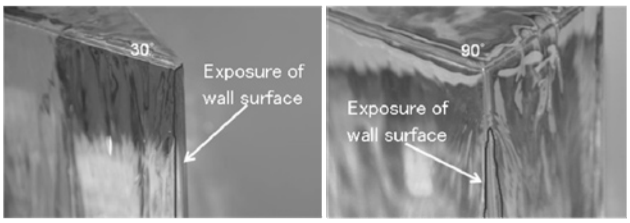

Fig. 1 Liquid film flow at 30° and 90° corners

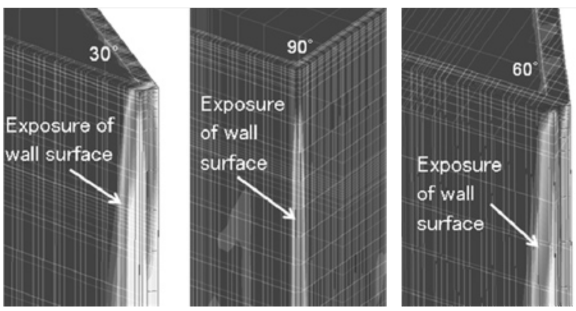

Fig. 2 Free surface contours of volume of fluid

From the flow visualization for the liquid film formation along the triangle channel wall, the qualitatively information were obtained. The liquid film on the sharp edge corner becomes thinner in the downward flow. The thin liquid film is easy to break by the surface tension, and the film break will cause the dry-out of the solid wall as shown in Fig. 1. According to the experiments, the liquid film could not cover along three sharp-corner walls due to the wall-wettability and the maldistribution of the liquid film flow. These tendencies were also confirmed by the numerical simulations as shown in Fig. 2.

In order to solve the maldistribution of the film flow along the walls, very thin convex structures were attached on the wall surface. Owing to this modification of the wall surface, it was found that the liquid film could flow from the center part of the wall to the corners as shown in Fig 3. Moreover, the numerical simulations regarding these experiments were conducted and the induction of the flow caused by the wall modification was also confirmed by the numerical simulations as shown in Fig. 4.

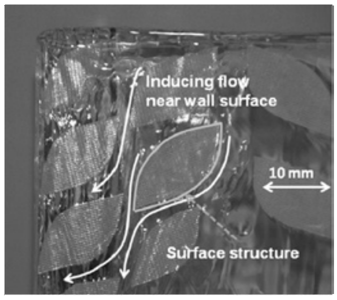

Fig. 3 Liquid film flow on the modified surface

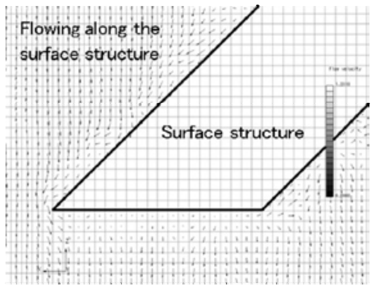

Fig. 4 Velocity vectors near wall surface

In the present study, the flow visualization experiments and the numerical simulations regarding the triangle shaped liquid-wall concept for the laser-fusion reactor were conducted for the availability on the saw-shaped liquid wall. It is found that the liquid film could not flow along three sharp-corner walls of the triangle channel and the wall surface modification would be useful for the improvement of the flow maldistribution for the triangle shaped first-wall concept.

1) Kozaki, Y., et al.: Proc. 7th Int. Conf. on Emerging Nuclear Energy Systems (1993) 76
2) Kunugi, T. et al.: Fus. Eng. & Design **83** (2008) 1888