§30. 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. The cascade-type First-wall for one step (30 cm height corresponding to 4 Hz laser duration) consists of a liquid tank having a free-surface for keeping the constant water-head located at the backside of the first wall, and connects to a slit which is composed of two plates: one plate is the first wall, and the other is maintaining the liquid level.

In the previous study [2], the authors concluded that the cascade type falling liquid film was able to be confirmed by the flow visualization experiment and the numerical calculation by using the commercial code (STREAM: unsteady three-dimensional general purpose thermofluid code).

In this study, precise measurements of the liquid film thickness formed to a liquid wall were conducted by using a confocal laser scanning microscopy (Keyence Ltd. LT8100). As a result, precise quantitative data of the liquid film thickness formed on the cascade-type liquid wall were obtained as shown in Fig. 1. Figure 1 shows the relationship between the liquid film thickness and the flow rate measured at 60 mm downstream from the top of the wall and the center on the width of the wall. The liquid film thickness is around 0.5-1.2 mm in this experiment, and it can be seen that the liquid thickness increases with increase of the flow rate linearly.

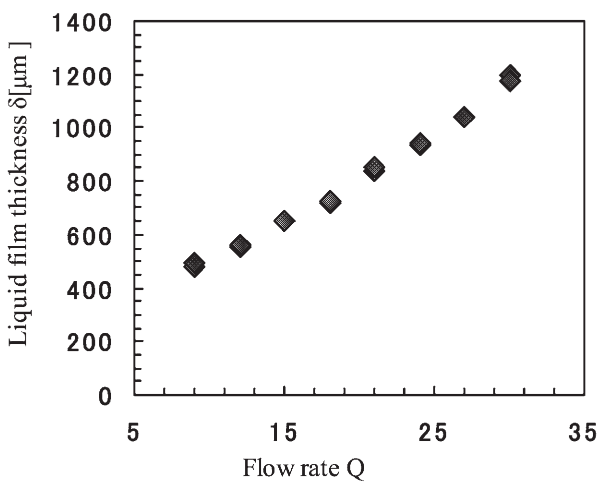

Fig. 1 Relation between liquid film thickness and flow rate

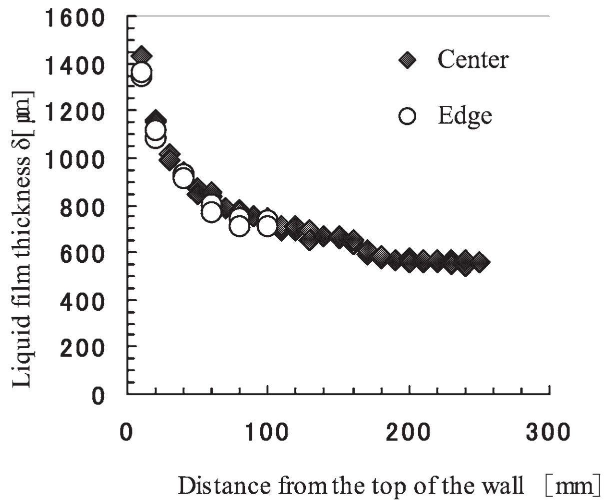

Fig. 2 Liquid film thickness distribution along the wall

Figure 2 shows an example of the liquid film thickness distribution along the wall every 10 mm downward from the top of the wall in case of the flow rate of 21 l/min. The solid diamond shows the film thickness at the center and the open circle shows it 50mm laterally away from the center. It is found that the liquid film reaches an equilibrium thickness after around 200mm: it means that the flow velocity is close to a constant. Moreover, it can be seen that the liquid film is almost uniform for whole flow region on the wall. These data would be useful to evaluate the heat transfer rate from the liquid film.

Next, flow visualization experiments and numerical calculations were conducted in order to examine whether a liquid film through the triangle shaped coolant channel of the first wall can cover the corner part of it. According to the flow visualization for the liquid film formation along the triangle channel wall, the qualitatively information were obtained: the liquid film could not flow along three sharp-corner walls of the triangle channel due to the wettability and the maldistribution of the liquid film flow. In order to solve the maldistribution of the film flow along the walls, convex ribs 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. Moreover, the numerical simulations regarding these experiments were also conducted. Both results were qualitatively agreed.

In the present study, the high precision liquid film measurement, the flow-visualization and the numerical simulation regarding the triangle shaped liquid-wall concept for the laser-fusion reactor were conducted. It is found that the stable liquid-film flow with 0.5-1.2mm thickness was formed, 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