§3. Improvement of a Gas Cooling Structure in a Forced Gas-Cooled Brewster Window

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High power over 1MW and CW (Continuous Waves) millimeter wave injection is required for electron cyclotron heating in LHD. One of the critical issues is to realize a vacuum barrier window. We have been developing a forced gas-cooled Brewster window for this purpose.

High power transmission test was successfully conducted and performed through the assembled Brewster window. With edge water-cooling and forced gas cooling, a temperature increase of about 60 degrees was observed during 58kW, 30sec. transmission.

In order to improve cooling efficiency of a gas-cooling structure, we manufactured a new manifold with 21 holes (diameter is 1mmϕ) for gas jet nozzles. Figure 1 shows a schematic drawing of the brewster window with the new manifold. Dry air is forced to flow from one side of the window along a shorter axis. A photograph of the window is also shown in Fig.1. The racetrack disk is a low loss silicon nitride composite (SN-287), of which size is $120 \times 320 mm^2$ and thickness is 2.53mm. The holes are distributed to maximize a flow speed around the disk center where heat generation due to wave absorption has a maximum.

First of all, the flow speed was measured and compared with the 9-hole manifold used in the high power millimeter wave transmission test. More holes and their concentration around the center make gas flow more uniform and increase gas flow speed, although total gas volume supplied naturally increases. The flow speed at the center of the disk reaches 1.6 times of the speed obtained with the 9-hole manifold.

The simulation experiments were performed by using an electrically heated film resistor as a heat source instead of millimeter wave power. This resister was mounted to attach the other side of the disk surface. Figure 2 shows temperature profiles along the shorter axis for both 9-hole and 21-hole manifold. More holes suppress a temperature increase over whole disk surface. Near the nozzles temperature rise is the lowest for the 21-hole manifold. Improvement of a film coefficient of gas-cooling is also noticed. It reaches 1.2 times higher values compared with 9-hole's one.

Reference

M. Shirasaka, MC thesis of Kanazawa Institute of Technology, 2001.

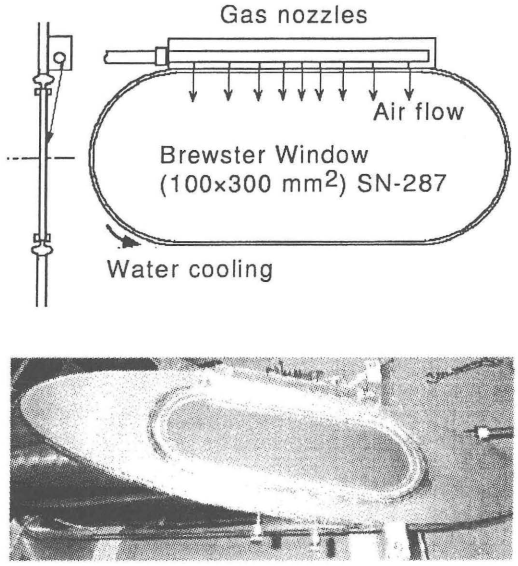

Fig. 1: A schematic drawing of the Brewster window with a gas cooling manifold. The photograph is an assembled Brewster window with a low loss silicon nitride composite. The effective window area is $100 \times 300 mm^2$

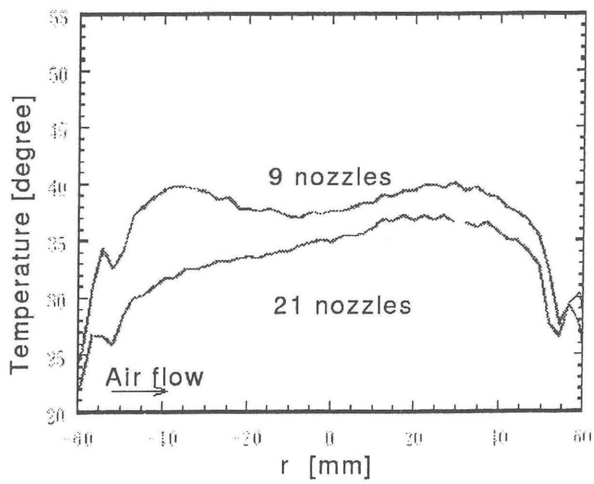

Fig. 2: Temperature profiles along a shorter axis are compared for both 9-hole and 21-hole manifold. More holes make the flow more uniform. Higher flow rate suppresses a increase of the window temperature.