§11. Studies on Cooling Performance of Gas-Cooled Elliptical Vacuum Windows for High Power Millimeter Waves

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To realize high power (~1MW), CW ECH system, development of vacuum window is one of the key technical issues. We have developed a forced gas-cooled, circular (diameter~90mm) single-disk window system and succeeded in a continuous operation of 84GHz, 130kW millimeter wave [1]. The heat transfer coefficient has reached to 0.1 kW/cm^2°C which is about 1/3 of the coefficient obtained with the liquid (FC-75) cooled double-disk window system. From this result, we can predict that the target of ~1MW and CW operation might be achieved by applying this method to an elongated elliptical window (120mm X 320mm) which is integrated to the circular wave guide (inner diameter, 90mm) at the Brewster angle (~70°).

In case of the elliptical window, cooling gas might be ejected in parallel along with the minor axis. So, we have studied cooling performance in such a situation using a rectangular window assembly in which two alumina (A479) disks (1.6mm thick each, 120mm X 240mm) are folded and held by the rectangular frame. Between these disks, a film resistor (0.12 mm thick, 110mm wide) is sandwiched and heated by DC currents of I=0~120A (dummy heat source). The cooling gas (dry nitrogen at a pressure of several kg/cm^2) is ejected through the nozzles distributed with equal distances of 20mm along the straight manifold. In the last year, we investigated how temperature distribution on the disk surface was affected by the distances between the gas nozzles. This year, we have examined the cooling performance for different nozzle sizes by changing the diameter from 1.0 to 1.3mm.

First, we measured gas flow speed using a hot wire anemometer. Figure 1 shows the flow speed distribution of the gas which is ejected into free space from a nozzle at an initial speed of 83m/s.

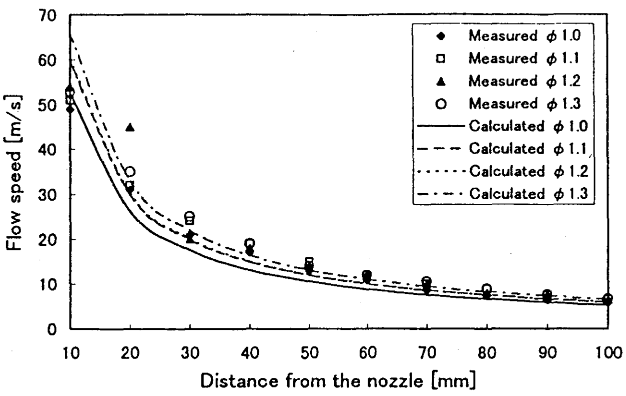

Fig. 1 Gas flow speed as a function of the distance from the nozzle.

The measured gas flow speed agrees well to the calculated one and shows a weak dependence on the nozzle size. Figure 2 shows the heat transfer coefficient at the disk center (derived from temperature decay curve after the turn-off of the heating power) as a function of the gas flow rate (3 nozzles). If the total flow rate is kept constant, the cooling performance is better for thinner nozzles, i.e., for higher gas flow speed. The observed heat transfer coefficient is almost same as one obtained previously in the circular window assembly. Finally, taking the above result into account, we designed a gas-cooled wave guide for the Brewster-type window which will be used for high power transmission test in the next year.

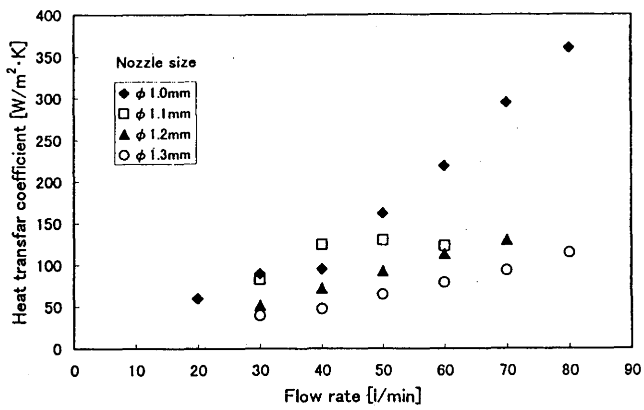

Fig. 2 Heat transfer coefficient as a function of the gas flow rate (3 nozzles).

[1] T.Shimozuma, S.Morimoto, M.Sato, et.al., International J. of Infrared and Millimeter Waves, Vol.18, 1479 (1997).