COMPARISON OF SWIRL TUBE AND HYPERVAPOTRON FOR COOLING OF ITER HIGH HEAT FLUX COMPONENTS*

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The ITER divertor will have a peak steady-state heat flux of 5 MW/m^2 and a heat flux of 15 MW/m^2 for up to 10 s duration. Hypervapotron (HV) and swirl tube (ST) enhancement techniques are under consideration for cooling, in order to achieve a sufficient margin on critical heat flux at a reasonable flow velocity. Comparison of HV and ST is difficult and can be misleading because of many fundamental differences between these two devises, such as: (a) ratio of surface heat flux to coolant channel heat flux: In case of swirl tube this ratio is about 1.5. On the other hand, this ratio is close to 1.0 for HV. (b) Flow area: Flow area per unit heat flux area is different for HV and ST. The area for HV is considerably smaller. (c) Critical Heat Flux (CHF): Not only are the correlations for critical heat flux values for the two concepts different but also the ratio of incident heat flux to wall heat flux different. For the ST the tube thickness is small and we will use the CHF values predicted by the GA-Tong correlation. For HV a new CHF correlation based on experimental data is presented. To compare the two concepts we will compare the incident critical heat fluxes (ICHF). (d) The Pressure Drop: The friction factor correlations for these two devices are different. The friction factor correlation for ST is well known. A new friction factor correlation for HV based on existing data is presented in this paper.

A comparison of the two concepts was performed based on equal heat flux area. The comparison shows that the pumping power required for HV is slightly higher (about 1%) and the ICHF is slightly lower (8%) for HV compared to ST. These differences are small enough and uncertainties in all correlations large enough so that the choice between the two concepts should be based on other considerations such as (1) cost and ease of fabrication, (2) ease of brazing, and (3) volume and reliability of available experimental data.

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