DESIGN, FABRICATION AND TESTING SWIRL ROD INSERT FOR ITER DIVERTOR COOLING*

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The peak heat flux for ITER divertors is expected to be 5 MW/m^2 steady-state during normal operation and more than 15 MW/m^2 for 10 s during start up and other transients. The copper coolant channels have to be above a minimum temperature of 150°C because radiation damage to copper is large below 150°C. The plasma facing materials (PFCs) for ITER are beryllium, tungsten and carbon fiber composites. The PFCs have to be below a specified maximum temperature to avoid melting, ablation and erosion. In order to satisfy these requirements, a heat transfer enhancement technique which will increase the heat transfer coefficient and the critical heat flux is required. In addition to the traditional methods such as swirl tape and the hypervapotron, a new concept, swirl rod insert (SRI), is proposed. SRI consists of two parts: a circular channel and a rod (or tube) with spiral fins. The rod is inserted in the channel and is held from ends. The annular gap forms the flow channel. The spiral fins increase the effective velocity of the flow and mix the flow from top to bottom of the flow channel. The flow mixing mitigates the effects of one sided heating and the circular motion of the flow causes centrifugal acceleration of the flow. Both these effects are expected to increase the heat transfer coefficient and the critical heat flux by at least a factor of two over the smooth channel. The manufacturing of this device is easier than other enhancement methods. Correlations for heat transfer coefficients and critical heat flux for SRI are proposed in this paper. It is expected that the thermal performance of this concept will be comparable to swirl tape. However, fabrication will be cheaper and more reliable. GA has fabricated a 24 cm long module with SRI as part of an internal R&D project. A 1 m long SRI module has been designed for ITER and fabrication is in progress. Analysis shows that a critical heat flux of more than 25 MW/m^2 could be achieved for this module at an inlet temperature of 150°C and an inlet pressure of 4 MPa. The fabrication and testing of this module is planned over the next few months.

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