ASSESSING THE HELIUM COOLING OF RAFM AND ODFS ALLOYS FIRST WALL FOR FNSF-AT AND DEMO

C.P.C. Wong, and A.M Garofalo
General Atomics, San Diego, California, USA
**Presenting Author email: wongc@fusion.gat.com*

Abstract

ITER is under construction and is scheduled to operate in 2020. This is the first 500 MW-class DT device and, when the design goal of Q=10 is achieved, it will provide significant information on physics operation and the selection of plasma facing materials as well as the quantification of heat load distributions around the chamber wall and divertor. For the nuclear components testing device like FNSF-AT, the US reference reduced activation ferritic martensitic (RAFM) alloy structural material is F82H, which has a temperature window of 350 to 550° C. At a helium pressure of 8 MPa, it has a first wall heat flux limit of ~0.7 MW/m^2, which is much lower than what ITER is designing to, with a maximum heat flux of the chamber wall of up to 5 MW/m^2. Therefore, it is critically important to learn from ITER and operating advanced tokamaks on how the peak chamber wall surface heat flux can be reduced and to determine how helium-coolant can be used to handle surface heat flux of higher than 0.7 MW/m^2. For the helium cooling capacity assessment, a first wall cooling unit channel of 1 m in toroidal length is used for the analysis. Results showed that higher heat flux removal capability could be achieved with higher helium-pressure of up to 20 MPa. Heat flux removal capability of 1.0 MW/m^2 can be projected when RAFM alloy is used. Higher surface heat flux removal capability of up to 1.9 MW/m^2 is possible with the use of structural material like oxide dispersion ferritic steel (ODFS), when the maximum allowable temperature can be extended to 700° C. With the selection of higher coolant pressure the application of closed cycle gas turbine (CCGT) system with inlet coolant temperature as low as 650° C, a gross thermal efficiency of 46% can be realized. The scenario of gradual increase of helium pressure to remove higher surface heat flux with time, and with the change of RAFM alloy to the advanced structural material like ODFS alloy can also match the staged approach of components testing of the FNSF-AT program.