DESIGN, FABRICATION AND TESTING OF HELIUM-COOLED VANADIUM MODULE FOR FUSION APPLICATIONS

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Vanadium alloys are attractive materials for fusion applications due to their low neutron activation and rapid decay of radioactivity with time. Design of high heat flux components with vanadium as the structural material is difficult due to its low thermal conductivity relative to copper and the lack of practical experience with fabrication of vanadium components. Similarly, helium is an attractive coolant for fusion power plants due to its chemical inertness, its transparency to neutrons, and stable heat transfer. However, there is a perceived difficulty that use of helium as a coolant will limit the maximum heat flux on components. Previously, GA has demonstrated that cooling of high heat flux components with helium coolant is feasible. A copper divertor module designed by GA was successfully tested to a heat flux level of 32 MW/m^2 over small area and 10 MW/m^2 over the entire area. As a continued effort to demonstrate practical application of fusion science, GA undertook the present effort to fabricate a vanadium module cooled with helium. Due to lower thermal conductivity of vanadium (6% of the copper), this module will withstand about 3 MW/m2 heat flux over the entire length. The module was fabricated from V-4Cr-4Ti alloy and is 22.8 cm long and 2.21 cm in diameter. The thickness of the vanadium tube is 0.176 cm. The internal flow path has been designed to enhance the heat transfer coefficient to a value of about 20,000 W/m^2-°C at a helium flow rate of 20 g/s. A thermal stress analysis of the design was performed with the finite element code ANSYS to ensure that at a heat flux level of 3 MW/m^2 and a helium pressure of 4 MPa the stresses are within limits. The module is ready to be tested at the helium loop (4 MPa pressure 20 g/s flow) at Sandia National Laboratory, Albuquerque. The test module has been hydrostatically tested to 7 MPa pressure and helium leak checked. The testing is planned for June 1996.