HELIUM-COOLED REFRACTORY ALLOYS FIRST WALL AND BLANKET EVALUATION*

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Under the APEX program the goal for the He-cooled system design task is to evaluate and recommend robust high power density He-cooled first wall and blanket design options and to recommend and initiate tests to address critical issues. We initiated our evaluation by designing for an average neutron wall loading of 8 MW/m^2. At a peaking factor of 1.4, this corresponds to a maximum neutron wall loading of 11.4 MW/m^2, and at maximum radiative power fraction of 100%, this corresponds to a surface heat flux of 2.8 MW/m^2.

To meet these severe design goals, we evaluated the use of refractory alloys like Ta, Mo, W, Nb and V alloys. In FY99, with support from the APEX team, we performed the scoping design evaluation and selected the separately cooled W-alloy first wall and V-alloy, lithium breeder blanket design as the first option. At a helium pressure of 8 MPa and an outlet temperature of 1000°C, when advanced Closed Cycle Gas Turbine power conversion system is used, a gross thermal efficiency of >50% can be reached. Critical issues on the first wall and blanket system include, module and coolant routing configuration, compatibility between potential impurities in the helium coolant and W and V alloys, and the design of the first wall. For the first wall heat transfer design we are evaluating the possible use of swirl tube and porous medium options. With the use of high-pressure helium for high power density components design, the safety related issues of helium leakage, de-pressurization, cooling tube bursting, and module pressurization will be addressed. These concerns are compounded when liquid metal is used as the tritium breeder, which is necessary to remove the maximum neutron wall loading of 11.4 MW/m^2. In coordination with the INEEL safety team we will scope these issues of helium-system reliability and safety.

We will identify critical thermal-hydraulics issues and initiate tests that can be performed by existing experimental facilities. In FY00, we will continue to develop and analyze the selected design(s), with focus on key performance, reliability and safety issues. For the area of thermal hydraulics performance of high heat flux system, 2-D and 3-D modeling of the heat transfer along the flow path in which there are significant temperature and pressure gradients will be done. We will model the impacts from necessary scale up from sample testing to design mock-up and designs. Experiments on enhanced heat transfer will also be recommended.

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