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A HELIUM-COOLED BLANKET DESIGN OF THE LOW ASPECT RATIO REACTOR*

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Abstract

An aggressive low aspect ratio scoping fusion reactor design [1] indicated that a 2 GW(e) reactor can have a major radius as small as 2.9 m resulting in a device with competitive cost of electricity at 49 mill/kWh. One of the technology requirements of this design is a high performance high power density first wall and blanket system. A 15 MPa helium-cooled, V-alloy and stagnant LiPb breeder first wall and blanket design was utilized. Due to the low solubility of tritium in LiPb, there is the concern of tritium migration and the formation of V-hydride. To address these issues, a lithium breeder system with high solubility of tritium has been evaluated. Due to the reduction of blanket energy multiplication to 1.2, to maintain a plant Q of >4, the major radius of the reactor has to be increased to 3.05 m. The inlet helium coolant temperature is raised to 436°C in order to meet the minimum V-alloy temperature limit everywhere in the first wall and blanket system. To enhance the first wall heat transfer, a swirl tape coolant channel design is used. The corresponding increase in friction factor is also taken into consideration. To reduce the coolant system pressure drop, the helium pressure is increased from 15 to 18 MPa. Thermal structural analysis is performed for a simple tube design. With an inside tube diameter of 1 cm and a wall thickness of 1.5 mm, the lithium breeder can remove an average heat flux and neutron wall loading of 2 and 8 MW/m^2, respectively. This reference design can meet all the temperature and material structural design limits, as well as the coolant velocity limits. Maintaining an outlet coolant temperature of 650°C,

one can expect a gross closed cycle gas turbine thermal efficiency of 45%. This study further supports the use of helium coolant for high power density reactor design. When used with the low aspect ratio reactor concept a competitive fusion reactor can be projected at 51.9 mill/kWh.