EVALUATION OF U.S. DEMO-1 HELIUM-COOLED BLANKET OPTIONS*

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As a part of the Starlite Project, the Demo Team has identified the mission and design requirements of the U.S. demonstration power plants. Demo-1, the initial focus of the study, is to satisfy the minimum design requirements and embody the minimum technological extrapolation required to achieve the Demo Mission. Evaluation was performed on Demo-1 18 MPa helium-cooled, vanadium-alloy blanket options. Low activation vanadium-alloy is selected as the structural material because of its higher temperature performance potential over ferritic steel alloy, and its possibility of reaching matured development before the construction and operation of the U.S. Demo by the year 2025. To optimize the helium coolant outlet temperature, a multiple coolant pass approach is used. The coolant at an inlet temperature of 400°C will cool the first wall and then the blanket leading to an outlet temperature of 650°C. To simplify the design of the power conversion system and to minimize potential in-leakage of impurities into the coolant, a closed cycle gas turbine power conversion system is recommended. The first wall, which will have to experience the harsh environment of the plasma vacuum chamber is designed to be mechanically separate from the rest of the blanket, and can be replaced in the hot-cell. With this definition of the blanket configuration, thermal hydraulics and neutronics evaluations were performed on the three breeder options of lithium-oxide, lithium liquid metal and a mixed breeder (20% lithium and 80% lithium-oxide). We find that these options have the possibility of providing adequate tritium breeding without the use of additional neutron multiplier. The options that contain lithium are preferred. They have advantages of high breeder zone effective thermal conductivity, no solid interface gap thermal resistance and no radiation damage of the solid breeder. The better thermal performance leads to thicker breeder radial zones and corresponding reduction on the number of layers of required cooling tubes. Tritium extraction can be achieved by the slow circulation of lithium. The other key advantage of the lithium approach is the control of chemistry between the breeder and vanadium alloy. For the lithium oxide option, a credible protective layer will be required to control the oxidation of vanadium which will cause degradation of its structural strength. With the additional presence of liquid lithium, the oxygen partial pressure would be so low as to prevent any oxidation of vanadium alloy. The key advantage of the mixed breeder option is to reduce the amount of vulnerable lithium in case of an accident. These options and corresponding design advantages and critical issues will be presented to the Demo design team for the selection of the Demo-I design.

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