NEUTRONICS ASSESSMENT OF BLANKET OPTIONS FOR THE HAPL LASER INERTIAL FUSION ENERGY CHAMBER

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The High Average Power Laser (HAPL) program led by the Naval Research Laboratory is carrying out a coordinated effort to develop Laser Inertial Fusion Energy based on lasers, direct drive targets and a dry wall chamber. A primary focus is the development of a tungsten-armored ferritic steel (FS) first wall (FW) that must accommodate the threat spectra from the fusion micro-explosion. Only a thin region of the armor (10-100 μm) will experience the highly cyclic photon and ion energy deposition transients. The FW structure behind the armor as well as the blanket will operate under quasi steady-state thermal conditions, similar to MFE conditions. This allows for the possible use of blanket designs that are being developed for MFE and allows maximum utilization of information available from the large international MFE blanket R&D effort. We carried out scoping studies of possible blanket designs that can be integrated with the FW protection scheme.

Three blanket design concepts were evaluated. One of the concepts is a self-cooled lithium blanket. The absence of magnetic field in IFE allows taking advantage of the high heat transfer capability of lithium without the MHD issue of concern in MFE. The second concept consists of a number of Li_4SiO_4 solid breeder (SB) and Be multiplier packed bed layers separated by helium cooling plates and arranged in parallel to the FW. The third design is based on the dual coolant lithium lead (DCLL) blanket concept where He is used to cool the FW and blanket structure. SiC inserts are used in the LiPb flow channels to thermally isolate the high temperature LiPb from the low temperature structure. All concepts utilize low activation FS structural material. In this paper, we discuss the main design features of the blanket concepts and compare the expected nuclear performance. For adequate tritium breeding ratio (~1.15) and for the He-cooled shield to be lifetime component, the required blanket thickness is 47, 65, and 52 cm for the Li, SB and DCLL blankets, respectively. For a fusion power of 1.8 GW, the total thermal power is 2.1, 2.3, and 2.1 GW for the Li, SB, and DCLL blankets, respectively. The large amount of Be in the SB blanket results in larger nuclear heating in blanket components. The FW damage rate is ~35% higher in the DCLL blanket resulting in more frequent replacement. With the poor Li shielding characteristics, a thicker (0.5 m) shield is required than with the other blankets (0.3 m) to allow rewelding of the vacuum vessel. We will shed light in the paper on differences in nuclear parameters resulting from the geometrical and spectral differences between IFE and MFE systems.