Applied Electromagnetics and Mechanics
T. Takagi and M. Uesaka (eds.)

A Sn-CLIFF Concept Assessment

Dai-Kai Sze, Jeff Brooks Argonne National Laboratory
Mohamed Abdou, Sergei Smolentsev, Mahmoud Youssef, UCLA
Tom Rognlien, LLNL
Brad Nelson, ORNL
Mohamed Sawan, UW

The Advanced Power Extraction (APEX) program is a new US initiative to assess the innovative first wall/blanket concepts to improve the attractiveness of fusion. The thin Convective Liquid Flow First Wall (CLIFF) concept is one of the innovative concepts being assessed in APEX. The idea of the CLIFF is to using a thin, fast flowing liquid layer in front of the first wall to remove the surface heat flux. With the CLIFF design, the first wall of the blanket behind the CLIFF does not need to handle the high surface heat flux, and have much more design flexibility. Also, because the reduced stress and erosion, the reliability of the first wall will improve. In addition, the CLIFF may provide the conducting path for the plasma stabilization shell if a flowing liquid metal is used for the CLIFF.

Various coolant materials have been considered for the CLIFF, including flibe, Li and Sn. Since the CLIFF is facing directly to the plasma, the vapor pressure of the material selected becomes very important. The maximum allowable temperatures for different CLIFF materials have been determined from plasma considerations. Due to the high vapor pressure and, for flibe, the high melting temperature, the CLIFF temperature windows for Li and flibe are either none exist, or too small. Due to the very low vapor pressure and low melting temperature, Sn-CLIFF has a very large temperature window, based on which we can have a robust first wall/blanket design. For this reason, a design based on Sn-CLIFF and a conventional breeding blanket was selected as one of the APEX design activities for further considerations.

The concept of Sn-CLIFF is based on a thin layer of Sn flow facing the plasma for first wall protection and surface heat removal. The reason that Sn is selected is because of the low vapor pressure that we can operate CLIFF at a high temperature to improve system thermal efficiency. The breeding blanket is based on a Li17Pb83 self cooled blanket. The structural material for the system is SiC composite. With limited experimental result available, it is expected that SiC composite is compatible to both Sn and Li17Pb83. The maximum allowable interface temperatures between Sic and both Sn and Li17Pb83 are 850C.

The maximum allowable temperature of Sn facing the plasma is calculated to be above 800C. With this as the temperature limit, the first wall can be can be calculated for te reference case with a neutron wall loading Of 7 MW/m2, and a surface heat flux of 1.4 MW/m2. With the coolant inlet and exit temperature, a power conversion system can be designed. A close cycle He system is adopted as the power conversion system, with a converting efficiency of 55%.

Other considerations, such as tritium breeding, tritium recovery, activation, safety, have also been calculted and will be reported in the paper.