

Nuclear Performance of the Thin-Liquid FW Concept of the CLiFF Design

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In the CLiFF design, a thin liquid layer of thickness ~ 2 cm is flowing in front of a solid wall. During the initial phase of the design, several liquid breeders (Li, Flibe, and Sn-Li) were explored. Without a multiplier, the maximum local TBR is ~ 1.5 [Li(25%Li-6)/V], 1.16 [Flibe(25%Li-6)/FS] and 1.26 [Sn-Li(90%Li-6)/FS]. Power multiplication with Flibe is marginal and is the largest with Sn-Li (PM ~ 1.4). The damage parameters at the vacuum vessel (VV) and TF coil case are about an order of magnitude less with Flibe breeder due to its superior attenuation power. The inclusion of the 2-cm layer reduces the FW damage parameters by 11-30%. For 10 MW/m² average wall load, the accumulated DPA in the VV over 30 years is 3, which makes the VV a lifetime component.

In the second phase of the design, Flibe with SiC structure were explored. Sn-Li was also thought with SiC. The maximum attainable TBR was explored under various parameter variations and the following were established: (1) Without a beryllium multiplier, local TBR for either Flibe/FS or Flibe/SiC is *marginal*. Flibe/SiC combination gives lower TBR at all Li-6 enrichment. It decreases with Li-6 enrichment whereas it peaks around 25% Li-6 enrichment in the case of Flibe/FS, (2) Local TBR for either Sn-Li/FS or Sn-Li/SiC increases drastically with increasing Li-6 enrichment (maximizes at 90%Li-6). TBR can reach values larger than Flibe/FS or Flibe/SiC cases, and (3) In the presence of Beryllium, the local TBR with Flibe is larger than TBR with Sn-Li (even at 90% Li6). Effect of Be is more pronounced in the Flibe/SiC case than in the Flibe/FS case. The TBR(max.) is (Be presents in entire blanket): *Flibe (Nat. Li)/SiC* ≈ 1.7 , *Flibe (25%Li6)/FS* ~ 1.68 , *Sn-Li (90%Li6)/SiC* ≈ 1.39 , *Sn-Li (90%Li6)/FS* ~ 1.39 . However, under practical condition (10 cm thick Be zone), local TBR are: *Flibe(25%Li6)/FS* ~ 1.5 , *Flibe(Nat. Li)/SiC* ~ 1.5 , *Sn-Li (90%Li6)/FS* ~ 1.31 , *Sn-Li(90%Li6)/SiC* ~ 1.29 . The impact of using other structural material on TBR was also studied. The materials considered are: W, V-4Cr-4Ti, TZM, and Nb-1Zr. The presence of Be in the Flibe blanket has an adverse effect on local TBR when the W structure is used everywhere. Likewise, the presence of Be in the Sn-Li blanket has an adverse effect on local TBR when the structure is made of W, TZM, or Nb-1Z.