Contribution ID: **437** Type: **Poster**

Conceptual Design Study for Heat Exhaust Management in the ARC Fusion Pilot Plant

Tuesday 23 October 2018 08:30 (20 minutes)

The ARC pilot plant conceptual design study [1] is extended to explore options for managing ~525 MW of fusion power generated in a compact high field (B_0 = 9.2 T) tokamak about the size of JET (R_0 = 3.3 m). Exploiting ARC's demountable high temperature superconductor toroidal field (TF) magnets, poloidal magnetic field (PF) coils located inside the TF, and vacuum vessel (VV) immersed in molten salt FLiBe blanket, this follow-on study identifies novel robust power exhaust solutions. The superconducting PF coil set is reconfigured to create double-null plasma equilibria that include an X-point target divertor geometry. Modeling shows that such long-leg configurations enhance power handling and can achieve passively-stable detachment fronts that stay in the divertor leg over a wide power window [2,3]. The VV is modified to include the divertors while retaining original core plasma volume and TF magnet size. The molten salt FLiBe blanket shields all superconductors, functions as an efficient tritium breeder, and, with augmented forced flow loops, serves as a single-phase, low-pressure coolant for the divertor and VV. MCNP neutronics calculations show a tritium breeding ratio of ~1.08. The neutron damage rate of the remote divertor targets is ~3 times lower than that of the first wall, which is beneficial because high neutron damage often leads to degradation in thermal performance. The demountable TF magnets allow for vertical maintenance schemes and replacement every 1-2 years, increasing tolerance for neutron damage. The divertor has tungsten swirl-tube cooling channels capable of exhausting 12 MW/m^2 of heat flux, which includes a factor of ~8 safety margin over anticipated steady state heat loads. Novel diagnostics supporting the heat exhaust mission compatible with the neutron environment are proposed, including the use of Cherenkov radiation emitted in FLiBe to measure fusion reaction rate, microwave interferometry to measure divertor detachment front location, and IR imaging through the FLiBe blanket to monitor divertor "hotspots."*The authors acknowledge support from the MIT Nuclear Science and Engineering Department and the PSFC.*

[1] B.N. Sorbom, *et al.*, *Fus. Eng. and Des.* **100** (2015): 378-405.

[2] M.V. Umansky, *et al.*, *Phys. of Plasmas* **24** (2017): 056112.

[3] M. Wigram, *et al.*, *Conts. to Plasma Phys.* (2018)

Country or International Organization

United States of America

Paper Number

FIP/P1-22

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Session Classification: P1 Posters

Track Classification: FIP - Fusion Engineering, Integration and Power Plant Design