MULTI-PHYSICS ANALYSIS OF SPHERICAL TOKAMAK CENTERPOST DESIGN FOR A COMPONENT TEST FACILITY

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The realization of commercialized fusion power will involve the development of new materials that can withstand the uniquely harsh nuclear fusion environment. Of particular interest are those materials that are closest to the plasma. As stated in the United States Department of Energy 2009 Research Needs Workshop (ReNeW) for Magnetic Fusion Energy document [1], "The material systems comprising the plasma facing components of present-day fusion devices, and those envisioned for ITER, share a common limitation. Given our current understanding of the extreme irradiation environment of next-generation reactors, none appear capable of withstanding the extraordinary combination of ion fluence and bulk neutron damage expected. Moreover, the plasma-surface boundary plays a key role in fusion performance of the core plasma by the self-consistent recycling of particles." An experimental Component Test Facility (CTF) is required that will create the environment that simultaneously achieves high energy neutrons and high ion fluence is necessary in order to bridge the gaps from ITER to the realization of a fusion nuclear power plant. One concept for achieving this is a high duty cycle spherical tokamak (ST) [2].

The centerpost is a critical component of the spherical tokamak design, as it controls the size of the entire reactor. The centerpost will experience significant thermal loading and thermal gradients from Ohmic heating, nuclear heating, and water cooling. Nuclear heating will also produce embrittlement and swelling in the centerpost. In addition to thermal loads, the centerpost must be designed to carry mechanical loads produced from the various magnetic fields (TF, PF, plasma currents), both steady-state and transient. The centerpost temperature must remain low enough to permit water cooling, and stresses must remain low enough so that the centerpost remains structurally sound against yielding, buckling, fatigue, and creep. A multi-physics, structural analysis, accounting for both magnetic and thermal loading is performed to optimize the design of the ST centerpost.

[1] *Research Needs for Magnetic Fusion Energy Sciences,* Report of the Research Needs Workshop (ReNeW), 2009. http://burningplasma.org/web/ReNeW/ReNeW.report.press1.pdf

[2] Neumeyer C, Heitzenroeder P, Kessel C, Ono M, Peng M, Schmidt J, Woolley R, Zatz I, "Spherical Torus Center Stack Design," 19th Symposium on Fusion Engineering (SOFE), pp. 413-417, Atlantic City, NJ, 2002.