SOFE05-037

OPTIMIZATION OF THE ARIES-CS COMPACT STELLARATOR REACTOR PARAMETERS*

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Stellarators have the potential for an attractive, fully ignited reactor. They are inherently steady-state without a large plasma current, which reduces both the power needed to sustain the plasma and the risk of plasma disruptions. However, earlier studies led to large stellarator reactor sizes; the most advanced concept had an average major radius R = 22 m. The ARIES Stellarator Power Plant Study reactor with R = 14 m was a first step toward a smaller size reactor. The recent development of the compact stellarator concept now allows reactors with major radius closer to that of tokamak reactors.

The most important factor determining stellarator reactor size is the distance needed between the edge of the plasma and the nonplanar magnetic field coils for the plasma scrapeoff region, the first wall, the blanket and shield, the coil case, and assembly gaps. Other considerations in determining the optimum reactor size are the minimum distance between coils, neutron and radiative power flux to the wall, and the beta limit.

A reactor systems/optimization code is used to optimize the reactor parameters for minimum cost of electricity subject to a large number of physics, engineering, materials, and reactor component constraints. Different transport models, reactor component models, and costing algorithms are used to test sensitivities to different models and assumptions. A 1-D power balance code is used to study the path to ignition and the effect of different plasma and confinement assumptions including density and temperature profiles, impurity density levels and peaking near the outside, confinement scaling, beta limits, alpha particle losses, etc. for a given plasma and coil configuration.

Two different magnetic configurations were analyzed: a three-field-period (M = 3) NCSX-based plasma with coils modified to allow a larger plasma-coil spacing, and an M = 2 plasma with coils that are closer to the plasma on the outboard side with less toroidal excursion. The reactors have major radii R in the 7-9 m range with an improved blanket and shield concept and an advanced superconducting coil approach. The low recirculating power should make compact stellarator reactors cost competitive with tokamak reactors.

*Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Dept. of Energy under contract DE-AC05-00OR22725."