PHYSICS AND TECHNOLOGY TRADE-OFFS IN OPTIMIZING COMPACT STELLARATORS AS POWER PLANTS

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The optimum stellarator configuration is quite dependent on the physics and technological constraints. In a stellarator, the majority of the confining field is provided by the external coils and the space between the coils and the plasma is a critical parameter, i.e., fixed-boundary analysis of stellarator configuration may lead to high-performance plasma configuration which cannot be produced with any practical coils and/or cannot accommodate a power-producing blanket. Constraint imposed by magnet technology such as maximum bend radius, support structure, and inter-coil spacing needed for assembly/maintenance of in-vessel components also play a critical role. As a whole, there are a large number of tradeoffs among physics parameters and engineering constraints.

A detailed and integrated study of compact stellarator configurations, ARIES-CS, was initiated recently. We explored several quasi-axisymmetric (QA) and quasi-helical configurations. Configurations with excellent QA have been found with $A \leq 6$ (both 2 and 3 field periods are possible.) We reduced α losses to ~10% (still higher than desirable). Stability to the linear ideal MHD modes was attained in most cases but at the expense of reduced QA (and increased α losses) and increased complexity of the plasma shape. Recent experimental results indicate, however, that linear MHD stability limits may not be applicable to stellarators.

It appears that the minimum plasma/coil stand-off distance is not as an important a parameter as envisioned previously. By utilizing a highly efficient shield-only region in strategic areas, we were able to reduce the minimum stand-off by ~20%-30% compared to a uniform radial build. This would allow a comparable relative reduction in machine size. The device configuration, assembly, and maintenance procedures appear to impose severe constraints: Three distinct approaches were developed, each applicable to a certain blanket concept and/or stellarator configuration. Modular coils are designed to examine the geometric complexity and to understand the constraints imposed by the maximum allowable field, desirable coil-plasma separation, coil-coil spacing, and other coil parameters. We have developed a cost data basis for components with irregular geometry. A cost-optimization system code has also been developed and is utilized to assess the trade-off among physics and engineering constraints in a self-consistent manner.