Attractive Design Approaches for a Compact Stellarator Power Plant

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The ARIES-CS study has been launched with the goal of developing through physics and engineering optimization a more attractive power plant concept based on a compact stellarator (CS) configuration. On the physics side, the first phase of the study involves scoping out different physics configurations including two and three field period options. Key considerations impacting the design of the CS include the size of the reactor, access for maintenance and the minimum distance between plasma and coil that affects shielding and also breeding if sufficient blanket coverage is not provided.

The first-phase engineering effort, carried out in close interaction with the physics effort, has focused on scoping out maintenance schemes and blanket designs best suited to a CS configuration. This has been done by building on information and results from past studies. The results from this effort will enable a down-selection to a couple of most attractive combinations of blanket configuration and maintenance scheme for more detailed studies which will then culminate in the choice of a point design for a full system design study during the final phase of the study.

To provide a broad range of possibilities to accommodate the physics optimization of the number of coils and the machine size, three possible maintenance schemes were considered: (1) replacement of an integral unit based on a field-period including disassembly of the modular coil system; (2) replacement of blanket modules through maintenance ports arranged between each pair of adjacent modular coils; and (3) replacement of blanket modules through a limited number of designated maintenance ports. Several possible blanket/shield configurations compatible with the maintenance schemes and the CS geometry were considered, covering the following three classes: (1) self-cooled liquid metal blanket with SiC_f/SiC composite as structural material or with He-cooled ferritic steel (with or without thermal/electrical insulation); (2) He-cooled solid or liquid breeder blanket with ferritic steel; and (3) self-cooled flibe blanket with ferritic steel. The divertor heat load for a CS is still uncertain but it is likely that, for a conventional divertor, He-cooling will be needed. As guidelines for the first phase of the study, it was decided to develop each concept to an extent sufficient for a credible case to be made regarding performance, fabrication and maintenance.

This paper summarizes the results from this first-phase engineering effort, covering the different blanket configurations and maintenance schemes. The main design parameters are summarized and key issues are discussed including the impact of different physics configurations on the engineering choices. These results will be used as the basis to down-select to a couple of combinations of blanket configuration and maintenance scheme for more detailed studies.