# Ceramic Breeder Blanket for ARIES-CS

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The first phase of the ARIES-CS study has focused on scoping out maintenance schemes and blanket designs best suited for a compact stellarator configuration. The study will then down-select to a couple of most attractive combinations of blanket configuration and maintenance scheme for more detailed studies culminating in the choice of a point design for a full system design study. One of the blankets developed during the early scoping phase is a helium-cooled ceramic breeder blanket. Consistent with the guidelines of the study, this concept was developed to an extent sufficient for a credible case to be made regarding performance, fabrication and maintenance.

Ceramic breeder designs tend to favor a modular configuration which, in the case of a compact stellarator, provides the flexibility in setting module sizes best suited to the particular reactor geometry. This also assumes a modular maintenance approach through ports. A ceramic breeder design has traditionally been coupled to a Rankine steam cycle since the maximum temperature of the coolant tends to be limited by the maximum temperature limit of the structural material (typically ferritic steel, FS). However, safety concerns have been raised about the possibility of a tube rupture in the module followed by a tube rupture in the steam generator which could eventually result in unacceptable steam/Be interaction in the case of failure of the pressurized module. Thus, unless a clear case could be made that such an accident is beyond design basis, the module would need to be designed to accommodate the pressurization, which translates into more structure and less tritium breeding. To avoid this issue, it was decided to reconsider the possibility of coupling a Brayton cycle to such a blanket, by optimizing the cycle as well as by maximizing the coolant temperature through limited utilization of ODS FS in high temperature regions, for example as an outside first wall layer diffusion bonded on regular FS.

The blanket module is then designed to accommodate a relatively low pressure of about 0.5-1 MPa compared to a He pressure of about 8 MPa. The overall configuration is relatively simple, consisting of a number of breeder and Be multiplier packed bed layers separated by cooling plates and arranged in parallel to the first wall. The dimensions are optimized to meet the breeding requirement and to accommodate the maximum temperature limits of the different materials. As fabrication technique, it is envisaged to fill the breeder regions outside the canister utilizing a membrane to contain the breeder pebbles, and then to insert the breeder unit in the canister which is finally filled with Be pebble beds.

This paper describes the conceptual design of this ceramic breeder blanket. Key parameters are summarized and major issues are discussed.