GAS-COOLED DIVERTOR DESIGN APPROACH FOR ARIES CS

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A gas-cooled divertor is envisaged for the ARIES-CS compact stellarator power plant study. The helium cooled, high temperature output (~ 700 °C) divertor type fits very well into the overall plant concept with in-reactor coolant transferring their energy through a heat exchanger to a helium working fluid driving a closed Brayton cycle.

As a key component, the heat exchange structure of a gas cooled divertor is likely to be built up from a modular arrangement of cooled refractory alloy parts, to handle the peak heat fluxes (assumed as ~10 MW/m^2 in anticipation of better estimates from the ongoing divertor physics modeling effort). Recently presented near-term design concepts [1] rely on simple shaped heat transfer caps. It was decided to explore new configurations with suitably increased single part size (relying on anticipated progress in tungsten alloy technologies), good heat flux accommodation potential, reasonably simple manufacturing and assembly procedures, and which could be well integrated in the CS reactor design. As a result of the present study, the proposed configuration consist of a "T-tube" (e.g. diameter 15 mm, length 100 mm) made from an optimized W-Re alloy (e.g. 5% Re).

The T-tubes will be favorably aligned with the magnetic field lines (likely toroidal), whereby supporting manifold modules (made from an advanced ferritic steel like 12YWT) below the tubes will be directed perpendicular to the tubes. The manifold structure is cooled actively to counteract the neutron heating. Within each T-tube the coolant enters a concentric cartridge and is accelerated through a slot nozzle towards the heat loaded inside of the tube. An almost 2D-shaped impinging slot jet is generated in this way, leading to a high heat transfer performance with a reasonable pressure drop. After impingement, the coolant flows as a highly turbulent wall jet along the large inside surface of the tube and then returns in the lower section of the annular gap between tube and cartridge. The tube is supported and fed through a T-junction, with the W alloy pieces connected to a base ferritic steel unit through a graded transition (e.g. using through diffusion bonded layers of graded W alloy/ODS FS composition) to minimize thermal stresses.

This paper presents a detailed description of this new and promising T-tube divertor concept for ARIES-CS. Major results from the thermo-mechanical analysis are summarized and key performance, fabrication and integration issues are discussed.

[1] T. Ihli, et al., An advanced He-cooled divertor concept, SOFT'04, P4C-F228, to appear in Fusion Engineering and Design