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# Recent development of actively cooled PFCs for WEST, JT-60SA

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In the current, and probably future, fusion devices, divertor is essential to achieve high performance plasma. In conjunction with the generic X-point configuration, its role is to absorb very intense heat flux located at the strike points, as well as keeping plasma impurities at a relatively low level.
For different reasons, such as melting temperature, erosion rate, He retention, tungsten is a material widely chose as main plasma facing material. The heat exhaust is then ensured by a heat sink generally made of CuCrZr, a copper alloy exhibiting acceptable mechanical properties, with water flowing through it. The fixation to the global divertor structure is done by steel parts. Such design with tungsten monoblock is used for ITER divertor, for which heat flux around 10MW/m², up to 20MW/m² on slow transients, may be expected. Its design and development of associated technological processes have lasted for more than ten years.
First part will show the design, manufacturing and qualification of this type of component for WEST lower divertor (Tore-Supra upgrade to a metallic machine), design to sustain pulse duration from 10s to 1000s. It has been equipped with 456 ITER grade components (called Plasma Facing Units –PFU), representing around 15% of the full ITER divertor area. Each PFU is made of 35 tungsten monoblocks assembled on a CuCrZr tube, via a copper interlayer ring, using hot isostatic pressure as assembly process. After the insertion of a twisted tape inside the tube, a stainless steel tube is welded by electron beam on both ends. Finally, the precise external shaping of the PFU is milled and grinded, including a 0.5mm / 1° bevel on the plasma interacting surface. This "fish-scale"shaping aims at protecting edges in case of misalignment, 0.5mm being also supposed for the bevel of ITER inner vertical targets. Finally, important surface modifications have been observed after a few campaigns in WEST, totalizing 4 hours and 25 minutes of plasma and 8.3GJ of deposited energy. Main observations are being reported, as a first step for future long pulse operations of fusion devices.
Second part will present current design studies regarding JT-60SA W divertor upgrade, expected to be operational in 2033. While the estimated maximal heat flux is also in the range 10MW/m² with possible excursions to 20MW/m² like in ITER and long pulse operations in the range of 100s, different environment (no D-T plasma) and different cooling conditions (from 90℃, 33bar, 10m/s to 40℃, 20bar, 7m/s) allow for a design different than ITER one. Recent development show that tungsten flat tiles assembled on a heat sink could be used, simplifying design and manufacturing processes. For heat sink material, several options are compared, including use of TZM, a molybdenum alloy capable of handling high temperature, or CuCrZr with a substantial increase of thermal capabilities using advanced design like hypervapotron combined with manufacturing process like additive fabrication. In addition to the power exhaust capacities, other specifications are taken into account, such as precise shaping, tolerance to the components misalignment and maintenance convenience.

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