Technology Developments at KIT towards a Magnetic Confinement Fusion Power Plant

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Complementing its intense efforts towards the finalization of the design, and the realization, of key components for ITER, the Karlsruhe Institute of Technology is pursuing vigorously also a number of important long-term technology developments towards a magnetic confinement fusion power plant. While ITER still will be an experimental device with a total run-time of only few percents of its total operation period, a power plant will have to be designed for (quasi-) continuous operation with severe implications on neutron doses, heat load cycles, and throughputs. Fundamental issues that cannot be solved by ITER nevertheless have to be addressed, due to their long lead time, already now in order to have the appropriate options prepared when the coherent design of a demonstration power plant will be started.

To this end, KIT is developing, within the overall EURATOM fusion programme, structural materials for fusion on the basis of both low-activation steels and refractory metals, in particular to withstand the neutron and thermo-mechanical loads the in-vessel components will be exposed to. On this basis, concepts for breeding blankets and divertor designs are being developed and verified step-wise, along with the development and qualification of suitable manufacturing and joining technologies. In parallel, KIT contributes to the engineering design and validation phase of the Fusion Materials Irradiation Facility (IFMIF) which will be needed for qualifying the materials to be used in a power plant. The specific characteristics of a fusion power plant fuel cycle, i.e., the processing of substantial tritium quantities within huge mass flows of exhaust gases and the related tritium compatible high throughput vacuum and pumping technologies, are being determined and translated into viable engineering approaches. As the cooling requirements of the superconducting magnet coils confining the fusion plasma will have a strong impact on the balance of plant and hence, on the overall efficiency, high temperature superconducting solutions are being developed, currently at the stage of strands, conductor cables and current leads. In order to increase the wall-plug efficiency of plasma heating, also critical for overall efficiency, advanced gyrotron tubes with power levels significantly beyond what is envisaged for ITER are being developed along with a frequency tuneability option for efficiently counteracting plasma instabilities.

The current status of these developments at KIT will be reported.