SEGMENTATION OF INTERNAL COMPONENTS AND IMPACT ON MAINTENANCE FOR DEMO

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This paper aims at giving an overview of the evolution of different blanket segmentation concepts for in-vessel integration, for Fusion Power Plants and DEMO Reactors, developed in the last decade at Karlsruhe Institute of Technology (KIT) and other European associations within the framework of the European Fusion Development Agreement (EFDA).
The integration of helium cooled blanket concepts in both versions currently supported by the EU, namely the HCPB and HCLL, is herein described and discussed, focusing on the chronological development and the reasons that led to segmentation concepts improvement.
During the Power Plant Conceptual Studies (PPCS), the so called “Large Module” (LM) concept for Blanket integration, derived from ITER, was assumed as basis to conduct plant lay-out and its performances assessment. The focus of this study was more on plant performances in term of power generation efficiency, safety, and more generally in terms of electricity cost. The maintenance concept was not investigated from an engineering point of view. Successive studies, attempting to further develop this concept, highlighted some major issues like thermal compensation of pipes and attachments, achievement of reweldability criteria for blanket hydraulic connections, and too long maintenance time related to the adopted segmentation concept.
This was the reason why in the successive DEMO Conceptual Studies, the maintenance concept was further revised and the so called “Multi Module Segment” (MMS) concept was proposed in the attempt to combine relatively small blanket modules, to minimize thermal and electromagnetic loads, with an assembly concept able to group together in a larger unit several blanket modules, reducing replacement time and minimizing cutting and rewelding operations inside the Vacuum Vessel (VV).
In particular, the most critical engineering issue characterizing this MMS concept has been identified in the thermal compensation between high temperatures (up to 550°C in the blanket region) and the low temperatures (about 150°C in the VV). This mismatching presents difficulties in the realization of an attachment system that should minimize thermal stresses and, at the same time, to be robust against electromagnetic loads coming from plasma disruptions; this need has also to cope with the very limited space available for attachment integration (when considering a compact reactor) and also with the problematic coming from the openings in the blanket for Heat and Current Drive systems insertion.
Different variants of this concept and the related maintenance strategy have been analyzed in this study. This paper presents a rationale of these concepts and an assessment analysis to highlight differences and open issues. The main elements of the design are analyzed and different options are compared in order to facilitate the selection of the most promising segmentation concept.