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Diffusion weld study for ITER test blanket module fabrication

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According to the current design for the European Helium Cooled Pebble Bed (HCPB) ITER Test Blanket Module (TBM) there are basically six subcomponents which have to be fabricated and assembled: first wall, caps, stiffening grid, breeding units, back plates/manifolds, and attachment system. The main technologies needed for blanket fabrication is joining of parts - particularly production of plates with internal cooling channels - and applying suitable post weld heat treatments. Both steps together are the key technologies that determine the mechanical strength of the blanket, the ductile-to-brittle transition temperature (DBTT) which is important under neutron irradiation, and the potential for a compact design. While it is certain that the structural material will be EUROFER or another, comparable reduced activation steel, most joining technologies and/or procedures have still to be developed, adapted, or qualified, although substantial advancements have been already reported. The designated fabrication route for plates with inner cooling channels is diffusion or solid phase welding which is either performed in a hot isostatic press (HIP) or in an uniaxial hydraulic press, both after different specific joint preparations. However, for an efficient TBM fabrication the application of different milling processes would be unavoidable. Therefore, the influence of six different common milling procedures on the diffusion weld properties has been studied by instrumented Charpy tests after a one-step and two-step low pressure welding process. The according microstructures have also been examined. Furthermore, the effect of nine typical states of surface contamination on the weld interface properties has been investigated and characterized. It could be demonstrated that two-step HIP diffusion welding can eliminate unfavorable surface fabrication defects and, therefore, might allow for more efficient milling processes.