Effect Of Irradiation Temperature and Dose On Mechanical Properties And Fracture Characteristics Of Cu//SS Joints For ITER

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By now, a number of technologies have been proposed for the production of Cu//SS joints for ITER, such as brazing, friction welding, HIP and cast-copper-to-steel (CC). The two lastmentioned technologies ensure sufficiently high mechanical properties and a high joint quality, when unirradiated. The data, however, on mechanical characteristics of irradiated of Cu//SS HIP joints are limited.

In this paper, the authors present the results of investigations into the mechanical characteristics after irradiation of GlidCopAl25/316L(N) and Cu-Cr-Zr/316L(N)-type joints produced by the HIP and CC technologies. Specimens of the joints were irradiated in the RBT-6 reactor in the dose range of $10^{-3}$ - $10^{-1}$ dpa at $T_{irr} = 200^\circ$C and 300$^\circ$C.

The tensile stress-strain curves for irradiated and unirradiated joint specimens show deformation processes occurring in both the Cu and SS parts of the specimens.

Irradiation at $T_{irr} = 200^\circ$C causes strengthening of the joints specimens (by about 100 MPa at the maximum dose). The uniform elongation drops from 8% in the initial state to 2-3 %. But the total elongation remains at a relatively high level of $\sim$7%.

Irradiation at $T_{irr} = 300^\circ$C causes a slight strengthening of the joints specimens ($\sim$30 MPa). The uniform elongation remains unchanged at $\sim$7%. The total elongation also maintains a relatively high level of $\sim$9-13%.

SEM investigations revealed that fracture occurs only in the copper part of the irradiated specimens, and ductile transcryalline fracture predominates in the joints.

3D finite element analysis of the tensile test indicates that the concentration of stresses and deformations in the copper layer adjacent to the joint line is responsible for this typical failure of the irradiated joints specimens.

Comparison of the behavior of the joints irradiated at $T_{irr} = 200^\circ$C and 300$^\circ$C indicate an increased embrittlement at lower irradiation temperatures. At a higher irradiation temperature of 300$^\circ$C the ductile properties of the joints are noticeably higher.

The investigations performed make it possible to recommend joints of Cu-Cr-Zr//316L(N) (CC) and Cu-Cr-Zr//316L(N) (HIP) type produced by the cast-copper-to-steel and HIP technologies, respectively, for ITER applications.

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