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Fabrication of Divertor Mock-up with ODS-Cu and W by Improved Brazing Technique

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It is considered that copper alloy could be used as a divertor cooling tube in not only helical reactor FFHR-d1 but also tokamak DEMO reactor, because of utilizing its high thermal conductivity. This study focused on using an oxide dispersion strengthened copper alloy (ODS-Cu) of GlidCop® (Cu-0.3wt%Al2O3) as the divertor heat sink material of FFHR-d1. This alloy has superior high temperature strength over 300 MPa even after an annealing up to ˜1000˚C. This characteristics provide two important advantages. The first advantage is that ensure the redundancy of the temperature margin of the divertor operation even when an unexpected temperature excursion occurs. The second one is the brazing procedures itself, since rapid cooling down phase does not need at the final stage of the brazing heat treatment. The rapid cooling down phase would be considered giving an undesired thermal stress to the material.

The changeable material properties of Pure-Cu, GlidCop® and CuCrZr by neutron irradiation are summarized in this paper. A primary dose limit is the radiation induced hardening/softening (˜0.2 dpa/1-2 dpa), and it has a temperature dependence. If the temperature of the GlidCop® is completely kept at 300˚C, radiation induced hardening/softening would be moderated. According to such an evaluation, the GlidCop® can be selected as the current best candidate material in the commercial base of the divertor heat sink, and its temperature should be kept at 300˚C as possible during operation.

Joining between tungsten armour and GlidCop® heat sink was successfully performed by using an improved brazing technique with BNi-6 (bal.%Ni,11%P) filler material (W/BNi-6/GlidCop®). The joint strength was measured by three-point bending test, and was reached to be around 200 MPa. Surprisingly, several specimen showed obvious yield point. This means that BNi-6 brazing layer caused relaxation of the applied stress.

The small divertor mock-up of the W/BNi-6/GlidCop® was successfully fabricated by the improved brazing technique. The heat loading test was carried out by electron beam device ACT2 in NIFS. The highest temperature under 8 MW/m2 is ˜350˚C in the tungsten plate. The temperature profile is quite reasonable by modelling calculation by a finite element method. The design of the W/BNi-6/GlidCop® showed an excellent heat removal capability for using in the FFHR-d1 divertor.

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