§4. Mechanical Strength Properties of Tungsten Material at High Temperature

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Tungsten will be used as armor material of the first wall/blanket in the demo fusion reactor because of its low sputtering yield and hydrogen retention. Operation temperature of the first wall/blanket will be 350～550°C because of irradiation creep and swelling of reduced-activation ferritic/martensitic steel used as the blanket structure material. In the present work, mechanical properties of tungsten have been investigated by tensile tests to examine material behavior under loading of stress at high temperature above ductile-brittle transition temperature (DBTT). In addition, tungsten coatings on reduced-activation ferritic/martensitic steel (RAF/M) F82H substrate (F82H: Fe-8Cr-2W), which is a leading structural material candidate for DEMO, by Atmospheric Plasma Spraying (APS) and Vacuum Plasma Spray (VPS), have been produced and high heat flux experiment have been carried to investigate thermo-mechanical properties at high temperature. In addition, FEM analyses have been performed to evaluate mechanical strength properties of tungsten material, which was jointed with F82H.

The material used for the tensile tests in the present experiments was pure tungsten. The purity was 99.9 %. Specimen size was 2.6mm×5.0mm×0.1mm in gauge and 16.0 mm in total length. Heat treatment for the specimens was conducted at 1273K for 3 h. Grain size was about a few μm. Tensile tests were performed on specimens at a strain rate of 1.39×10^{-3} s^{-1} at RT and 773 K in vacuum. The tensile tests were carried our parallel and perpendicular direction for rolling.

Figure 1 and 2 show stress strain curves at RT and 773 K of parallel and perpendicular for rolling direction, respectively. Brittle fracture occurs at RT because of temperature below DBTT. On the other hand, ductibility appears and ductile fracture occurs at 773 K. In addition, a dependence of rolling direction for stress strain curve is also observed.

Figure 3 shows a model for the FEM analyses of the tungsten coated RAF/M F82H jointed OFHC under active cooling condition. The temperatures and thermal stresses have been calculated using FEM analyses. Stress analyses showed that large stresses are applied at four corners of W/F82H, upper part of F82H and lower part of W. Quantitative evaluation has been carried out by comparison with the FEM and the experimental results.

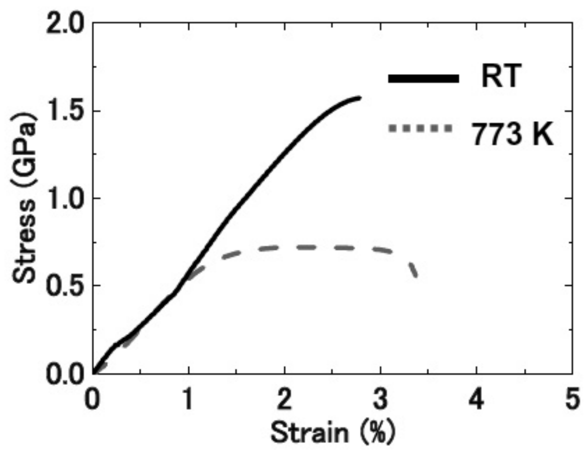

Fig. 1 Stress strain curve of parallel for rolling direction at RT and 773 K.

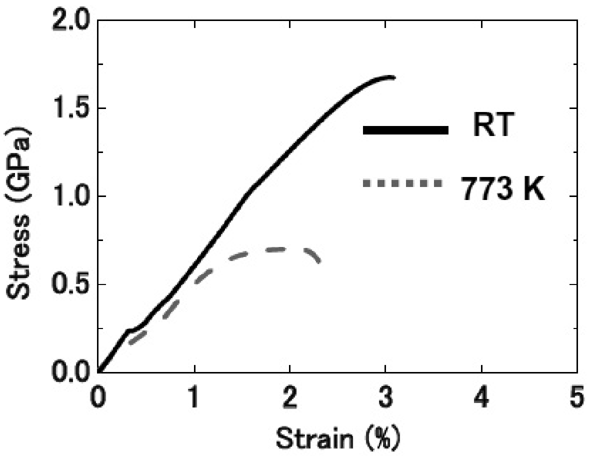

Fig. 2 Stress strain curve of perpendicular for rolling direction at RT and 773 K.

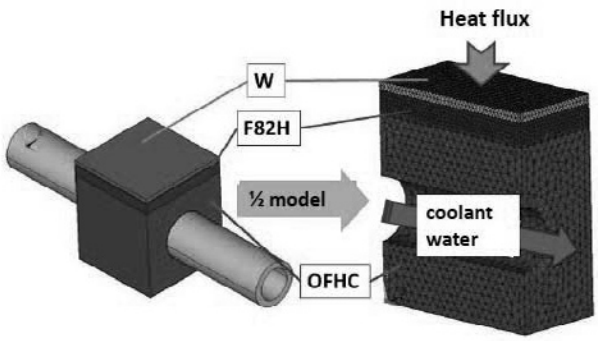

Fig. 3 Model for FEM analyses of tungsten coated RAF/M F82H jointed with OFHC under active cooling condition.