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低放射化フェライト鋼の高速引張変形挙動
High-speed tensile deformation of reduced-activation ferritic steel

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1. Introduction

In fusion reactor, huge electromagnetic forces are loaded on the structural materials by eddy currents induced by the plasma disruption within 10ms]. Obviously, the possible strain rate of structural materials during plasma disruption events is a design-dependent and operation-dependent parameter. Tanigawa et al. have calculated eddy current distribution generated by the disruption. Plasma current of 16.7MA was assumed to linearly decrease in 30 ms [1]. Substantial electromagnetic forces are loaded on the blanket structures across the large toroidal magnetic field. In this case, estimated strain rate during current plasma disruption event is 0.1/s. According to the safety management of fission reactor pressure vessel steels, dynamic fracture toughness will be the key property to guarantee the structural safety of nuclear power plants including fusion reactor. However there is no sufficient data of dynamic tensile properties and dynamic fracture toughness of reduced-activation ferritic (RAF) steel F82H.

Generally, the tensile strength and toughness of bcc alloys have temperature dependence. Considering the thermal activation process of gliding dislocation responsible to the deformation, therefore, high strain-rate may have an impact on the mechanical properties of RAF steels. In addition, irradiation damage may have a significant impact on the strain-rate sensitivity. Objective of this study is to investigate the high-speed tensile deformation behavior of RAF steel F82H.

2. Experimental procedure

The material used in this study is F82H BA-07 heat. The specimens used are small round bar type of which gauge length and diameter is 10 mm and 2 mm. High-speed tensile tests were carried out using Hydroshot HITS-T10, SHIMADZU Co. Testing temperatures were 296 K and 423 K. Nominal strain rates were from 0.01 from 1400 s^{-1}. Fracture surface was observed by scanning electron microscopy (SEM) using JEOL JSM-5600LV.

3. Results and discussion

Nominal stress-strain curves obtained by the high-speed tensile machine were shown in Fig. 1 (a) at 276 K and (b) at 423 K. The results clearly show strain-rate effect on the both of strength and elongation at 296 and 423K. Both nominal stress and nominal fracture strain increased with strain-rate. However the reduction of area obtained by SEM resulted in the similar values as shown in Fig. 2.

Modified R parameter with considering temperature rising during the high strain-rate deformation can explain the temperature dependence of the tensile strength with different strain-rates. The higher strength with higher strain-rate can be explained by activation volume analysis, suggesting a change of deformation mechanism from kink-pair formation to dislocation interaction. The mechanism of higher uniform elongation with higher strain rate will be discussed through a true stress-strain approach.

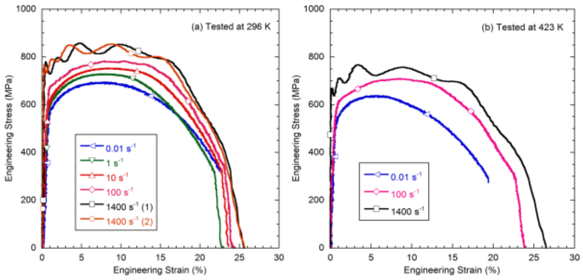

Fig.1 S-S curves of F82H obtained from high-speed tensile tests.

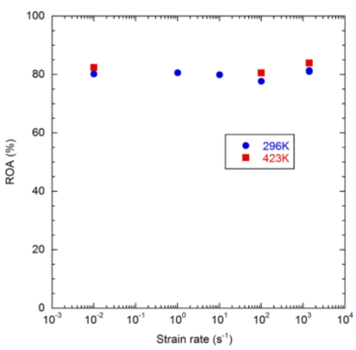

Fig.2 Reduction of area (ROA) of F82H after testing.

[1] H. Tanigawa et al., 24th IAEA Fusion Energy Conference – IAEA CN-197, Oct. 2012, USA.