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§11. Influence of Stress during Thermal Ageing on Mechanical Properties of JLF-1 and CLAM Steels

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Introduction

In fusion application, Reduced Activation Ferritic/Martensitic (RAFM) steels will be exposed to high temperatures during long-term service, which may result in recovery of microstructure and change of mechanical properties. This is called thermal ageing. Study of microstructure and mechanical properties changes for JLF-1 and CLAM steels during long-term ageing was performed in the previous studies.[1,2] The present efforts focus on the influence of low level of stress during the ageing, which may accelerate the recovery of microstructure even if the stress is lower than the creep deformation regime.

The ageing experiments with stress were carried out. The effects of stress during the ageing on tensile and creep properties were reported in this report.

Experimental

Thermal ageing treatments for JLF-1 (JOYO-II-HEAT) and CLAM (0603 HEAT) steels were carried out at 973 K for 100 h with different applied stress. The stress of 9 MPa was applied as close to the no stress condition. This was called “aged specimen” in this study. The stresses of 30 and 50 MPa were applied as the low level of stresses. These were called “stress-aged specimens”.

After ageing, some specimens were taken out for hardness measurements and tensile tests. Some specimens remained in the creep machine for subsequent creep tests.

Results

The hardness results are shown in Fig. 1. Compared with that before ageing, the hardness rapidly decreased for JLF-1 and CLAM after ageing at 973K/100h/9MPa. This was caused mostly by the thermal ageing. The hardness decreased further with the increase in the stress from 9 to 50 MPa.

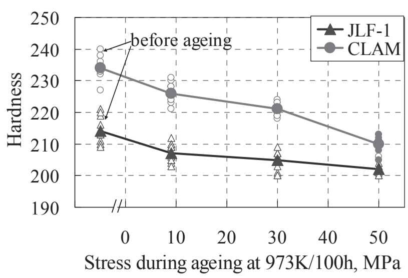

Fig. 1 Effect of stress during the ageing at 973K/100h on hardness for JLF-1 and CLAM steels

The effects of stress during the ageing on ultimate tensile strength (UTS), yield stress (YS) and total elongation (TE) are shown in Fig. 2.

The results showed that, compared with those before ageing, both UTS and YS were reduced for aged specimens (973K/100h/9MPa). Especially, the decrease in YS was more remarkable. However, the decrease of UTS and YS became smaller when the stress increased from 9 to 50 MPa. The tendency for total elongation change was opposite to that of strength, which increased after ageing and stress-ageing.

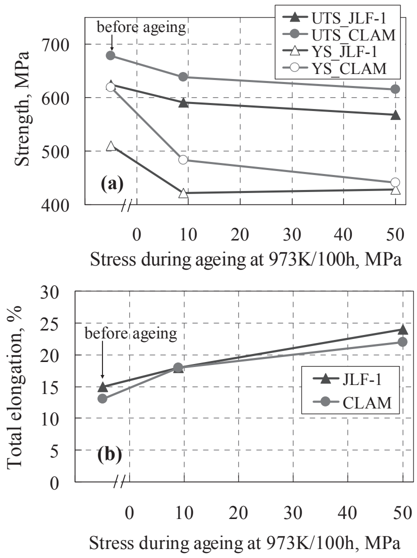

Fig. 2 Effect of stress during the ageing at 973K/100h on tensile properties for JLF-1 and CLAM steels

The creep results are shown in Fig. 3. As shown in the figure, the effects of stress during the ageing on subsequent creep curves were significant. With the increase of stress from 9 to 50 MPa, the minimum creep rate (the slope of second creep stage in the curves) increased and the rupture time decreased gradually for JLF-1. However, the creep properties for CLAM degraded much already by the ageing and, with the stress, the degradation was slightly enhanced.

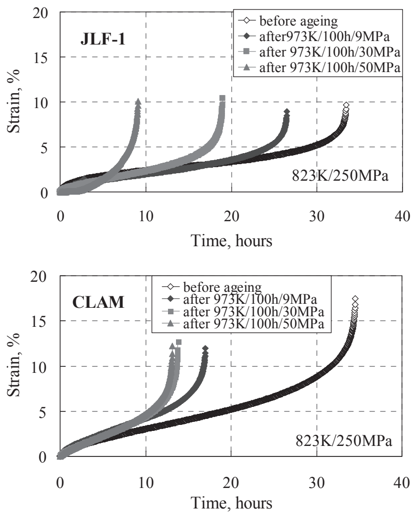

Fig. 3 Effect of stress during the ageing at 973K/100h on creep properties for JLF-1 and CLAM steels

1) Li, Y.F., J. Nucl. Mater., **386-388** (2009) 495
2) Li, Y.F., Fusion Sci. and Tech., **56** (2009) 323