§3. Correlation of Microstructure of Ferritic/ Martensitic Steel with Mechanical Properties at Elevated Temperatures

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Introduction

Reduced activation ferritic steels (RAFs) JLF-1 (9Cr-2W-V,Ta steel) is one of the reference materials of the IEA RAF R&D activity for fusion blanket structural material. JLF-1 was reported to keep excellent mechanical properties and microstructural stability after heavy neutron irradiation up to 100dpa[1]. Recently, JLS-series (9Cr-xW-V,Ta steels; x=2.5, 3.0 and 3.5) have been produced as options of RAFs for use at higher temperature in advanced blanket systems. In this series, improved creep and tensile properties at elevated temperatures were intended by increased tungsten contents. In this present, correlation between microstructure of RAF and mechanical properties at elevated temperature.

Experimental

JLS-series were named as JLS-1, JLS-2 and JLS-3 with the increase of tungsten content. To obtain fundamental properties of RAFs at elevated temperature, creep rupture test was performed. Microstructural observation was performed by TEM to investigate correlation with creep property. TEM specimens were prepared from creep-ruptured specimen in order to investigate phase stability under creep condition. TEM specimens were cut from tested specimens close to fracture surface

Results and discussion

Figure 1 shows the creep properties of JLF-1 and JLS-series. According to the result, creep properties improved with tungsten addition. Microstructures in tested specimens are shown in figure 2. With the increase of tungsten content, martensite lath width became narrower and dislocation density increased. Precipitates in JLS-2 were smaller than in JLF-1. Like this precipitation morphology improve mechanical property by inhibiting movement of dislocation.[2] Generally, degradation of creep properties is caused by coarsening precipitates on grain boundaries and within grains such $M_{23}C_6$ type carbides and Laves phase, diminishing dislocation density and evolution grains.[3),4)]

From making comparison with microstructures, JLS-2 had better microstructural features, from the view of improvement of creep property, for example very fine precipitates within grain, high dislocation density in martensite structure. In addition to that, JLS-2 tungsten content is more than in JLF-1, so it can be considered that JLS-2 tungsten content in matrix was more than JLF-1 too. Solutes in matrix inhibit climbing of dislocation and iron self-diffusion, these contributed to the improvement of creep property with the increase of tungsten content.

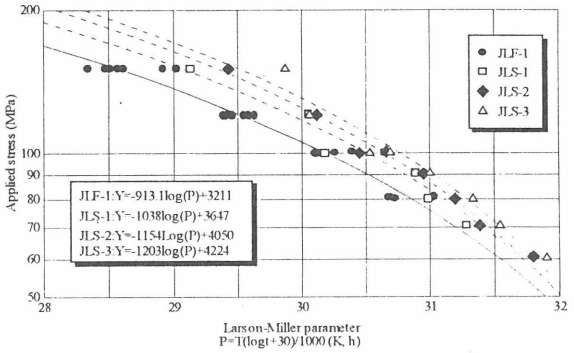

Figure 1 – *Creep properties summarized by Larson-Miller parameter*

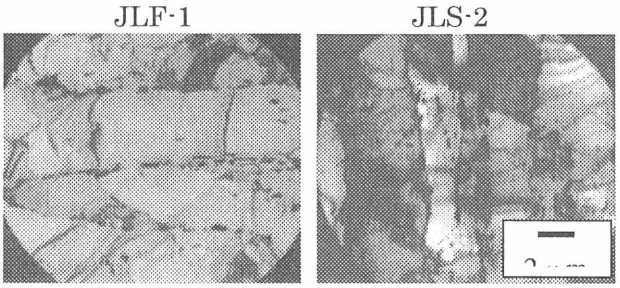

Figure 2 – *Microstructure of crept specimen @ 700C*

Reference

1) Y. Kohno, A. Kohyama, T. Hirose, M. L. Hamilton and M. Narui, Journal of Nuclear Materials, 258-263 (1998) 145.
2) T. Shibayama, A. Kimura, H. Kayano, "The effect of small additionl elements on the precipitatetion of reduced activation Fe-9Cr-2W steels", Journal of Nuclear Materials 233-237, 1996, p.270-275
3) Wendel B.Jones, "Effects of Mechanical Cycling on the Substructure of Modified 9Cr-1Mo Ferritic Steel", ASTM Metals Park, Ohio 44073, 1983, p.221-235
4) F. Abe, H. Araki, T. Noda, "The effect of tungsten on Dislocation Recovery and Precipitation Behavior of Low-Activation Martensitic 9Cr Steels", METALLURGICAL TRANSACTIONS A, 22A, 1991, p.2225-2235