§ 7. Effects of Increased Tantalum Content on Creep Property of Reduced Actication Ferritic/Martensitic Steels

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Reduced Activation Ferritic/Martensitic steels (RAFs) are leading candidates for structural materials of D-T fusion reactors. RAFs have great interest to simplify the special waste storage of the highly radioactive blanket and first-wall structures from fusion reactors after service. One of the RAFs, JLF-1 (9Cr-2W-V, Ta), has been developed and proven to have good resistance against high-fluence neutron irradiation and good phase stability.

Recently, in order to achieve better energy conversion efficiency by using RAFs at higher temperatures in advanced blanket systems, improvement of high temperature mechanical properties is desired. For examples, modification of chemical composition and developments of oxide dispersion strengthened steels (ODS steels) are performed. Among the strengthening mechanisms precipitation hardening is the most reliable in developing RAFs and other heat resistant steels. Precipitates carbo-nitrides of MX type particles, such as TaX (X=C, N), are usually extremely fine and stable for a long time at high temperatures. However, detailed effects of MX type particles on creep property are not known sufficiently.

Based on such back grounds, effects of increasing tantalum content on creep property of RAFs were studied in this work. Used materials are JLF-1 LN+B and JLF-1 LN+BTa. These steels were prepared to improve high temperature mechanical properties by reducing nitrogen content, adding boron and increasing tantalum content.

Table 1. Chemical compositions and heat treatments.

(wt%)		C	N	Cr	W	Ta	B	Mn	Si	P	S	Fe
	IEA-heat	0.097	0.0237	9.04	1.97	0.070	-	0.46	<0.1	0.0030	0.0002	Bal.
JLF-1	LN+B	0.097	0.0150	8.99	2.01	0.100	0.0027	0.50	0.049	<0.002	0.0004	Bal.
	LN+BTa	0.096	0.0151	8.97	2.01	0.140	0.0026	0.49	0.050	<0.002	0.0007	Bal.

Normalized at 1323 K x 3.6 ks followed by air-cooling
Tempered at 1053 K x 3.6 ks followed by air-cooling

Fig. 1 shows creep rupture test results performed at 923 K. With increasing tantalum content, creep rupture time decreased and intended developments of creep property were not obtained.

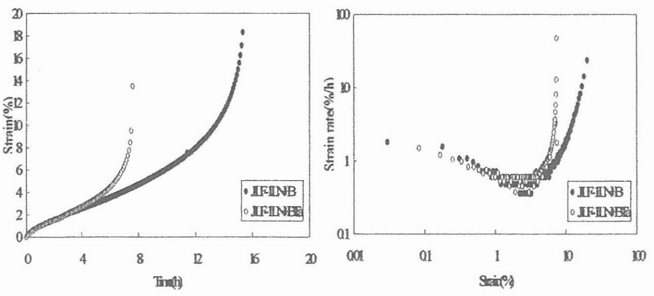
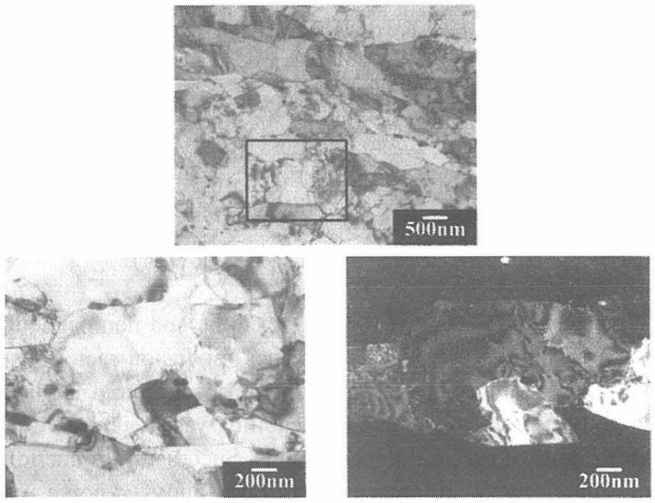
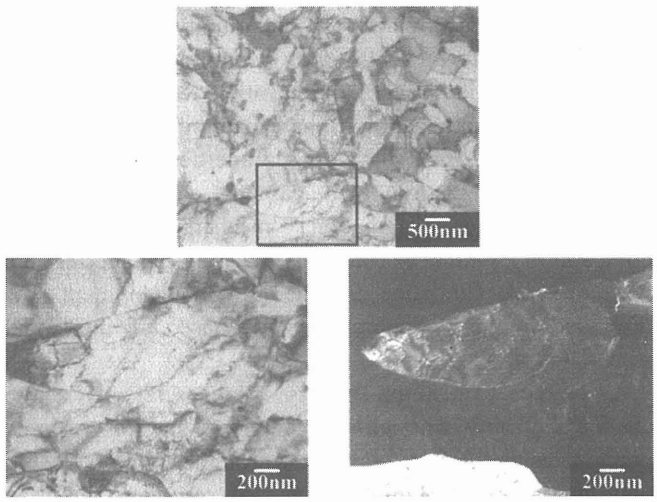


Fig. 1. Creep rupture test results.



(a) JLF-1 LN+B as NT ($z \approx [\bar{1}11], g = [110]$)

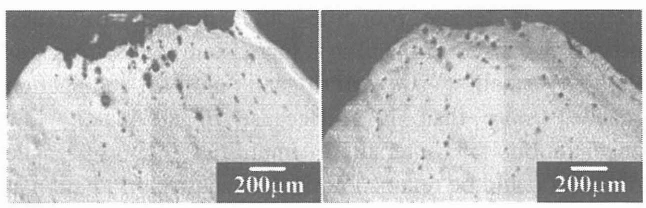


(b) JLF-1 LN+BTa as NT ($z \approx [\bar{1}11], g = [110]$)

Fig. 2. TEM images before creep rupture tests.

Microstructural features observed by TEM are given in Fig. 2.

Comparing JLF-1LN+B and JLF-1LN+BTa, in differences of MX type particles dispersion and in dislocation structures can be observed. From the observation of optical microscope images, prior austenite grains were refined with increasing tantalum content. However, fine grains can cause intergranular slips and formation of cavities during creep rupture tests. It is well known that such microstructures weaken creep properties. These cavity formations during creep rupture test are shown in figure 3. In order to apply effect of precipitation hardening by MX particles, it is necessary to optimize chemical compositions such as increasing carbon content and to optimize heat treatments.



(a) JLF-1 LN+B (b)JLF-1 LN+BTa

Fig. 3. Cavities in creep ruptured specimens.