§3. Analysis on Precipitation Behavior of Reduced Activation Ferritic/martensitic Steels with Extraction Residue Tests

Nagasaka, T., Hishinuma, Y., Muroga, T.,
Watanabe, H. (RIAM, Kyushu Univ.),
Sakasegawa, H., Tanigawa, H., Ando, M. (JAEA)

Reduce activation ferritic/martensitic (RAFM) steels, such as F82H and JLF-1, have been developed as the structural materials for fusion blanket. Aging tests for the RAFMs has indicated that additional precipitation of MC (M = V, Ta) strengthened the steels, while precipitation of Laves phase (Fe_2W) reduced the strength due to loss of solution hardening by W. However, more investigation for their precipitation behavior is essential especially under the conditions with long term aging and stress, which can simulate operation condition for the fusion reactor blanket. The purpose of the present study is to make analysis on the precipitation behavior of the candidate RAFMs.

Materials used were F82H-IEA heat, F82H-BA07 heat and JLF-1 steels. All the steels are aged at 700 °C for 100 hr. F82H-IEA heat was aged at 400-650 °C for 100 khr. Creep tests were conducted on F82H-IEA heat. After the creep tests, the gauge section and grip of the creep specimen were aged at 700 °C for 100 hr. The specimens with and without the aging and the creep tests were examined by extraction residue tests with the standard methods of JIS G0577 and JIS G0579. The extraction residue was separated by using the filters with different pore size, such as 0.05, 0.1 and 1 μm. Weight measurement was conducted for the residues. The filters containing the residues were chemically analyzed by Inductive-coupled plasma atomic emission spectroscopy (ICP-AES). The residues were also identified by X-ray diffraction (XRD) spectrometry.

Figure 1 depicts the amount of extraction residue for the RAFMs. Increase in the amount of residue was observed in F82H-IEA heat at the 100 khr aging and creep condition above 550 °C. In the XRD analysis, $M_{23}C_6$ was identified in all the size of residue and in all the conditions. Laves phase were identified in the 1-10 μm residues above 550°C. TaC peak were detected for all the steels at as-NT condition. From the ICP-AES analysis and XRD analysis, this increase was attributed to enhanced precipitation of $M_{23}C_6$ and Laves phase. 100 hr aging at 700 °C did not lead to significant change in the amount of residue in all the steels.

Since degradation of the creep strength with longer rupture time than 10 khr has been reported for 10-12Cr steels due to formation of Z phase (Cr (V, Nb) N) accompanied by disappearance of fine MX precipitates, the present study tried to find the Z phase carefully by the detailed XRD analysis. Fig. 2 plots XRD spectra after the 700 °C aging around the Z phase peak angle (2θ = 39.9°). In Fig. 6, no Z phase peak was detected in the present conditions. Possible reason is low concentration of N in F82H-IEA heat (0.006 mass%) compared with the typical 10-12Cr steels (~0.05 mass%). Moreover, Z phase is thought to be formed due to the decomposition of MX (M: Ta, V, X: C, N), therefore very few original TaC could not be a source for Z phase. Since F82H-BA07 heat and JLF-1 contain more N and precipitate TaC more effectively than F82H-IEA heat, Z phase should be analyzed carefully during the longer time creep tests than 10 khr.

This work was supported by NIFS budget code NIFS11-UFZG002-4, and JAEA-NIFS Joint Work contract No. 24K-393, as a part of Broader Approach activities.

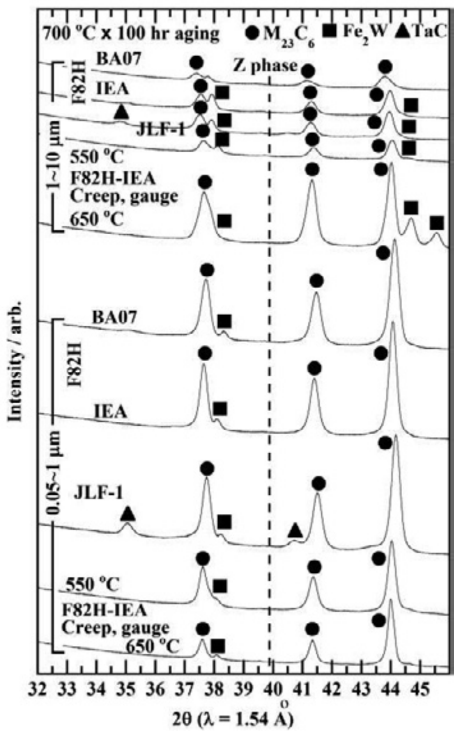

Fig. 2 XRD spectra for the residues from F82H-IEA heat with the NT heat treatment and the creep tests followed by the aging at 700 °C for 100 hr.

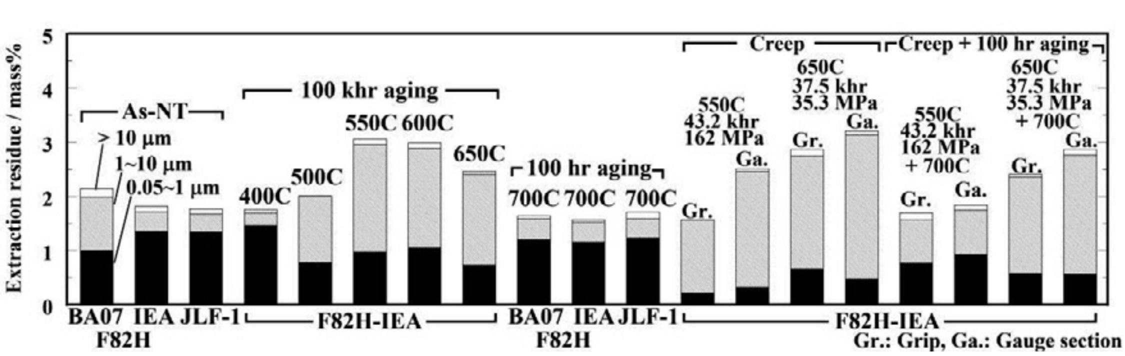

Fig. 1 Amount of extraction residue of the RAFM steels.