§12. Prediction of Creep Performance in Typical Blanket Conditions for JLF-1 and CLAM Steels

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Introduction

Reduced Activation Ferritic/Martensitic (RAFM) steels are the candidates of the blanket structural materials in fusion reactors.[1] They should be in service at high temperature for more than 10 years. The maximum operation temperature of blanket will be determined mainly by the thermal creep deformation of the materials. Thus evaluation of the creep performance in blanket conditions is the key necessity.[2] In addition, the thermal ageing during the operation may affect the creep properties.[3] However, the research into the thermal ageing effects on the creep deformation is quite limited.

Since testing materials for the actual operation time is extremely costly and time-consuming, prediction of creep performance in blanket conditions was carried out by Larson-Miller parameter, based on the results of short-term creep experiments at higher temperature with higher stresses.

Experimental

The materials used were JLF-1 (JOYO-II-HEAT) and CLAM (0603 HEAT) steels, which are Japanese and Chinese candidates of RAFMs, respectively.

Thermal ageing treatments were carried out at 823 to 973 K up to 2000 h. The creep tests were conducted at 823 to 923 K with the applied stress from 150 to 300 MPa in a vacuum of < 1 x 10^{-4} Pa.

Results

The Larson-Miller (L-M) parameter (P_{LM}) is one of the popular methods for predicting the long-term creep performance, which is described by the following equation:

$$P_{LM} = T(C + \log t_r) \times 0.001 \qquad (1)$$

where T is the test temperature, K;

t_r is the rupture time, hour;

C is a material constant, (C=30 for JLF-1 and CLAM).

This relation shows that the two parameters, temperature (T) and rupture time (t_r), can be combined into one equation. In addition, the data by short-term experiment at higher temperature can be used for predicting those by long-term experiments at lower temperature.

The prediction results for the both steels are shown in Fig.1. The results including the ageing effects are shown in Fig.2 and Fig.3 for JLF-1 and CLAM, respectively.

The results showed that, in a typical blanket condition, 823 K for 100 000h, the L-M parameter is equal to 28.8, and the estimated rupture stress was about 135 MPa for the both steels.

In addition, the present ageing treatments can influence the rupture stress by about ±15MPa for the both steels. This sort of variations should be considered in the design of blankets.

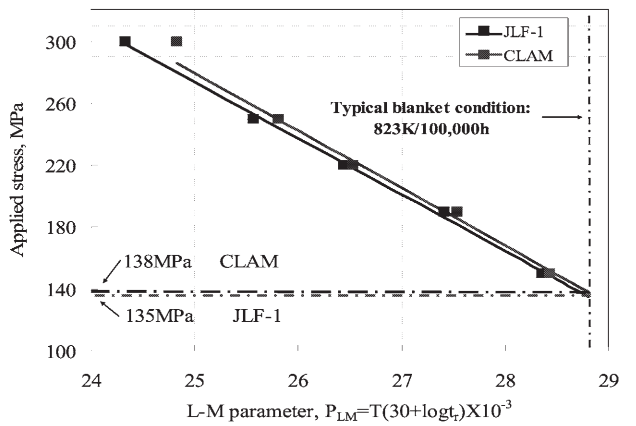

Fig. 1 The applied stress as a function of L-M parameter for JLF-1 and CLAM before ageing.

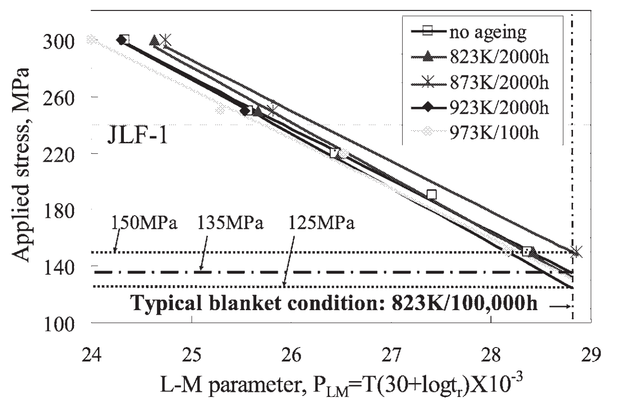

Fig. 2 The dependence of applied stress on L-M parameter for JLF-1 after different ageing treatments.

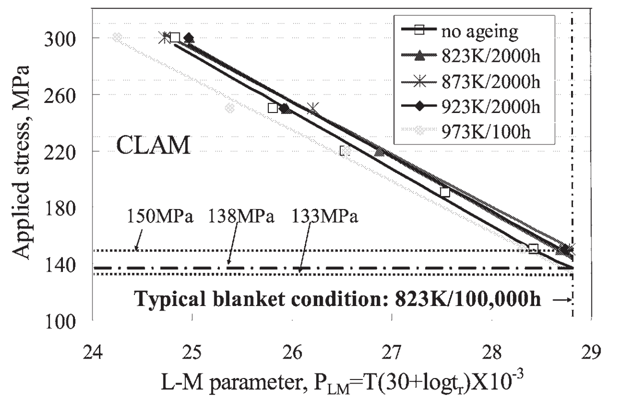

Fig. 3 The dependence of applied stress on L-M parameter for CLAM after different ageing treatments.

1) T. Muroga, et al., Fus. Eng. & Des.**61-62** (2002) 13.
2) F. Abe, Mater. Sci. Eng. A, **319-321** (2001) 770.
3) J. Lapeña, *et al.*, J. Nucl. Mater. **283-287** (2000) 662