

Development of Creep Strain Model of Alloy 690

Seongin Moon, Joon-Yeop Kwon, Jong-Min Kim, Bong-Sang Lee, Kwon-Jae Choi and Min-Chul Kim
 Korea Atomic Energy Research Institute
 Simoon21c@kaeri.re.kr

1. Introduction

Steam generator (SG) tube rupture in nuclear power plant has been a concern of environment contamination in a severe accident scenario. Creep is a kind of irreversible time-dependent nonlinear deformation process and the creep damage during a severe accident accumulates within only several hours or days [1]. Hence, accurate modeling of creep behavior of the SG tube is important to SG tubes integrity assessment. In this paper, a new creep model for Alloy 690 SG tube material was proposed. The model is based on theta (θ) projection method and contains all three stages of a creep process.

2. Creep Test

A series of creep tests for Alloy 690 SG tube material was conducted in the temperature range of 650 ~ 850 °C. The specimens were machined along the longitudinal direction of SG tubes. The geometry and dimension of test specimens are shown in Fig. 1. Fig. 2 shows the experimental creep strain curves for Alloy 690 at 700 °C.

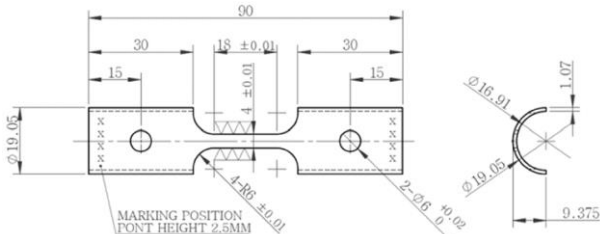


Fig. 1 Geometry and dimension of creep specimen

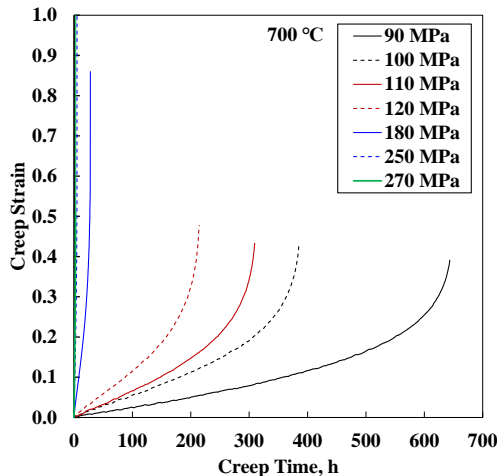


Fig. 2 Creep curves for Alloy 690 SG tube

3. Modified Theta Projection Method

Modeling all three stages might be beyond interest for industrial structure designs but is so important to SG tubes integrity assessment during a hypothetical severe accident. The θ projection method is one of whole creep modeling methods. Original θ projection method was not able to properly fit the tertiary stage of the creep curves. Hence, a new modified θ projection method was proposed to more accurately fit the creep curves in all three creep stages as follows:

$$\varepsilon = \theta_1(1 - e^{-\theta_2 t}) + \theta_3(e^{\theta_4 t^{\theta_5}} - 1) \quad (1)$$

where θ_i ($i = 1, 2, 3, 4$ and 5) are the 5 theta coefficients obtained by regression analysis from experimental creep curves. The model parameters, $\ln\theta_i$, can be assumed as a linear function of temperature, T , and stress, σ , but θ_5 is independent on the temperature and stress.

Fig. 3 illustrates the creep curves predicted with the modified θ projection method compared with experimental ones at 700 °C. The predicted curves proved to show the three-stage creep process. Good agreement has been achieved between the experimental creep curves and the corresponding prediction ones.

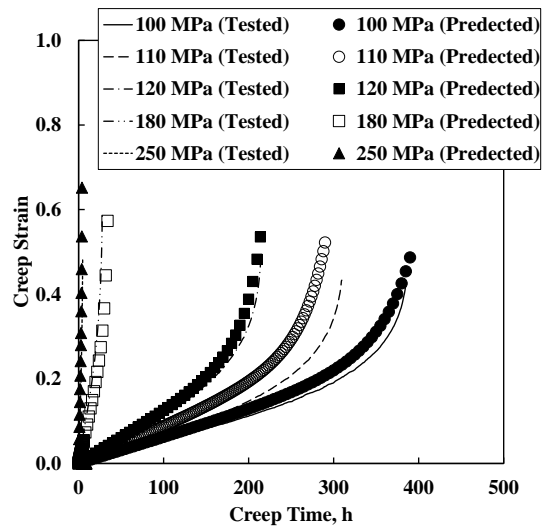


Fig. 3 Creep strain prediction result using θ projection model-based model

REFERENCES

- [1] Y. Liao, S. Guentay, Potential steam generator tube rupture in the presence of severe accident thermal challenge and tube flaws due to foreign object wear, Nucl. Eng. Des. 239, pp. 1128-10, 2009.