Creep Strength Evaluation Based on Creep Strain Analysis for High Temperature Materials

Y.-H Huh[1*], J. Hahn[1], S.G. Hong[1], D.W Kim[1], J.H. Hwang[1], I.H. Chung[1]

[1]Division of Industrial Metrology, Korea Research Institute of Standards and Science, Daejeon, South

*Corresponding author: yhhuh@kriss.re.kr

1. Introduction

A lot of high temperature materials, including ferritic, austenitic steels and Ni-base superalloys, have been used and developed for upgrade of the coal-fired power plants. Recently, as the SC(Supercritical), USC(ultra-supercritical) and AUSC(Advanced ultra-supercritical) power plants have been developed and established, compatibility of these materials for use in operation of the upgraded plants became a key issue for clean coal technology

Allowable stress of the creeping materials at high temperatures could be determined from the standard code, like ASME or EN, based on the creep rupture strength. The stress can be defined from the creep-strain properties analysis, as well. So, in this study, the allowable stresses for high temperature materials were determined from the creep strain properties analysis. From the analysis, creep strain rate, creep-rupture, 1% creep strain and initiation of tertiary creep could be obtained, and the allowable stresses determined from these different criteria were compared.

2. Determination of allowable stress

In this study, creep strain properties of typical candidate materials for SC, USC and AUSC boiler and piping system, like T91, TP347HFG, Super304H, and TP310HCbN, were obtained from the creep test.
The allowable stress was determined from the time dependent criteria defined from ASME Section III Div. 1, NH, which can be referred to as the followings;

• 100% of the average total stress required to obtain a total strain of 1% (elastic, plastic, primary and secondary creep)
• 67% of the minimum stress to cause rupture
• 80% of the minimum stress to cause the initiation of tertiary creep

The allowable stress based on the properties at 100,000 hours could be obtained, and the stresses was predicted with LMP(Larson-Miller Parameter).

3. Results and Discussion

The creep properties, including creep rupture and creep strain, for four high temperature materials were obtained at testing temperatures ranging from 500 to 750 °C. Creep rupture hours were ranged from 180 to 7000 hours, depending on the materials, testing temperature and stress level. These properties were compared to those obtained in NIMS(Japan). Fig. 1 shows an example of creep strain curves, obtained in this study, for Super304H.

The minimum creep rate, stress at creep strain of 1%, and stress at the initiation of tertiary creep, which was determined from 0.2% offset, were determined for the respective materials and creep temperatures and stresses.

The allowable stresses at the creeping temperatures ranging from 500 to 700 °C for T91 alloy, and from 600 to 750 °C for TP347HFG, Super304H, and TP310HCbN were determined using LMP approach. These stresses were compared to those determined from NIMS data.

Comparison of these stresses based on the respective criteria was found to be used in design by analysis of the boiler components of the upgraded coal power plants.

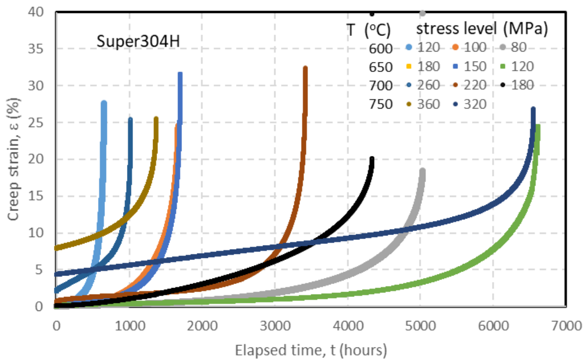

Fig.1 Creep strain curve for Super304H

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