Predictions of Long-Term Creep Life of the family of 9-12 wt% Cr martensitic steels

B8. High Temperature Material Characterisation, Testing and Mechanical Properties

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Introduction/Purpose

The contemporary power-law creep methodologies, from Wilshire et al. (2008) and Zhao et al. (2017), for predicting the long-term creep life of metals from short-term lab-based creep experiments were extended to forty eight different alloy compositions in the family of 9-12 wt% Cr steels available in the NIMS database. Both methods as empirical tools which illustrated the importance of data collection given that the short-term experiments are limited to a maximum of 6000 hours. In both methodologies, it was concluded that the mechanism-specific activation energy terms were constant for a single alloy composition in the family of 9-12 wt% Cr steels and over a limited range of normalized creep stresses (i.e., applied-stress/ultimate tensile strength).

Methods

The present study extends these methodologies to a larger range of compositions and normalized creep stresses, which highlights the limitations that the data impose on the conclusions that can be drawn from the two methodologies. In addition, the effects of alloying additions and tempering temperature on the creep mechanism were explored using a variety of data science visualization tools.

Results

It was found that by calculating activation energy using the available creep data from over fifty compositions and 1700 creep experiments, that a dependency between the activation energy and creep test conditions is observed. This contradicts the conclusions made by previous authors.

Conclusions

This raises questions about the physical interpretation of fitting parameters in the modified power-law adopted by both methods and questions the reliability of the predictions made for lifetimes extrapolated beyond the short-term experiments.

Selected references

B. Wilshire and P. J. Scharning, “A new methodology for analysis of creep and creep fracture data for 9–12% chromium steels,”*International Materials Reviews*, vol. 53, no. 2, pp. 91–104, Mar. 2008.

Y. R. Zhao, H. P. Yao, X. L. Song, J. Jia, and Z. D. Xiang, “On the physical models for predicting the long-term creep strengths and lifetimes of modified 9Cr-1Mo steel,” *Journal of Alloys and Compounds*, vol. 726, pp. 1246–1254, Dec. 2017.