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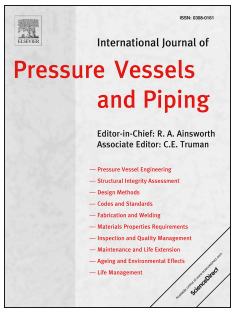

Reliable analysis and extrapolation of creep rupture data

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Reliable analysis and extrapolation of creep rupture data

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Abstract:

The P-NID (Parametric, Numerical Isothermal Datum) method of extrapolating creep rupture data has been applied to the four large datasets recently analysed by the European Creep Collaborative Committee in order to re-evaluate its own recommended procedure. It is demonstrated that the P-NID method provides a very reliable basis for extrapolation.

Keywords: Creep rupture, rupture model, extrapolation, P-NID method

1. Introduction:

The progressive development of high-temperature plant since the 1950s has depended upon the development of creep-resistant materials; and the provision of design data for their long-term rupture properties has relied upon extrapolation from shorter-term rupture tests. Numerous techniques of modelling and extrapolation have been developed over that period for that purpose. The models employed, whether long-established or of recent origin, and whether or not they purport to represent creep mechanisms, are generally in the form of a mathematical equation for rupture life as an explicit function of temperature and stress. Each contains a number of numerical coefficients that are determined by fitting to the data. However, such models have achieved only intermittent success, being found to fit data satisfactorily for one material but less well for another.

It is not unusual for researchers within different organisations to favour different types of model, or different procedures for model optimisation, with the result that wide divergences may be found between predictions of long-term life. In consequence, it is likely that some extrapolations that form the basis of current design data are less reliable than design engineers suppose. It has long been the aim of analysts concerned by such divergences to establish a greater consistency of practice, both in the comparative review of candidate models and in the application of validity tests.

Much work has been done to improve matters by the European Creep Collaborative Committee (ECCC), which has recommended a set of validity tests applicable to any mathematical model, but this approach has met with only partial success. As a result of known problems within this procedure, the relevant ECCC Working Group (WG1) performed a recent re-evaluation of their own recommendations using large datasets for 2.25Cr1Mo steel, 11%CrMoVNb steel, Type 304 stainless steel and Incoloy 800 as test cases. Their results were published in [1].

The present article reports a similar exercise in which a fundamentally different approach, the P-NID method [2, 3] was applied to the same datasets, which were made available for that purpose by ECCC. The method is described in the context of its application to each material in the following sections, and a general synopsis of the method is given in Appendix A. Comparisons are made between P-NID models for these datasets and models proposed by ECCC [1]. Reliability in extrapolation is tested by constructing models from short-term data and comparing their predictions to long-term data omitted from the modelling process.

2. Analysis of 2.25Cr1Mo steel data:

2.1 Determination of median rupture lives

The ECCC dataset for 2.25Cr1Mo includes the results of 1016 tests to rupture at temperatures between 450 ^{o}C and 650 ^{o}C, after the elimination of anomalous and duplicated results. It incorporates