

ELASTIC-PLASTIC CONSTITUTIVE EQUATIONS FOR TYPE 304 STAINLESS STEEL

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Type AISI 304 stainless steel is a primary candidate for use in liquid-metal-cooled fast breeder reactor systems. Because of the performance demands to be placed on the components of these systems, it is necessary to have reasonably precise predictions of structural behaviors throughout the projected load and temperature histories for critical components.

This paper presents a mathematical analog for describing isothermal, small-deformation, elastic-plastic behavior of AISI 304 stainless steel. This analog is derived on the basis of observations from uniaxial tests wherein the specimens were subjected to various cyclic loading histories. The data show that a nonlinear kinematic hardening model is required to describe the salient features of plastic behaviour, including Bauschinger effects. In addition, there is pronounced material hardening during the first 10-15 cycles under repeated cyclic conditions.

It is shown that existing constitutive equations do not predict the observed behavior and that additional concepts must be introduced. The second rank tensor, α_{kl} , which represents the total translation of the yield surface in Prager's kinematic hardening rule, is defined in this paper so that it will reflect nonlinear characteristics of the material behavior and, at the same time, include parameters representing the history of plastic deformation. Thermodynamic principles and studies by Kadashevich and Novozhilov as well as by Kröner are used to provide guidance for the formulation. The resulting multiaxial plastic stress-strain relations of flow theory are then derived.

Comparisons are made between predicted and experimental results for selected uniaxial cases of loading. In addition, calculated results for a simply supported rectangular beam, subjected to cyclic loadings by application of concentrated loads at the center, are compared with experimental results.