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Cyclic accumulation of the inelastic strain in the 304L SS under stress control at room temperature: Ratcheting or creep?

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ABSTRACT

The main objective of the work is to investigate the importance of time dependent phenomena in the cyclic behavior of the 304L SS at room temperature. The contribution of creep in the cyclic evolution of the inelastic strain observed under stress control is particularly studied through various tests using proportional and non proportional loading paths. The test results demonstrate that the behavior is strongly rate dependent. Moreover, most of the cyclic accumulation of the inelastic strain is due to creep which implies that ratcheting is very small for the different conditions considered. The study clearly shows that a correct description of the behavior of the 304L SS at room temperature cannot be obtained without time-dependent constitutive equations. The tests performed have been simulated with the multimechanism constitutive equations after the identification of its 17 parameters. The quality of the simulations is in good agreement with the experimental results especially for the non proportional loading paths.

1. Introduction

The cyclic behavior of steels still draws researchers' attention, especially the effect of non proportional loading paths under stress as well as strain control (Abdel Karim and Ohno, 2000; Aubin et al., 2003a,b; Aubin and Degallaix, 2006; Bari and Hassan, 2002; Bocher et al., 2001; Chaboche, 2008; Hassan et al., 2008; Kang et al., 2001, 2004, 2005; Kang and Gao, 2004; Khan et al., 2007; Ohno, 1997; Ohno and Wang, 1993, 1994; Portier et al., 2000; Taleb and Hauet, 2009; Taleb and Cailletaud, 2010) and so on. Austenitic stainless steels are among the most studied materials with a special interest for the 304L for its industrial use. Different works in literature point out the importance of viscous effects at room temperature for this material (see for instance Krempl, 1979). The stress/strain rate has an effect on tensile stressing (Yoshida, 1990) (Fig. 1) as well as on ratcheting (Kang et al., 2006). Under strain control, the role of the peak strain hold on hardening is demonstrated by Kang et al. (2006). The pre-cycling has also a significant effect on the subsequent creep/relaxation phenomena (Mayama and Sasaki, 2006). Under stress control, Yoshida (1990) and more recently Kang et al. (2006), pointed out the influence of the peak stress hold (Fig. 2a) and the stress rate (Fig. 2b) on ratcheting.

However, even if all agree about the existence of time dependent phenomena in the behavior of the 304L austenitic steel, this material is often simulated with time independent constitutive equations. This choice neglects implicitly the contribution of creep in the cyclic accumulation of the inelastic strain; the latter is then attributed totally to ratcheting. However, the validity of this choice needs to be investigated.

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