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A self-optimizing inverse analysis method for estimation of cyclic elasto-plasticity model parameters

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ABSTRACT

In this paper, a novel inverse analysis methodology call a Self-Optimizing Inverse Method (Self-OPTIM) has been presented, which inversely estimates cyclic elasto-plastic constitutive model parameters using global forces and displacement on the same partial boundaries and full-(or partial-) field displacement data. A novelty of the methodology is that it automatically self-estimates material parameters by updating "full-field" reference stresses and strains through two parallel nonlinear finite element simulations. Although a well-known classical cyclic plasticity model is chosen in this paper, it must be emphasized that the proposed Self-OPTIM method is a model-independent method, which means that any advanced model can be naturally integrated with the proposed methodology. Thus, using numerically generated test data of low-carbon steel specimens (AISI 1010), the proposed Self-OPTIM method has been verified showing its successful performance to estimate nonlinear isotropic and kinematic hardening parameters, yield stress, Young's modulus and Poisson ratio. The effects of experimental noises from CCD camera and measurement errors of the boundary forces are also investigated for the Self-OPTIM method.

1. Introduction

Cyclic plasticity models considering Bauschinger effect, cyclic hardening or softening with strain range effect, non-proportional hardening, and strain ratcheting under asymmetric stress cycling has been substantially advanced in the past several decades (Abdel-Karim, 2009; Chaboche, 1986, 1991; Chaboche et al., 1991; Chen and Jiao, 2004; Chen et al., 2005; Jiang and Kurath, 1997a; Khan and Cheng, 1996; Krishna, 2009; Mayama et al., 2004; Moosbrugger et al., 2008; Ohno and Wang, 1991, 1993; Sai and Cailletaud, 2007; Taleb and Hauet, 2009; Taleb et al., 2006; Wolff and Taleb, 2008; Yoshida, 2000; Zhang and Jiang, 2008). Particularly, significant research and studies to better understand complex cyclic plastic behavior of various engineering materials and improve capabilities of the cyclic plasticity model have been undertaken focusing on the superposed hardening mechanism (Bari and Hassan, 2000; Chaboche, 1989; Johansson et al., 2005; McDowell, 2000), the strain ratcheting (Abdel-Karim, 2009; Chen and Kim, 2003; Johansson et al., 2005; Mayama et al., 2004; Nakane et al., 2008; Ohno and Wang, 1991; Rahman et al., 2008; Taleb et al., 2006) and the non-proportional hardening (Doring et al., 2003; Jiang and Kurath, 1997b; Krishna, 2009; Krishna et al., 2009; Moosbrugger and Mcdowell, 1989; Taleb and Hauet, 2009; Tanaka, 1994). According to literatures (Choi et al., 2006; Jiang and Zhang, 2008; Krishna et al., 2009; Shamsaei et al., 2010; Wang et al., 2006), materials subjected to complex, multi-axial and non-proportional strain paths could show very different response compared to that subjected to rather simple deformational states often observed in traditional material testing.

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