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Experimental analysis and constitutive modelling of cyclic behaviour of 316L steels including hardening/softening and strain range memory effect in LCF regime

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Abstract

Cyclic behaviour prediction of materials and structures is always of great interest to industry. In this work, total strain controlled low cycle fatigue (LCF) tests of two 316L austenitic stainless steels (named 316L-A and 316L-B) were conducted under strain amplitudes ranging from ±0.3% to ±1.5%. The analysis of the experimental results shows that both of the studied steels undergo an initial hardening, followed by a long range of softening, especially under lower strain amplitudes (from ±0.3% to ±0.5%). For 316L-B, obvious secondary hardening can be observed under higher strain amplitudes (from ±0.8% to ±1.25%). In addition, the two steels exhibit a significant strain range memory effect during cyclic loading. It is revealed that the observed hardening/softening behaviour as well as the strain range memory effect are mainly attributed to the back stress, while the isotropic hardening variation under different strain amplitudes has a similar trend. This phenomenon is contradictory to the conventional cyclic models in the literature, in which the hardening/softening behaviour and the strain range memory effect are generally modelled through isotropic hardening variables.

From these experimental results, a cyclic constitutive model is developed and implemented to describe the cyclic behaviour of 316L-A including the hardening/softening and the strain range memory effect. First, a new non-linear kinematic hardening rule is proposed based on the classical decomposed Armstrong and Frederick's description, by introducing a kinematic hardening coefficient φ to incorporate the hardening/softening effect in the back stress. Second, a functional relation between the kinematic hardening coefficient φ and the accumulated plastic strain is established according to the analysis of cyclic hardening/softening behaviour. Then, the strain range memory effect is considered by incorporating the effect of the memory surface in the parameters of the kinematic hardening coefficient φ. An identification procedure is developed to determine all the material parameters of the cyclic constitutive model. With the constitutive model implemented, a series of strain controlled cyclic simulations are performed using cyclic jumping method. The

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