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EXPERIMENTAL DETERMINATION OF ALUMINUM 7075-T6 HARDENING PARAMETERS TO PREDICT THERMAL RATCHETING

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ABSTRACT

In this paper to predict the thermal ratcheting, kinematic hardening parameters C, γ, isotropic hardening parameters and also k, b, Q combined isotropic/kinematic hardening parameters have been obtained experimentally from the monotonic, Strain controlled condition and cyclic tests at room and elevated temperatures 20^0C, 100^0C and 400^0C. These parameters are used in nonlinear combined isotropic/kinematic hardening model to predict better description of loading and reloading cycles in cyclic indentation as well as thermal ratcheting. After each test and using stable hysteretic cycles, material parameters have been obtained for using in combined nonlinear isotropic/kinematic hardening models. Also the methodology of obtaining the correct kinematic/isotropic hardening parameters is presented in the article.

Keywords: thermal ratcheting, isotropic hardening, kinematic hardening, aluminum.

INTRODUCTION

The literature review shows that accurate closed form solutions may not be found to analyses the ratcheting behavior of the aluminum alloys under cyclic thermal loading. However, approximate solutions have been developed by Wada et al., Bree and other researchers which can be used to calculate the induced incremental plastic strains caused by ratcheting. The evaluation procedures of thermal ratcheting in the present thermal ratcheting design of ASME rules shows that the primary stresses play an important role, so that they do not cover the case of ratcheting under pure or dominant thermal cyclic loads.

The ratcheting occurs under the prescribed asymmetrical cyclic stressing for materials, and ratcheting strain increases progressively cycle by cycle. However, the materials do display some differences in ratcheting behavior. When the nonlinear isotropic/kinematic hardening model is used, the center of the yield surface moves in stress space due to the kinematic hardening component and the yield surface range may expand due to the isotropic component. These features allow modeling of inelastic deformation in metals that are subjected to cycles of load or temperature, resulting in significant inelastic deformation and, possibly, low cycle fatigue failure. The nonlinear isotropic/kinematic hardening model can provide more accurate results in many cases involving cyclic loading. Use of this model requires the hardening parameters. In this work material parameters are determined experimentally at room (20^0C) and elevated, 100^0C and 400^0C.

RESULTS AND CONCLUSIONS

A typical Curve-fit data to calculate combined hardening parameters calibration for aluminum 7075-T6 are shown in Fig 1. The values of hardening constants for the same type of material are given in Table 1.

Table 1 - Values of hardening constants for aluminum 7075-T6

Material	Experiment	T(^{0}C)	C(MPa)	γ	Q(MPa)	b
Aluminum 7075-T6	Stabilized cycles	20	5324	31.06	137.6	6.82
		100	6226	73.9	134.5	7.379
		400	1768	28.68	164.5	9.56

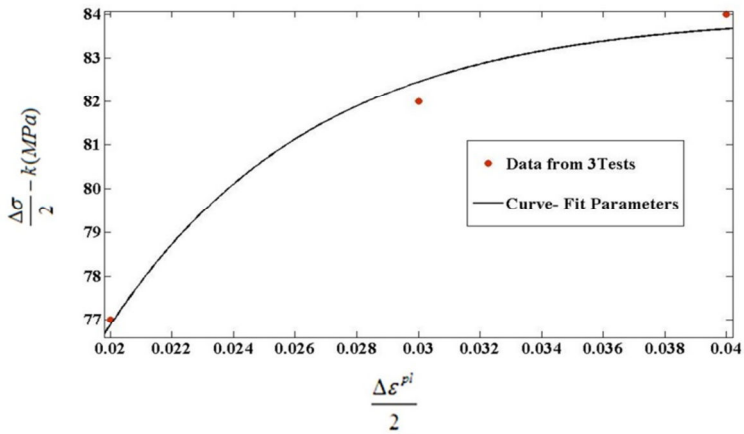

Fig. 1 - A typical Curve-fit data for obtain kinematic hardening parameters for the aluminum 7075-T6 at 100^{0}C

The information in this study may serve as a starting point for researchers wishes to use combined hardening model to predict the ratcheting. Using nonlinear isotropic/kinematic (combined) hardening model to predict the ratcheting behavior is more accurate results. For using this model to predict thermal ratcheting, stress-strain data and kinematic hardening parameters C, γ and also isotropic hardening parameters k, b, Q have been obtained for aluminum 7075-T6 from the monotonic and cyclic tests at 20^{0}C, 100^{0}C and 400^{0}C and strain controlled condition experimentally. Also the methodology of obtaining the correct kinematic/isotropic hardening parameters is presented in this work.

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