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The Prediction of Isothermal Cyclic Plasticity in 7175-T7351 Aluminium Alloy with Particular Emphasis on Thermal Ageing Effects

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Abstract

Rapid thermal ageing has been observed in the literature for certain aerospace aluminium alloys under conditions which are foreseeable in their intended component applications. While several experimental programs have explored this phenomenon in the laboratory, efforts to incorporate these effects in unified constitutive models have, to date, been lacking. In the present work, a modified elastic-viscoplastic material model has been fitted to 7175-T7351 aluminium alloy data under fully-reversed uniaxial (strain-controlled) isothermal loading conditions at 160°C and 200°C. These temperatures were chosen in order to represent nominal and extreme (but still operationally relevant) conditions experienced by aero-engine gearbox components. The modified elastic-viscoplastic model is able to accurately predict the hysteresis loops of the strain-controlled fatigue data of each sample at 160°C and 200°C. Additionally, it was found that the isotropic hardening can be effectively de-coupled into material ageing and mechanical softening components.

1 Introduction

The Advisory Council for Aviation Research and Innovation in Europe (ACARE) aim to reduce CO_2 emissions per passenger kilometre by 75% and NOx emissions by 90% by the year 2050, in relation to the year 2000 emission records. One way to improve the specific fuel consumption is to reduce the weight of the aircraft. This would result in less fuel being consumed and less emissions being produced [1]. Both cast aluminium and titanium alloys are currently used for aero-engine gearbox housing applications, with the former offering comparatively low density and moderate yield and fatigue strength properties. 7000 series alloys are usually used for structural components such as aircraft wing, airframe and fuselage applications because of their remarkable combination of low density, high yield strength and fatigue strength, and easy formability [2]. If aluminium materials can be demonstrated to be suitable for housing applications, then reductions in component weight of around 40% could be achieved[3], along with estimated reductions in manufacturing costs of approximately 60%. The use of aluminium alloys for this application is however limited at elevated temperatures due to the detrimental evolution of the alloys metastable microstructure. Elevated temperatures in the present context may be considered, at