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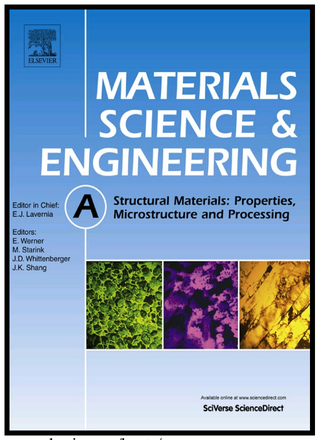

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Wu ZENG, Huang YUAN

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Mechanical Behavior and Fatigue Performance of Austenitic Stainless Steel under Consideration of Martensitic Phase Transformation

Wu ZENG[a], Huang YUAN[b,*]

[a]School of Mechanical and Vehicular Engineering, Beijing Institute of Technology, Beijing, China
[b]School of Aerospace Engineering, Tsinghua University, Beijing, China

Abstract

The martensitic phase transformation of the metastable austenitic steel increases yield strength and ultimate stress, but decreases ductility. Evolution of the martensite depends on both plastic strain and stress triaxiality. Experiments at room temperature reveal that the martensitic phase transformation in the austenitic stainless steel 06Cr19Ni10 becomes obvious only for large strains, e.g. >30%. Increasing the material temperature may diminish the phase transformation significantly. By testing specially fabricated specimens, the cold hardening of the material was decomposed into a plastic strain related part and a martensitic phase part. Comparison with experiments confirms that the mechanical behavior of the austenitic-martensitic material can be described by J_2 plasticity, combining with the Santacreu model for the phase transformation. Furthermore, the stress-controlled fatigue experiments on the distorted stainless steel display that in the high cycle fatigue regime the plastic strain improves the material's fatigue resistance, while the martensitic phase transformation increases the fatigue property in the finite life regime. However, in the $\epsilon - N$ diagram the benefits from the martensitic phase transformation decrease with loading amplitude and the plastic deformation may reduce fatigue performance. In the LCF region the distorted material shows generally worse fatigue property than the base material.

Keywords: Strain-induced phase transformation, martensitic phase, plasticity modeling, fatigue damage, fatigue life

1. Introduction

It is known that the austenitic steel may change its crystallographic structure if the material is distorted severely, the face centred cubic austenitic phase may transform into the body centred cubic martensitic phase [1–3]. Martensitic phase transformation is a spontaneous crystal lattice rearrangement of a parent phase into a product phase and driven by the Gibbs free energy difference between the parent and the product, or by the external applied loads [4, 5]. The martensitic phase possesses higher yield strength and may improve the fatigue resistance of the austenitic steel. Additionally, the transformation of the austenitic phase into the martensitic phase generally induces compressive residual stresses and enhances performance of the materia [6, 7]. Therefore, the phase transformation becomes an important mechanism for manufacturing high performance parts. The mechanical behavior of the mechanical part is changed depending on the fraction of the phase transformation.

The crystallographic structures can transform to martensitic phase under plastic deformation [8–13]. However, the quantified evaluation of the martensitic phase transformation needs detailed

*Corresponding author.
Email address: yuan.huang@tsinghua.edu.cn (Huang YUAN)