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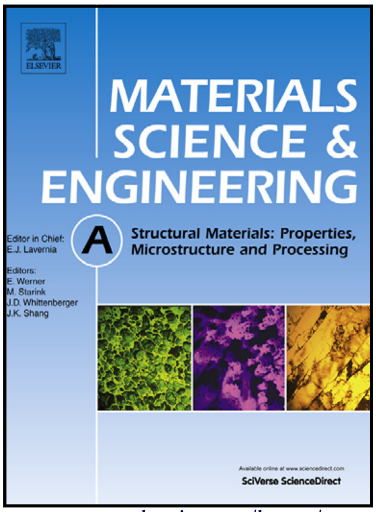

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Flavien Vucko, Cédric Bosch, David Delafosse

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Experimental investigations of internal and effective stresses during fatigue loading of high-strength steel

Flavien VUCKO, Cédric BOSCH, David DELAFOSSE

Ecole Nationale Supérieure des Mines, SMS-EMSE, CNRS: UMR 5307, LGF: Laboratoire Georges Friedel, 158 cours Fauriel, 42023 Saint-Etienne, France

Corresponding author: Flavien Vucko. Tel.: +33 4 77499775; fax: +33 4 77420157; E-mail address: vucko@emse.fr

Cédric Bosch e-mail address: bosch@emse.fr

David Delafosse e-mail address: david.delafosse@emse.fr

Abstract

Low cycle fatigue tests are performed on a high strength tempered martensitic steel at different plastic strain amplitudes at room temperature. Internal and effective components of the flow stress are analyzed using Handfield and Dickson's method. The internal stress is affected by the plastic strain amplitude. Conversely, the evolution of the athermal component of the effective stress with the number of cycles is independent of the plastic strain amplitude. The thermal part of the effective stress increases with the plastic strain amplitude, but remains constant with plastic strain accumulation. Microstructural changes in the cyclically deformed material are investigated by means of TEM and X-Ray characterizations. Internal and effective stress evolutions are discussed based on these observations.

Keywords: High strength steel; Fatigue; Internal stress; Effective stress; Dislocations

1. Introduction

The fatigue lifetime of materials is mainly controlled by initiation of a crack from microstructural or surface defects [1]. Without pre-existent critical defects, as porosity or coarse precipitates, initiation is induced by emergent persistent slip bands (PSB) or dislocation cells, depending on materials composition and crystallography [1]. The rearrangement of dislocations is directly linked to strain and stress state in the material. The aim of this study is to use a mechanical approach which could be correlated to the evolution of the microstructure leading to the crack initiation.

The cyclic behavior of high-strength steel is characterized by the shape and the evolution of the cyclic stress-strain hysteresis loops [2–9]. At room temperature, the cyclic plastic strain is fully controlled by the mobility