CAN POLYCRYSTALLINE MICROSTRUCTURE ACCOUNT FOR THE SCATTER IN THE NUMBER OF CYCLES TO INITIATION OF A HIGH-CYCLE FATIGUE CRACK?

M. Sauzay*, P. Blondel**

This paper is dedicated to an attempt to model the link between random microstructures and the initiation characteristics of high-cycle fatigue of Face-Centred Cubic (FCC) polycrystals (scatter, grain size effect). Crack initiation usually takes place along slip bands. This mechanism is modeled using an energy criterion. Statistical computations permit us to take into account random microstructures. Predictions are compared to experimental results and are discussed with respect to the influence on scatter of cubic elasticity and micro/macro plasticity.

Key words: *high-cycle fatigue, polycrystal, scatter, crack initiation, slip band, cubic elasticity*

1. Introduction

High-cycle fatigue is one of the major cause of failure of components. Based on observations, the main part of the lifetime corresponds to initiation and propagation of microstructurally short cracks (stage I) [1]. During stage I, the local microstructure (crystallographic orientations, grain sizes, ...) is of great importance. Initiation and propagation/arrest of a given short crack depend in fact on its local environment [2]. These observations explain partially the high scatter of the numbers of cycles to failure which is classically observed when carrying out high-cycle fatigue tests [3]. Even if two specimens are identical on a macroscopic scale, their local microstructures at the grain scale are different. For Face-Centred Cubic (FCC) polycrystals, these microstructures are generally assumed to be random. Surface defects and experimental problems are other sources of scatter, but even if they are the smallest possible, a high degree of scatter is still observed. Concerning high-cycle fatigue properties, a grain size effect is usually observed too [4] and sometimes a specimen size effect [5].

All these observations could be characteristic of the initiation and/or short crack propagation periods. For the sake of simplicity, only short crack initiation is considered in the following. This is defined as the germination of a crack of one grain size length (before eventually propagating through other grains). This paper proposes a model of the link between random microstructures and initiation characteristics of high-cycle fatigue of FCC polycrystals. Modeling is divided into two steps. First, the most common crack initiation mechanism in FCC polycrystals is modeled using an energy criterion following the proposition of Mura and co-workers [6,7]. Second, thanks to statistical computations, random

* CEA, DEN/DMN/SRMA, Bât. 455, 91191 Gif-sur-Yvette cedex, France
** AREVA, Centre Technique Framatome ANP, BP 181, 71205 Le Creusot cedex, France