Accepted Manuscript

Damage Accumulation and Crack Initiation Detection Based on the Evolution of Surface Roughness Parameters

Ali Haghshenas, M.M. Khonsari

PII: S0142-1123(17)30402-4
DOI: https://doi.org/10.1016/j.ijfatigue.2017.10.009
Reference: JIJF 4483

To appear in: *International Journal of Fatigue*

Received Date: 15 August 2017
Revised Date: 15 October 2017
Accepted Date: 17 October 2017

Please cite this article as: Haghshenas, A., Khonsari, M.M., Damage Accumulation and Crack Initiation Detection Based on the Evolution of Surface Roughness Parameters, *International Journal of Fatigue* (2017), doi: https://doi.org/10.1016/j.ijfatigue.2017.10.009

Damage Accumulation and Crack Initiation Detection Based on the Evolution of Surface Roughness Parameters

Ali Haghshenas, M. M. Khonsari[1]
Department of Mechanical and Industrial Engineering, 3283 Patrick Taylor Hall, Louisiana State University, Baton Rouge, LA 70803, USA

Abstract

Cyclic strain localization generates sharp surface slip markings in the form of depressions and elevations on the surface of materials. The process gives rise to the formation of persistent slip bands and results in immanent changes that manifest themselves in the form of surface roughening. The heights and depths of these extrusions and intrusions grow during cyclic loading up to a critical value leading to crack initiation. In this study, we investigate the evolution of the surface roughness parameters starting from pristine specimens and ending in final fracture in fully-reversed cyclic bending tests. Results are presented for both low-and high-cycle fatigue that covers a wide range of surface finish. Two types of contacting (via a stylus) and no-contacting (optical) profilometers were used in this investigation. The most sensitive and useful surface roughness parameter for the assessment of fatigue growth in low-and high-cycle fatigue is identified, and it shown that results can be utilized to detect the onset of fatigue crack nucleation. For this purpose, a surface roughness criterion for detecting crack initiation at different applied loads is introduced.

Keywords: Fatigue; surface roughness parameters; persistent slip bands; extrusions and intrusions; onset of fatigue crack

1. Introduction

Fatigue is the most common type of failure in many structures and components subjected to cyclic loading. One of the most concerning issues in fatigue analysis is the difficulty in detection of crack initiation in the material. While progress has been made, a reliable methodology for the determination of the onset of crack still remains elusive.

Cracks initiate on the surface, grow and coalesce due to the localization of plastic deformation and the corresponding dissipated energy that eventually leads to final fracture. Thus, naturally, the consideration of energy dissipation and the associated degradation of microstructural parameters in materials has driven many scientists to investigate the fatigue phenomenon using the energy-based approaches [1-9]. The existing methods are generally considered to be satisfactory for low-cycle fatigue (LCF) applications in which the strain energy and macroscopic plastic strain are simpler to evaluate [10]. Recently researchers suggest new methods and techniques to develop the energy approaches to the high-cycle fatigue (HCF) applications [11-13], wherein the onset of crack remains to be a major problem.

During fatigue loading, defects in the form of dislocations produce and accumulate within the material. These accumulations gradually increase the dislocation density produced by strain localization, and manifest themselves in the form of slip bands [14]. Slip bands are the main form of surface damage, often referred to as the persistent slip marking (PSMs). The word ‘’persistent’’ indicates the reappearance of PSBs on the surface of the material on the same location, even after polishing the surface [15]. Studies have shown that this reappearance is responsible for the roughening of the surface during fatigue loading. PSMs include extrusions and intrusions created at the advent of PSBs. Encroachments or macro-PSBs are large clusters of extrusions and intrusions in the form of hills and valleys. These macro-PSMs are

[1] Corresponding author, khonsari@me.lsu.edu, V: 225.578.9192, F:225.578.5924