Engineering Failure Analysis 18 (2011) 2137–2148

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

A computer simulation of four-point bending fatigue of a rear axle assembly

Mehmet Firat

University of Sakarya, Dept. of Mech. Engineering, 54187 Adapazari, Turkey

ARTICLE INFO

Article history:
Received 12 January 2011
Received in revised form 24 June 2011
Accepted 1 July 2011
Available online 6 July 2011

Keywords:
Fatigue
Local approach
Notch analysis
Plasticity
FEA

ABSTRACT

The bending fatigue test of a rear axle assembly is simulated by using a FE-integrated fatigue analysis methodology. The presented technique is based on local stress–strain approach in conjunction with two critical plane damage parameters. The stress–strain response at a material point is computed with a cyclic plasticity model coupled with a notch stress–strain approximation scheme. Linear elastic FE stress analyses are used in the calculation of local fatigue loading. All computational modules are implemented into the software tool and used in the four-point bending fatigue test simulation of rear axles made of a high-strength alloy steel. In fatigue models, proportional loadings with a static preload are considered, and the effects of residual stresses are neglected. The fatigue test cycles and crack initiation locations are predicted using Smith–Watson–Topper and Fatemi–Socie fatigue damage parameters. Both damage parameters provided conservative test cycle estimates for the test conditions simulated. It is also observed that von Mises stress distributions cannot be used to predict fatigue crack initiation locations while Smith–Watson–Topper critical plane parameter estimated the cracking location suitably. Comparisons with the prototype tests showed the applicability of the proposed approach.

1. Introduction

The design verification practices of load-bearing structural parts of ground vehicles are commonly based on accelerated fatigue sign-off tests that a component failure is usually assumed to occur when a measurable crack is detected under a simulated loading condition. Although the structural integrity may still be preserved on the component level, number of loading cycles during the growth of fatigue cracks does not contribute the designed fatigue life of the component [1]. Consequently, the fatigue crack initiation concept plays a crucial role in durability assessment in ground vehicle industries [2]. The local stress–strain approaches are, therefore, convenient engineering tools for fatigue life prediction in this context [3]. Local stress and strain approaches are based on the hypothesis that smooth specimens tested under strain control can simulate fatigue damage in the critical location of a component if both highly-stressed region and the specimen experience identical stress and strain histories. Furthermore, a fatigue damage parameter or criterion can be defined by means of stress and/or strain functions in order to describe the equivalent damage that material is subjected in both cases. The fatigue damage of individual loading cycles is assessed on the basis of a damage parameter, and then transformed into an equivalent fatigue process that was determined by laboratory tests of smooth specimens [4,5]. Various fatigue damage parameters have been proposed in the literature [2–7] and some of them are also included in engineering design codes [8]. The scalar parameters using stress and strain ranges or amplitudes were the earlier proposals, and recent research have been directed to more

E-mail address: firat@sakarya.edu.tr

1350-6307/$ - see front matter
doi:10.1016/j.engfailanal.2011.07.005