NONDESTRUCTIVE CHARACTERIZATION OF FATIGUE DAMAGE IN A NICKEL-BASE SUPERALLOY USING NONLINEAR ULTRASONIC WAVES

J.-Y. Kim[1], L. J. Jacobs[1, 2], J. Qu[1]

G. W. Woodruff School of Mechanical Engineering
[2] School of Civil and Environmental Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0355 USA
jianmin.qu@me.gatech.edu

This research develops a robust experimental procedure to track the evolution of fatigue damage in a nickel-base superalloy with the acoustic nonlinearity parameter, β, and demonstrates its effectiveness by making absolute and repeatable measurements of β in multiple specimens subjected to both high- and low-cycle fatigue. The systematic measurement procedure developed in this research is capable of reducing the nonlinearities associated with the instrumentation, while isolating the contributions due to material damage. The experimental results show that there is a significant increase in β linked to the high plasticity of low-cycle fatigue, and illustrate how these nonlinear ultrasonic measurements quantitatively characterize the damage state of a specimen in the early stages of fatigue. The high-cycle fatigue results are less definitive (the increase in β is not as substantial), but still show a clear relationship between β and remaining fatigue life. One application of the measured β versus fatigue life data is to potentially serve as a master curve for life-prediction based on nonlinear ultrasonic measurements.

Keywords: nonlinear ultrasonic, fatigue, nondestructive evolution.