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Abstract

Some fractographic and metallographic contributions to understanding fatigue crack growth in metallic materials are reviewed, with an emphasis on environmentally assisted fatigue. The formation of ductile and brittle striations at intermediate-to-high ΔK, where each stress cycle produces a striation, is reasonably well understood at the microscopic level, but the details of the dislocation activity involved are still controversial. The evidence suggests that, in fairly benign environments, egress of dislocations around crack tips predominates, whereas environmentally assisted fatigue crack growth of many materials in liquid-metal, hydrogen, and aqueous environments involves an adsorption-induced dislocation-emission (AIDE) process at crack tips. There is also fractographic evidence that nanovoids often form just ahead of crack tips at intermediate-to-high ΔK in all environments. The effects of variables such as solution composition, electrode potential, and cycle frequency can be qualitatively explained largely in terms of surface-reaction kinetics and adsorbed-hydrogen coverage in many cases, but a quantitative understanding is lacking. Fatigue crack growth at low ΔK, even in inert environments, is not well understood, and only speculative explanations can be offered.

Keywords: Fractography, fatigue striations, embrittling environments, adsorption, dislocation activity.

1. Introduction

Fractographic studies have played (and continue to play) a pre-eminent role in understanding fatigue crack growth, although many other disciplines have, of course, made important contributions. The present paper outlines some of the key fractographic observations of fatigue at ambient temperatures, what was learnt, and what is still not well understood (or controversial). Explanations for transgranular environmentally assisted fatigue crack growth (at 'intermediate' ΔK), and the effects of variables such as the composition of the environment, electrode potential, temperature, and cycle frequency are discussed in particular. Transgranular crack growth at low ΔK in inert and embrittling environments is then considered, followed by brief comments on intergranular cracking. However, a comprehensive review is not attempted.

2. Some Key Fractographic Observations

Fatigue fractures were first studied and described in the 1840s (for railway axles), and it was noted that fracture surfaces had a smooth, cleaved ('crystalline') appearance with blue/purple interference colours around the periphery, with a fibrous appearance in the centre (where fast fracture had occurred) [1]. Macroscopic crack-front (progression) markings were probably