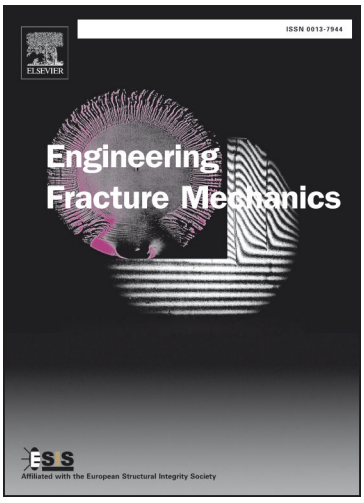

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Macro-scale fatigue fracture analysis of multiphase bodies, aircraft design, and catastrophic failure: two aircraft accidents

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Abstract

Slattery and Cizmas [1] introduced macro-scale fatigue fracture analysis (including the entropy inequality), using seven relatively simple examples (such as laminates) to demonstrate that fracture/failure could be predicted. Here we apply this same analysis to very complex multicomponent, multiphase systems: aircraft that suffered structural failures. The first was an Airbus 300-605R on American Airlines flight 587 that lost its vertical stabilizer while in flight. The second was a BAE Jetstream 31 SX-SKY aircraft whose right main landing gear failed on touchdown. Possible implications of this study for aircraft structural design are posed. It was not necessary to make any judgement about possible pilot error.

Nomenclature

$\mathcal{A}$	fresh fracture surface
CVR	cockpit voice recorder
E	Young's modulus
E_{input}	energy input
FDR	flight data recorder
G	acceleration of gravity
G_c	critical energy release rate
K_{Ic}	toughness
M	takeoff/landing mass of aircraft
Δt	critical time period
γ	thermodynamic surface tension

1. Introduction

According to the NTSB report [2], on November 12, 2001, about 0916:15 eastern standard time, an Airbus Industrie A300-605R on American Airlines flight 587, crashed into a residential area of Belle Harbor, New York, shortly after takeoff from John F. Kennedy International Airport (JFK), Jamaica, New York. The right rear lug attachment for the vertical stabilizer de-laminated and fractured, and the vertical stabilizer separated from the aircraft. On February 12, 2009, the right main landing gear on a BAE Jetstream 31 SX-SKY aircraft failed as it touched down at Heraklion, Greece. Both of these accidents are analyzed using macro-scale fatigue fracture analysis.

1.1. Macro-scale fracture analysis

There are several recent reviews of fracture [3, 4, 5, 6, 7, 8]. For this reason, we give only a limited discussion of the literature. We will focus our attention here on the use of the second law of thermodynamics (entropy inequality) in discussions of fracture, since it is the entropy inequality that allows us to predict failure.

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