Capability of Determining Fatigue Mechanisms in 7075 Aluminum by Combining Ultrasonic Attenuation and Acoustic Emission Monitoring

J. C. Duke Jr.
Johns Hopkins University

R. E. Green Jr.
Johns Hopkins University

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CAPABILITY OF DETERMINING FATIGUE MECHANISMS IN 7075 ALUMINUM

BY COMBINING ULTRASONIC ATTENUATION AND ACOUSTIC EMISSION MONITORING

J. C. Duke, Jr., and R. E. Green, Jr.
Department of Mechanics and Materials Science
The Johns Hopkins University
Baltimore, Maryland 21218

ABSTRACT

Despite the prevalence of fatigue and fatigue related failures little is known about the actual mechanisms which cause fatigue. Two nondestructive investigation techniques which have been found to be extremely sensitive to the microscopic changes in the material during fatigue deformation are ultrasonic attenuation and acoustic emission monitoring.

The work reported here indicates the ability of both techniques to provide an early warning of fatigue failure in 7075 aluminum. Additionally, the results point out the sensitivity of the techniques to different mechanisms active during fatigue deformation. Through the complementary use of solitary and combined monitoring the potential of these techniques for revealing the actual mechanisms responsible for fatigue is shown.

METALLURGY . . . 7075 ALUMINUM

Composition: 5.5% Zn, 2.5% Mg, 1.5% Cu, 0.3 Cr.
Typically 7075 is found to contain three distinctively different types of particles in addition to the matrix material (1)

1) Fe, Si, and Cu rich primary inclusions ranging in size from 0.1 to 10\(\mu\) in diameter, 1 to 5 percent by volume, appearing light in optical micrographs.

2) Cr, Mn, or Zr rich intermediate particles ranging from 0.5 to 5\(\mu\) in diameter, which serve to control recrystallization and grain growth, 0.05 to 0.5 percent by volume, appearing dark in optical micrographs.

3) Precipitate particles ranging from 0.01 to 0.1 \(\mu\) in diameter, a transition form of \(\text{Mg}_2\text{Si}\), strengthen the matrix and are only visible by transmission electron microscopy. Additionally, spherical dispersoids of \(\text{Al}_2\text{Mg}_5\text{Zr}_2\) having a mean diameter of 0.05\(\mu\) are also present, and like the \(\text{Mg}_2\text{Si}\) are finely dispersed.

ACOUSTIC EMISSION DURING TENSILE DEFORMATION

Sources of Acoustic Emission

Burst type emissions occurring prior to yield in the as received condition and throughout the deformation in the solution treated condition may be related to the breakaway of dislocations from pileups. The increase in acoustic emission, not associated with burst emission, occurring after yield in both materials results from the fracture of inclusions, decohesion of these inclusions and cracking of the aluminum matrix initiated by the fractures. Creation of dislocations, which trigger other dislocation sources, cause the large peak in emission at yield in the solution treated material.

(2)

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REFERENCES


METALLURGY .... 7075 ALUMINUM

POLISHED
AS RECEIVED

AS RECEIVED
FATIGUED
SOLUTION TREATED

ACOUSTIC EMISSION DURING TENSILE DEFORMATION

[Graphs showing acoustic emission during tensile deformation for solution-treated and as-received conditions]
SPECIMEN AND TESTING CONFIGURATION

COMBINED MONITORING DURING FATIGUE

- Acoustic Emission Sensor
- Ultrasonic Transducer
- Clamp
- Acoustic Insulation
- Clamped Region
- Region of Load Application

AS RECEIVED

SOLUTION TREATED