THERMALLY INDUCED ACOUSTIC EMISSION IN HOMOGENEOUS METALS AND COMPOSITES

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INTRODUCTION

Both nonuniform heating in a homogeneous material and uniform heating in an inhomogeneous material produce local stresses. Inhomogeneous materials include polycrystals with anisotropic grains, two or more phase materials and composites. The thermally generated stresses can potentially induce acoustic emission via microscopic deformation and dynamic stress relieving mechanisms. It is anticipated that the ability to follow the history and characteristics of acoustic emission would be useful as a research tool for the study of microscopic deformation mechanisms, and could serve as a basis for establishing accept/reject criteria during thermal proof-testing of these inhomogeneous materials and composites. The current work reports some results on acoustic emission detected by a simple system equipped with energy processing capabilities, during thermal cycling in anisotropic, polycrystalline alumina, silicon carbide whisker reinforced aluminum, and a continuous graphite fiber reinforced epoxy.

EXPERIMENTAL PROCEDURE

The metal and ceramic specimens studied were 0.5 in. diameter, 6 in. long rods. The graphite epoxy specimen was a uniaxially reinforced plate of approximately 8 in. long, 2 in. wide, and 0.2 in. thick. Three approaches for heating were attempted. The first was a laboratory furnace which allowed heating one end of a ceramic specimen, while the acoustic emission sensor was mounted on the other end. The sensor end of the specimen was cooled with a clamp-on, water circulating device. The furnace was modified for D.C. operation to minimize electromagnetic noise. The second approach to specimen heating was by means of a 500 watt heat lamp. Both the acoustic emission sensor and the thermocouple were screened off from direct heating, and the ceramic and metal specimens were supported by strings to minimize potential noise generated by mechanical fixtures. The acoustic emission sensor was a commercial piezoelectric unit, with a resonant frequency of 800 KHz, and was coupled to the specimen via a viscous fluid. Thermal cycling of the specimens was achieved by periodically inserting and withdrawing the specimen from the furnace, or by turning on and off the radiant heating lamp. Cooling was achieved by forced convection. The third approach to heating was by means of a C.W. Ar laser. This was focused on the surface of the graphite/epoxy specimen by a lens of 50 in. focal length. Thermal cycling was achieved by simply blocking off the laser beam periodically.
The acoustic emission measurement system is shown in Fig. 1. Besides the usual amplification and low pass filtering, this system was equipped with an "energy" processor. Briefly, this allowed the voltage sensed by the transducer to be integrated in time, and was achieved by the squaring and voltage control oscillator circuitry. Acoustic emission burst type signals above a presetable level were converted to "energy counts" which were accumulated as thermal cycling proceeded. The number of bursts and the "energy" associated with them were measured and stored, controlled by a program implemented in a LSI-II microcomputer. The output from the computer during an experiment were data tables as well as x-y recorder displays of 2 acoustic emission or temperature parameters versus time.

This system was calibrated using ring down signals generated by a conventional ultrasonic transducer facing the acoustic emission sensor, excited with square wave voltage waveforms. Figure 2 shows that, for continuous excitation, there was a linear relationship between the frequency output of the "energy" processor and the power output from a R.M.S. voltmeter. Furthermore, the number of energy counts was related approximately linearly with the square of the excitation voltage as shown in Fig. 3. This indicated that the energy counts did approximate the strength or the energy associated with bursts type acoustic emission signal. Only those bursts with voltage levels above 200 \( \mu \text{V} \) at the transducer before amplification were recorded in our experiments.