JTTEE5
DOI: 10.1007/s11666-009-9334-1
1059-9630/$19.00 © ASM International

The Use of Acoustic Emission to Characterize Fracture Behavior During Vickers Indentation of HVOF Thermally Sprayed WC-Co Coatings

N.H. Faisal, J.A. Steel, R. Ahmed, and R.L. Reuben

(Submitted January 20, 2009; in revised form April 14, 2009)

This paper describes how acoustic emission (AE) measurements can be used to supplement the mechanical information available from an indentation test. It examines the extent to which AE data can be used to replace time-consuming surface crack measurement data for the assessment of fracture toughness of brittle materials. AE is known to be sensitive to fracture events and so it was expected that features derived from the AE data may provide information on the processes (microscale and macroscale fracture events and densification) occurring during indentation. AE data were acquired during indentation tests on samples of a WC-12%Co coating of nominal thickness 300 μm at a variety of indentation loads. The raw AE signals were reduced to three stages and three features per stage, giving nine possible indicators per indentation. Each indicator was compared with the crack profile, measured both conventionally and using a profiling method which gives the total surface crack length around the indent. A selection of the indents was also sectioned in order to make some observations on the subsurface damage. It has been found that reproducible AE signals are generated during indentation involving three distinct stages, associated, respectively, with nonradial cracking, commencement of radial cracking, and continued descent of the indenter. It has been shown that AE can give at least as good a measure of cracking processes during indentation as is possible using crack measurement after indentation.

Keywords acoustic emission, fracture toughness, HVOF, surface crack length, Vickers indentation, WC-12%Co coating

1. Background

Various authors have used crack patterns at, and beneath, the surface of indentations to assess the fracture toughness of ceramics (Ref 1-6), study the hardness of plasma-sprayed coatings (Ref 7-9), and evaluate the residual stress, adhesive strength, and fracture toughness of thermally sprayed high velocity oxygen fuel (HVOF) cermet coatings (Ref 10-14). However, there has been no work on microfissuring of sprayed HVOF coating materials during the indentation process.

Acoustic emission (AE) is a nondestructive technique that has been used to monitor damage processes in engineering materials (Ref 15), as well as for condition monitoring (Ref 16, 17). It is well-established that crack extension processes give rise to AE which can be recorded using sensors placed on the surface of the structure or sample of interest. There have been some limited studies of the use of AE to study fracture during indentation, for example by Safai et al. (Ref 18), who found the total AE event count during Brinell indentation tests to be related to the porosity of plasma-sprayed alumina coatings. They noted that the high critical loads for this particular coating-substrate couple were not enough to generate de-bonding at the interface during indentation, but they suggested that some of the AE sources might be due to mechanically induced closure of pores. Ajit Prasad et al. (Ref 19), working on plasma-sprayed alumina-titania coating systems, suggested that the AE signal associated with plastic deformation during indentation is of a more continuous type with a lower characteristic frequency content (35-40 kHz), whereas the instantaneous relaxation associated with cracking produces burst type AE signals with a characteristic frequency in the range 220-280 kHz. Vijayakumar et al. (Ref 20) have found the frequency of the AE signal associated with impact indentation (at 20 kHz) to be in the range of 200-400 kHz for the as-sprayed coatings and 800-900 kHz plasma-sprayed alumina-titania coatings with and without subsequent microwave treatment, respectively. Finally, Senturk et al. (Ref 21) found that the presence of a bond coat layer of NiCrAl in partially stabilized, plasma-sprayed zirconia ceramic coatings suppresses AE activity during Hertzian indentation, and attributed this to surface compressive stresses inhibiting cracks. Thus, there is some evidence that AE is associated with the indentation of

N.H. Faisal, J.A. Steel, R. Ahmed, and **R.L. Reuben**, Department Mechanical Engineering, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh EH14 4AS, UK. Contact e-mail: R.Ahmed@hw.ac.uk.

Published online: 07 May 2009