ELECTRON MICROSCOPIC STUDIES OF PLASMA-SPRAYED COATINGS

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ABSTRACT

This work characterizes the coating surface and profile (cross-section perpendicular to the substrate surface) of plasma-sprayed deposits. Metal (mild steel and a composite of Ni-Al) and ceramic (alumina and zirconia based materials) deposits were produced and examined by scanning electron microscopy. The ceramic coatings were also examined by transmission electron microscopy. Structural observations from the controlled fracture of coatings are also included.

The ceramic coatings exhibited similar morphological features to the metal coatings in the form of flattened particles, dendritic artefacts on the particle surface, a columnar crystal structure and porosity of various forms. The columnar structure that was observed in some flattened particles may be explained by assuming efficient heat extraction through the underlying structure (substrate or coating). In a similar manner the dendritic artefacts would be expected to preferentially nucleate on the surfaces of large particles.

INTRODUCTION

Plasma-sprayed coatings are produced by injecting powder of approximately 25-125 microns in diameter into the tail flame of a

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DC thermal plasma (1, 2). The particles are accelerated and heated by the plasma effluent so that they may flow on impact against the substrate to form a saucer-shaped deposit. The deposition of many particles builds up an integral coating which has unique structural and materials properties. The physical state of the coating particles at their moment of impact and any interactions with the substrate may be determined by microscopy. Much work has previously been carried out on the metallography of coatings (3); for example to study how coating structure is controlled by plasma spraying variables such as the particle size and distribution (4) the type of arc gas (5), the plasma device used during the spraying procedure (6), the substrate surface topography (7), and the torch to substrate distance (8).

This work presents some electron microscopic studies of plasma-sprayed coatings. These structural observations may be related to the physical processes which occur during particle deposition. It should also be remembered that the materials properties of the coating will be influenced by the coating microstructure.

EXPERIMENTAL

Table 1 details the chemistries and size distributions of the powders used in this study. The powder morphologies were not the same and reflected the methods used in their preparation. The mild steel powder was produced by an atomization process, the nickel-aluminum was a composite of the individual components, the alumina was produced by grinding, and the yttria-zirconia material was prepared by crushing and then reaction at a high temperature.

The preparation of the substrate surface influences the coating adhesion (9). The substrates were prepared in the standard manner (10) by grit blasting with alumina (-59 to +0.58 mm) at a pressure of 0.15 to 4.00 MPa. The center line average surface roughnesses of mild steel, brass and aluminum grit-blasted substrates were approximately 8 µm. The roughness increased to values greater than 10 µm upon spraying metal powders whereas sprayed ceramic coatings exhibited values of about 3 µm.

The samples which were procured from industry were plasma-sprayed at power levels of either 18 kW (for metal coatings) or 31 kW (for ceramic coatings). Samples which were prepared for the controlled fracture experiments were plasma sprayed in the laboratory with a low power (7kW) N2-Ar DC plasma. These coatings were incorporated into a loading fixture so that the coating could be subjected to a tensile load.