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Thermal spraying — Determination of interfacial toughness of ceramic coatings by indentation

Projection thermique — Détermination de la ténacité interfaciale des revêtements céramiques par indentation

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

Introduction

The interfacial toughness of thermal spray ceramic coatings is required for two reasons:

a) to understand quantitatively degradation of adhesion in service;

b) for life assessment of the coated components.

Adhesion strength of thermal spray coatings is usually measured in accordance with the tensile method specified by ISO 14916. However, there is a technical limitation in the application of ISO 14916. It requires preparation of a tensile adhesion test specimen using glue and, as such, coatings with higher adhesion strength than glue cannot be quantitatively evaluated. By virtue of its simplicity and practicality, an indentation method is a promising method to evaluate the adhesion of such coatings. In this method, a Vickers hardness tester is used. An interfacial toughness value is evaluated by measuring a length of the crack formed after pushing the indenter on the coating interface. The application of the method specified in this document can reduce uncertainty over the adhesion strength evaluation of coatings and makes it possible to evaluate the adhesion strength in a simpler way.

The results can be expressed either as a stress intensity factor, in $MN \cdot m^{-3/2}$, or as a fracture surface energy, in $J \cdot m^{-2}$.

“Interfacial toughness” can have several meanings.

a) Interfacial fracture toughness, K_{Ic}, in $MN \cdot m^{-3/2}$, is a material constant that shows how easily the coating may be peeled away from a substrate.

b) Energy release rate (or work done to fracture), G, is an alternative expression for interfacial fracture toughness, often obtained by converting K to G [i.e. $G = K^2(1 - \nu^2)/E$, where E is Young’s modulus and ν is Poisson’s ratio]. G has units of $J \cdot m^{-2}$.

For the purposes of developing the test method, the term indentation interfacial toughness, K_{IFC}, is defined separately from interfacial fracture toughness, K_{Ic}. The indentation interfacial toughness is a value obtained by using Vickers hardness tester, and is calculated from the total length of cracks induced along the interface by the indentation. Shorter crack lengths indicate that the coating has higher interfacial toughness or adhesion strength than other samples with longer cracks. There is no standard method to determine such interfacial toughness for thermal spray ceramic coatings, and different organizations or groups currently use their own evaluation procedures.

When measurements are carefully performed following the methods defined in this document, the evaluation of crack length, and thus interfacial toughness, will not require much effort and can describe the adhesion characteristics of the system (substrate chemistry, pre-preparation/roughness of substrate surface, coating chemistry and properties). This document recommends good practice to minimize uncertainty in the measurement procedures.