Mullite coatings on ceramic substrates: Stabilisation of Al₂O₃–SiO₂ suspensions for spray drying of composite granules suitable for reactive plasma spraying

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Received 29 September 2008; received in revised form 22 January 2009; accepted 28 January 2009
Available online 23 February 2009

Abstract

The present work deals with the preparation of stable alumina + silica suspensions with high solid loading for the production of spray-dried composite powders. These composite powders are to be used for reactive plasma spraying whereby the formation of mullite and the coating on a ceramic substrate are achieved in a single step process. Electrostatic stabilisation of alumina and silica suspensions has been studied as a function of pH. Silica suspensions are most stable at basic pH whereas alumina suspensions are stable at acidic pH. The addition of ammonium polymethacrylate (APMA) makes it possible to stabilise alumina and prepare a stable 50 wt% alumina + silica suspension at pH 10. The optimum amounts of dispersant and binder have been determined by zeta potential, viscosity and sedimentation measurements. Spray drying of the suspension yields composite powders whose morphology, size distribution and flowability have been characterized before realizing reactive plasma spraying tests.

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Keywords: D. Mullite; E. Refractories; A. Suspensions

1. Introduction

Plasma spraying is a well-known industrial technique, suitable to make metallic or ceramic coatings. Oxide ceramic coatings are used to improve the resistance to corrosion, heat and wear of metal components. For example, mullite (3Al₂O₃·2SiO₂) ceramic coatings are being developed as thermal control coatings and as hard and abrasion-resistant thermal barrier coatings (TBC) for application in space. During the plasma spraying process, solid particles are injected into a plasma jet created either by a D.C. arc or by a R.F. field. The feedstock material is melted in the high temperature region of the plasma and the molten particles are accelerated until impact on the substrate. Then, rapid solidification of impacted droplets and deposit build up occur. The coating quality depends on various process parameters but also on the characteristics of the powder. Two kinds of ceramic powders are generally used for plasma spraying: “fused and crushed” or “agglomerated and sintered”. The fused and crushed route usually yields angular particles, whose poor flowability is a drawback in the case of plasma spraying. On the contrary, agglomerated powders with spherical morphologies and free flowability can be obtained by spray drying, a versatile industrial process during which a water-based suspension is transformed into a dry agglomerated powder by atomisation of the fluid feed material into a stream of hot air. Both the slurry properties (initial solid content, viscosity, etc.) and the drying conditions (atomiser design, drying temperature, etc.) are known to affect the morphology of the granules. In the conventional plasma spraying technique of multicationic oxides, the granules of agglomerated powders are sintered prior to their use in the plasma spraying equipment. However, since