Spray-dried ceramic powders: A quantitative correlation between slurry characteristics and shapes of the granules

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Abstract

The characteristics and consequently the properties of ceramic coatings performed using plasma spraying means depend not only on the operating conditions but also on the powder feedstock. Oxide powders are commonly prepared in one stage or in a combination of stages of fusing, crushing, agglomerating and sintering. The spray drying process (which corresponds to the agglomerating route) is a technique in which small constituent particles dispersed in water (which is called slurry) are sprayed in hot air and granulated thanks to a binder (latex or PVA). Spray drying is carried out for a variety of reasons, two major motivations being the production of composite and shape controlled powders for thermal spray applications. The aim of the present work was to establish a correlation between the slurry formulation and the characteristics of the spray dried granules for two oxide ceramics: Al\textsubscript{2}O\textsubscript{3} and Y\textsubscript{2}O\textsubscript{3}–ZrO\textsubscript{2}. Detailed studies on the dispersion and stability of the slurries were performed using sedimentation tests, electrophoretic mobility measurements as well as adsorption isotherms experiments. Then, a drying experimental test based on the drying of a suspended droplet was developed to assess the drying mechanisms, identify the correlation between the slurry characteristics and the morphology of the dried granules and finally to predict the shapes of the spray-dried powders. It was shown that there is a qualitative relation between the sedimentation behaviour (as measured by the sediment ratio) and the granule shape (solid or hollow) and a quantitative relation between the thickness of the shell (for hollow granule) and the state of dispersion and the nature of the binder used. Finally, several powder batches were prepared in the spray-dryer which confirm the reliability of the drying simulation test.

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1. Introduction

Plasma sprayed oxide ceramics based on alumina, titania, zirconia, and so on are currently used as surface coating materials to improve resistance to corrosion, heat and wear for metal components and thus extend their service life (Normand et al., 2000; Abdel-Samad et al., 2000; Wang et al., 2000; Jordan et al., 2001; Cao et al., 2004). For example, 6–8 wt% yttria stabilized zirconia which is commonly deposited as top coating in thermal barrier coatings in the aeronautical industries has proved to be the most effective insulating coating, (Schulz et al., 2003). Plasma spraying is a complex process during which solid particles are injected into a plasma jet created either by a D.C. arc or a R.F. field, the material feedstock is molten and accelerated in the high temperature region of the plasma, and then the molten droplets spread onto the substrate to form a cohesive coating. Among the numerous parameters that influence the coating quality, the powder morphology has a great importance (Allen et al., 2001; Friis et al., 2001). Two kinds of ceramic powders are generally used: fused and crushed or agglomerated (spray-dried) and sintered. The latter ones have numerous advantages, and some of them are to present spherical morphologies and homogeneous composition of different materials.