Dry Coated Particle for Plasma Spraying

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Abstract

The preparation of composite powders for plasma spraying by an in-house designed mechanofusion process is investigated. Results show that dry particle coating depends on the chemical and mechanical properties of powders. In metal/oxide and metal/oxide/carbide powder mixtures, fine ceramic particles coat the surface of the metallic coarser particles. A nearly rounded shape of the final composite particles is induced by the mechanical energy input with no formation of new phases. However with the carbide/metal powdered system, only an intimate mixture of components is achieved. It is suggested that the coating mechanism is governed by agglomeration and rolling phenomena.

Keywords : mechanofusion, dry particle coating, agglomeration

1. Introduction

Microstructural characteristics of plasma sprayed coatings are much dependent on the feedstock powder characteristics. This is related to the particle behaviour during their flight in a plasma jet. Therefore the powder characteristics have a significant influence on the resulting coating properties [1].

In some cases, particles can react with the entrained air, be decomposed or evaporated (metals or carbides for example) during their flight in the plasma jet thus affecting the thermomechanical properties of plasma sprayed coatings [2]. However, the combination of different materials helps to limit these effects and even more to increase the coating properties provided that the ceramic particles are uniformly distributed within the coating.

Then, a variety of methods was employed to obtain a metal/ceramic composite matrix such as co-spraying two different powders or spraying agglomerates of fine particles of metal and ceramic. A promising possibility to form composite particles by is the mechanofusion process that improves the powder flowability because a spherical-shaped composite is achieved with a controlled of both size and ceramic content [3].

The present paper summarizes the works conducted to develop composite materials to be plasma sprayed provided that a dense microstructure composed of hard particles embedded uniformly in a metallic matrix was obtained. The composite powder, prepared by the mechanofusion process, consists of stainless steel particles covered by a ceramic shell composed of either alumina or alumina/silicon carbide fine particles.

The interest of spraying cermet powders is sustained by the formation of dense and relatively ductile coatings with hardness and toughness higher than those of the pure metal considering the dependence of substrate conditions such as surface temperature, oxidation state and roughness on coating properties [4, 5]

2. Experimental and Results

Commercial gas atomised 316L stainless steel with two particle size distributions are used as host particles whereas finer α-alumina (Baikowzki, France) and silicon carbide (Carborex, Norway), with mean particle sizes of 0.6 and 3.8 µm respectively, are introduced as guest particles. The two stainless steel powders are 63 and 120 µm in mean particle size.

The preparation of composite particles is performed using an in-house designed mechanofusion set-up described elsewhere [3]. It consists of a cylindrical chamber with an internal diameter of 150 mm and internal height of 50 mm rotating at 146.58 radians/sec (1400 r.p.m.). The gap between the internal wall of the chamber and the inner pieces was adjusted to 1.3 mm. The powder introduced is dynamically mixed and subjected to a powerful compression through the gap when the chamber rotates. During processing, several phehomena such as compression, attrition, frictional shearing and rolling conduct to dry coat coarser particles, considered as host particles, by the finer ones (guest particles) with no need for binders [3,6].

The charge of host particles was, in all cases, 150 g of 316 stainless steel raw powders. To obtain a metal/oxide composite powder, the alumina content was 12 wt % whereas the metal/oxide/carbide composite powder was composed of 4 wt % alumina and 1.6 wt % silicon carbide.

Samples of stainless steel/Al_2O_3 and stainless steel/Al_2O_3/SiC reveal similar results after processing by mechanofusion, whatever the starting size of the stainless steel particles. The composite particles consist of a stainless steel core uniformly coated by a ceramic shell composed by either only Al_2O_3 or a mixture of Al_2O_3/SiC. Typical morphologies of these powders are shown in Fig. 1.

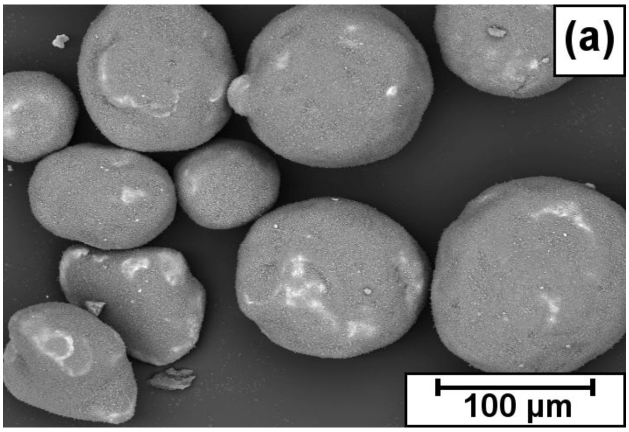

Fig. 1. Morphology of Stainless Steel/Al_2O_3 mechanofused-composite powders.

All composite powders are found to be nearly spherical with a mean shape factor of 1.05. No phase transformation or contamination was detected after the mechanofusion processing as confirmed by XRD analysis. This confirms that no diffusion is promoted by the mechanical energy input by the compression pieces. Then, it is suggested that agglomeration is gouverned exclusively by the large difference in particle size.

In the case of SiC/Stainless steel system (SiC/SS), a most likely incipient formation of a protective shell is detected. Instead of a strong dispersion of both constituents was achieved (Fig. 2). The last is probably due to differences in dielectric constant between carbide and metal particles avoiding agglomeration.

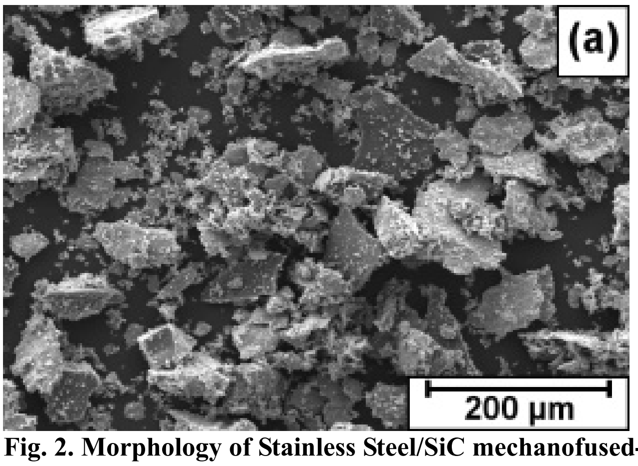

Fig. 2. Morphology of Stainless Steel/SiC mechanofused-powder.

3. Summary

The in-house designed Mechanofusion process is an effective means to control the plasma spray raw material by covering stainless steel particles with a ceramic shell. The high energy input of the mechanofusion process is directed towards the creation of particle interfaces via agglomeration of particles with a very fine size, in our case alumina (0.6 μm) and silicon carbide (3 μm), coated on stainless steel particles (either -140 μm + 100 μm or -90 μm +45 μm). It is likely that agglomeration of fine alumina and silicon carbide particles on stainless steel particles is gouverned by the large difference in particle size distributions. However, a well mixed powdered charge is obtained when particles, featuring no agglomeration character, are processing by mechanofusion.

4. References

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