Key Engineering Materials *Online: 2007-04-15*
ISSN: 1662-9795, Vols. 336-338, pp 1791-1792
doi:10.4028/www.scientific.net/KEM.336-338.1791

Influence of Agglomerate Size on the Properties of Al_2O_3-Al_2Cu_3 Multiphase Ceramic Coatings

Haiping Cui, Jun Yan, Shiguo Du and Xinkang Du

Shijiazhuang Mechanical Engineering College, Shijiazhuang 050003, China

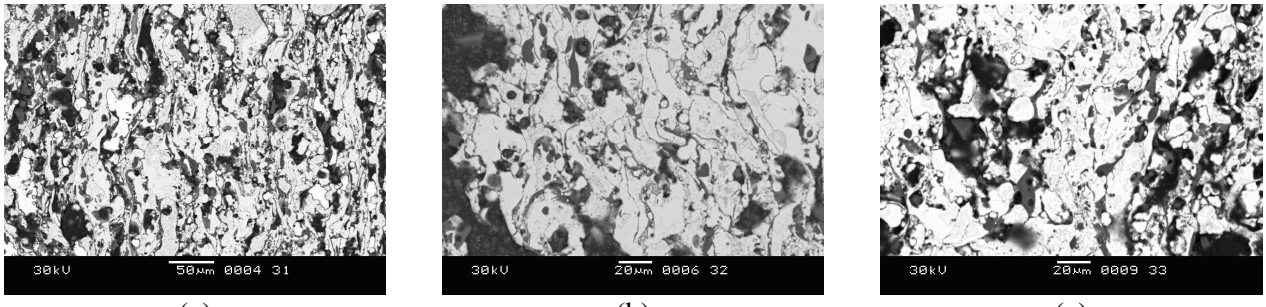
Keywords: Reactive Flame Spray, Metallic ceramics coatings, Size, Properties

Abstract. Al_2O_3-Al_2Cu_3 multiphase coatings were prepared on the surface of steel by reactive flame spray. The binding strength, microhardness and abrasion quality of the coatings were measured and analyzed. The influence of the agglomerate size on the properties of the coatings was emphatically studied to choose suitable size range for Al-CuO reactive system. The results showed that coatings prepared by using –150~+250 meshes agglomerates exhibited good mechanical properties.

Based on the conventional thermal spray method, researchers have successfully put forward reactive spray technology and developed several corresponding methods including reactive arc spray, reactive plasma spray, and thermally explosive spray and so on. By these methods coatings such as Ti-C, Ti-B, Mo-Si system etc. were fabricated [1]. Reactive spray is different from conventional thermal spray in its purposeful use of SHS reactions during the spraying process to form dense coatings with low energy consumption and cheap reactive materials [2]. In this work metallic ceramic multiphase coatings of $Al_2Cu_3O_2$ were fabricated on the surface of steel by reactive flame spray. Al-CuO agglomerated powders were sprayed using a converted acetylene-oxygen flame spray gun. Effects of the size of the agglomerates on mechanical properties of the coatings were discussed.

Al powders (purity of 99.8%) and analytically pure CuO were agglomerated in a solution of phenolic resin and dried at 100-120ºC and then sieved. The agglomerated powders were sprayed on steel targets of 50 × 50 mm^2 and thickness of 6mm. The top surface had been cleaned and sanded to remove grease and corrosion layer. Carrier gas was 3×10^4 Pa of nitrogen, and auxiliary energy was supplied by oxygen of 4×10^4Pa and acetylene of 8×10^4Pa. The microstate and microstructure of the coatings were characterized by scanning electron microscope. The crystal structure of the coatings was analyzed by X-ray diffraction (XRD). The microhardness was tested with a load of 200g. The abrasion performance was tested on a abrasiometer with a load of 50kg and a rotating speed of 400 r/min. The binding strength was tested according to GB9786-88.

Effect of agglomerate size on binding strength. Three kinds of agglomerated powders were used for spraying, and the size range was –250~ +325 meshes, –150~ +250 meshes and –100~ +150 meshes, respectively. The binding strength of each sample was 16.8×10^6Pa, 15.6×10^6Pa, and 12.1×10^6 Pa, respectively. Fig. 1 shows the SEM photos of the coatings surface.



(a) (b) (c)

Fig.1 SEM photos of the coatings sprayed by different size of agglomerates (a, agglomerate of –250~+325 meshes , b, –150~+250 and c, –100~+150)

The result shows that small agglomerated particles will be helpful in forming coatings of higher density and binding strength. Small particles can be easily ignited in the flame, causing a rapid and complete reaction. If the particles were melt to the liquid state when they reach the substrate surface, the gases in the coatings that are produced during the reaction would be discharged in time through the collision between the high speed molten droplets and the substrate, and coatings with higher density and binding strength would be formed [3].

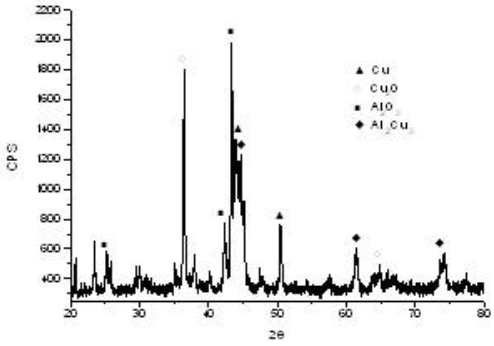


Fig.2 XRD of the coatings

Effect of agglomerate size on microhardness. The micro hardness of the three coatings described above was HV317.4, Hv 29.7 and Hv302.8, respectively. The coating surface mainly consisted of ceramic phase of Al_2O_3, intermetallic compound of Al and Cu, and alloy of Cu and Al, as shown in fig.2. Two distribution patterns of Al_2O_3 phase were also found, as shown in fig.3. One was distributed in irregular lump state over boundary area of Al-Cu phase, and the other was in state of particles with the size range from ten to several hundreds nanometers over the internal area of Al-Cu phase, thus forming internal crystal structure.

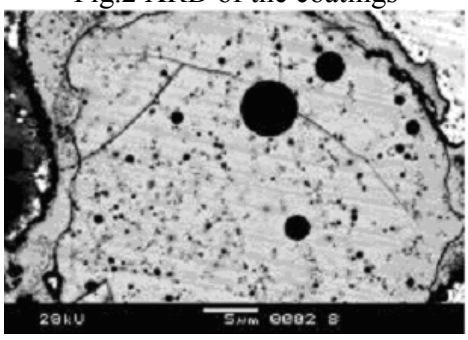


Fig.3 Inner-crystalline Al_2O_3

The mircohardness of the coatings depends on the content and distribution of hard phase [4]. The more homogeneous the distributions are, and the higher the content is, the higher the hardness will be. Small particles with large surface area are reactive enough to be completely burnt and melted before impacting on the top surface of the substrate, which helps form denser coatings. So the agglomerate of size range of –250~ +325 meshes can form coatings with distinct laminate structure and less unmelt particles. The micro hardness of such a coating is low. Particles of size range of –150~ +150 meshes with low reactivity will fail to adhere to the substrate, and subsequently give coatings with the lowest micro hardness in this work.

Effect of agglomerate size on abrasion performance. The abrasion performance of the coatings depends on the content and distribution of the hard phase. We can predict from the above analysis that agglomerates with the size of –250~ +325 and of –100~+500 meshes will produce coatings with low anti-abrasion property, while agglomerates with the size of –150~+250 meshes will produce coatings with high anti-abrasion property. The result shows that the weight loss for the three coatings is 0.00281, 0.00149 and 0.0174, respectively. Obviously coatings prepared with agglomerates of –150~+250 meshes have the best anti-abrasion property.

Summary. The binding strength of the coatings prepared by reactive flame spray method depends mainly on the reactivity of the agglomerated particles, and particles smaller than 150 meshes produces coatings with high binding strength. The mircohardness and abrasion performance depends mainly on the distribution and content of hard phase. The agglomerated particles of +250~–100 meshes are spayed giving coatings of the highest mircohardness and abrasion performance in this work. So the proper size range for Al and CuO system is –150~ +250 meshes.

References

[1] P. Fanchail, A. Vardelle, A. Denoirjean: Surf. Coat. Technol. Vol. 97 (1997), pp. 66.
[2] S. Dallaire, H. Levert: Surface Technology Vol. 50 (1992), pp. 241.
[3] T. Kodama: Journal of Thermal Spray Technology Vol. 8 (1999), pp. 537.
[4] Z.Y. Fu: Acta Materiae Compositae Sinica Vol. 17 (2000), pp. 5.