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Abstract

Title	Investigation on Splat Formation Mechanism in Individual Particle Deposited by Thermal Spraying

Thermal spraying is a cost effective method in which melted materials with high velocity are sprayed onto a surface to form a dense coating to protect the substrate, this technics has been widely used in industry applications in the past few decades. As the flattening of an individual sprayed particle on the flat substrate is a fundamental process for the coating fabrication, the coating microstructure and properties depend strongly on the flattening nature of each splat. Hereby, it is necessary to study in detail the splat formation process of the sprayed individual particle.

In this investigation, commercially available powders with diameter of several tens micrometers were thermally sprayed onto mirror-polished substrate surface. The effect of experimental conditions such as ambient pressure, substrate temperature and substrate duration after preheating on splat formation process has been systematically investigated. Roles of adsorption/desorption of adsorbed gas/condensation, wetting of substrate by molten droplet, and initial solidification at splat-substrate interface has been considered. Millimeter-sized molten Cu droplets were deposited on AISI304 substrate surface by free falling experiment. The flattening behavior and heat transfer at interface between free falling droplet and substrate was investigated as well.

Firstly, the splat shapes on flat substrates underwent a transition from a distorted shape with splash to a disk-shaped one with a decrease of ambient pressure. The adsorption/desorption of the adsorbates and condensates on substrate surface might induce the pore formation process at splat bottom surface. More favorable wetting could be obtained under the reduced ambient pressure. Typical initial solidification has been observed at splat-substrate interface, in particular, at the periphery part of the splat deposited under reduced ambient pressure. A model has been presented to quantify the effect of initial solidification on the splat formation process. Furthermore, the adhesion strength of coatings fabricated on the blasted substrates has an intimate relation to that of the splat shape on flat substrate.

Secondly, particles were sprayed onto flat substrates held at various temperatures. Splat shape had a transitional changing tendency from a splash splat to a disk one with the increase of substrate temperature. Very favorable wetting could be generated by removing the adsorbed gas/condensation through substrate preheating, surface roughness increased in nanometers scale also promoted the wetting, however, the very fast increase of droplet viscosity due to the initial solidification at splat-substrate interface might restrain the splat spreading prior to the solidification finish and finally contributed to the disk-shaped splat formation.

Thirdly, a part of flat substrates were preheated to designated temperatures for 10 minutes then exposed to an air atmosphere for different duration of up to 48 hours. The wetting was weakened along with the extension of duration after substrate preheating. Cu powders were thermally sprayed onto pre-treated substrates, the splat shape had a changing tendency from a splash splat to a disk one on the substrate with a short duration after preheating, however, splash splat re-appeared with the increase of duration in an air atmosphere could be confirmed. In general, wetting of substrate surface by molten particles may dominate the flattening behavior of thermal sprayed particles in this case. The occurrence of desorption of adsorbed gas/condensation caused by substrate preheating likely provides good wetting. On the other hand, the poor wetting may be attributed to the re-adsorption of gas/condensation on the substrate surface with the increase of duration. In addition, the shear adhesion strength of coating fabricated on blasted AISI304 substrate was enhanced on the once heated substrate, but weakened with the increase of duration.

Moreover, temperature history of free falling droplet during the flattening and solidification process was measured at splat-substrate interface. The heat transfer from droplet to substrate was enhanced both by substrate heating and ambient pressure reduction, which can be attributed to the more intimate contact at splat bottom surface, and the enhanced wetting of substrate surface by molten droplet. The droplet shapes in free falling experiment showed similar changing tendency as thermal sprayed particles. Consequently, substrate temperature and ambient pressure have an equivalent effect to contact condition at interface between droplet and substrate surface. Substrate heating and pressure reduction may enhance the wetting during splat flattening, and then affect the flattening and solidification behavior of the molten droplet.

Among the current working, the splat formation mechanism in individual particle deposited by thermal spraying was generally discussed. The investigation on the flattening behavior of the sprayed particles is significantly meaningful for the practical use of actual thermal spray coatings.