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Title	Deposition Mechanism and Properties of Coating Developed by Cold Spraying

（800 words）

Cold spraying is a new developing coating process in which the powder is accelerated to an extremely high velocity and then they impacted, deformed and finally adhered with the substrate. The coating is built through the depositing of the sprayed material in the solid state condition. As a new technique, the cold spraying needs some optimizations such as a correctly selection of process parameters, suitable substrate conditions, proper substrate/powder combination, and appropriate powder condition. Though the numerical simulation works regarding to bonding mechanism is provided in the literatures, the verification bonding through the experimental work is still limited. In addition, the bonding of coating with a nonmetallic substrate is still a phenomenon. The main purposes of this study were to understand deposition behavior of copper and aluminium and their bonding characteristics. In the experimental works, the coatings have been performed on the metallic and nonmetallic substrates. The micro-sized aluminium and copper powder have been selected as the sprayed material. Coating performances were investigated through the observation of the coating microstructure, shear adhesion test, measurement volume resistivity and coating hardness. The results of the study are separately discussed in five experimental works as follows:

Firstly, the influence of the particle velocity on the adhesion strength is carefully investigated without other factor's effects such as the residual stress. Though the residual stress in the cold-sprayed coating is in compressive state, the effect of the residual stress on the adhesion strength is poorly known. In this work, stress relief treatment is introduced for predicting the effect of residual stress on the bonding at the interface. It was found that the higher magnitude of residual stress leads lower shear adhesion strength. However, the residual stress effect on adhesion strength can be eliminated by using higher process gas temperature. The result also shows that higher particle velocity leads better adhesion strength by individually higher gas pressure or higher gas temperature.

Secondly, the importance of the substrate surface conditions on the shear adhesion strength of the coatings on an aluminum alloy substrate is carefully investigated. The results show that the shear adhesion strength of the coatings is improvable when the grit-blasted substrate condition is used. Higher particle velocity provides higher cohesion which useful for adhesion strength in grit-blasted condition. On the other hand, although the cohesion strength improved by using the higher particle velocity, the adhesion strength is not improved when the as-received substrate is used.

The next work discussed the influence of an alloying element on the deposition behavior of the copper powder. Three binary copper bases (Cu-Ni, Cu-Al and Cu-Zn) and a pure copper powders with a diameter of 20 μm were cold sprayed on the copper, aluminium and stainless steel substrate for investigating the importance of the material combination. The results showed that the Cu-Ni powder exhibited similar deposition behavior with the pure copper powder. Copper and nickel have almost similar in atomic size and completely miscible in each other. Hence, there is no significantly different in physical and mechanical properties. Consequently, they have similar deposition ability. Meanwhile, Cu-Al and Cu-Zn powder are exhibited much lower deposition efficiency. XRD result showed that Al and Zn altered the lattice size of the unit cell of the copper; hence, they changed physical and mechanical properties. The result also showed that the substrate material did not affect the deposition efficiency. However, the substrate material affected the shear adhesion strength of the coating.

Fourthly, the cold spraying aluminum on a CFRP was studied. The fabrication of a coating directly on the CFRP substrate using cold spraying is still difficult. Though the fine aluminum powder could be deposited, but the coating was peeled off when the thickness was around 30 μm. It caused by the limited bonding area particle/substrate where, almost no deformation of the particle upon impact but the substrate surface revealed excessive deformation. On the other hand, it was possible to fabricate a coating on the CFRP substrate by plasma spraying. In this study, the thin plasma-sprayed coating is used as an interlayer, and they used to improve the depositing-ability of the cold-sprayed material. The interlayer with larger contact area could retain on the substrate which able to facilitate the deformation of the next incoming of cold-sprayed particles to build a thick coating. In addition, the volume resistivity of cold-sprayed coating is lower than of the plasma sprayed coating.

The last, a metallization of the polymer surface was also attempted. The purposes of this work are to improve the properties of the polymer such as electrical conductivity and erosive resistance. However, similar to the case of CFRP, it is still hard to develop a dense and thick coating on the polymer surface by cold spraying due to excessively erosion of the surface during the processing. The present work, two different types of interlayers were proposed. The polyvinyl chloride polymer substrate was initially coated with spherical copper powder and tin powder separately; then a thick copper coating was fabricated by using a dendritic copper powder. The thick coatings were successfully developed on PVC with both interlayers. The deposition ability of the dendritic shaped powder is related to the impact energy and contact area with interlayer. The results showed that adhesion strength of coating was higher with tin interlayer than spherical copper interlayer due to the contributed tin on the inter-particle bonding. The volume resistivity of coating with tin interlayer is lower than with spherical interlayer due to the inserted fraction of substrate material in bonding inter-particle.