CHARACTERIZATION OF Cu-Al AND Cu INTERMETALLIC COATING PRODUCED BY ARC SPRAYED

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Abstract

The twin-wire electrical arc spraying (TWAS) process is widely used for worn-out surface restoration. The industrial benefit of arc spray coatings is the possibility of cost-effective coating solutions to minimize surface problems. Alloys including Cu-Al intermetallic coatings are new candidates for use in tribologic and corrosion environments because of the combination of low cost and a remarkable resistance to abrasion under different working conditions. In this study the surface properties of Al-Cu twin-wire arc-spray coatings are product to investigated

Keywords: TWAS, intermetallic coatings, surface

1. INTRODUCTION

Wire arc spraying is an economical coating process, therefore it has been used widely to coat engineering structures to protect them against corrosion and wear [1-2]. The attractions are the low cost and the operational simplicity. The material to be deposited is introduced into the arc in the form of two wires serving as consumable arc electrodes. A cold gas jet across the arc drives the molten atomized droplets from the electrode tips. A recent development of wire arc spraying is to prepare intermetallic compound coatings, alloy coatings and metal-ceramic composite coatings. These coatings were prepared by wire arc spraying with cored wires or pre-alloyed wires [3-5].

Nowadays, metallic and intermetallic coatings are being intensively verified as oxidation- and corrosion-protecting materials in the hotter parts of power plants and engines. These intermetallic compounds have been actively researched for application in aerospace, automobile and gas turbine engines Nevertheless, a wide implementation of such high-alloyed feedstock materials is limited because of economic reasons and technological limitations. However, a number of factors determining the microstructure formation and thus influencing properties of such coatings remain unknown, namely, - an influence of the content of alloying elements in cored wire on the microstructure, residual stresses and hot-gas abrasive resistance of the coatings; - an evolution of phase composition and mechanical properties under a long-term exposition at elevated temperatures; - an influence of inner and outer oxidation, composition and morphology of the oxide films on the exploitation behaviour of the coatings [2,4-5].

Copper (Cu) is widely used reactive metal in electrical and electronic devices. It is rapidly replacing aluminum as the interconnect material of choice in integrated circuits, particularly microprocessors, because of its low resistivity and its improved electromigration performance. Despite the fact that copper is noble, it readily corrodes in a variety of environments. However, only very few studies have been carried out on the corrosion protection of copper by conducting coatings in spite of its use in wide range of technological applications. In the copper-rich side of the binary diagram several intermetallic besides Al-Cu solid solution exist or coexist. The common properties of these intermetallic are their high hardness, low toughness, relatively low electrical resistivity and complex crystal structure. [2, 3-6]

2. EXPERIMENTAL PROCEDURE

Fig. 1 shows the smart arc sprey system. The Sulzer Metco smart arc spray system we used consists of a power supply, a control unit and a robot-controlled arc spray gun. AISI 1020 low-carbon steel with a thickness of 3 mm was used as substrate for Cu coating in this study, and all the specimens to be coated were pretreated by grit blasting. Aluminum and copper wires with a diameter of 1.6 mm were sprayed with air used as an atomizing gas. The parameters of coating treatment was given in **Table 1**.

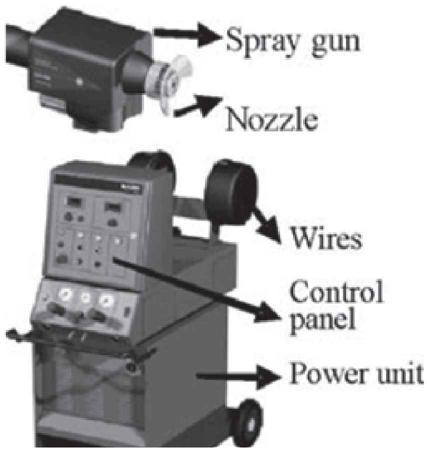


Fig. 1 The Smart Arc sprey (Sulzer) apparatus

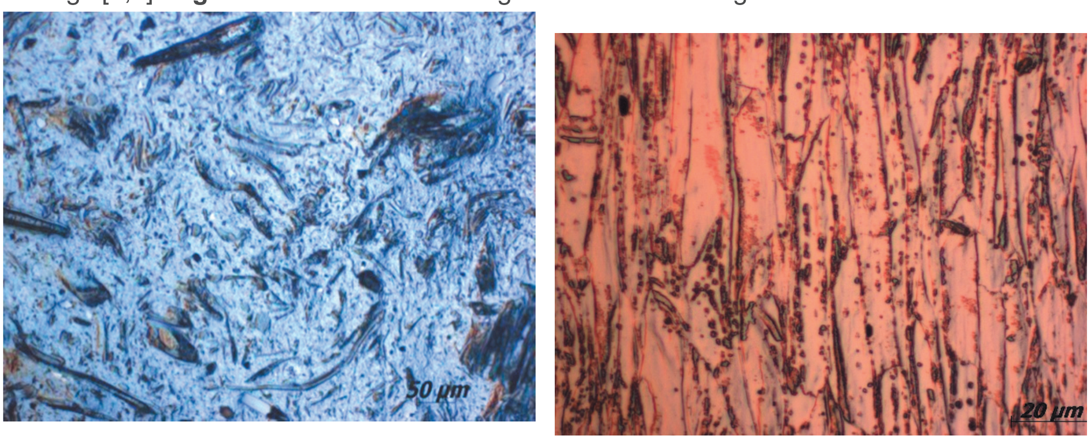
Table 1 The Arc Spray Process Parameters

Current (Ampere)	205–210
Voltage (Volt)	26–28
Spray Distance (mm)	120–150
Gas Pressure (bar)	4

For the production of binary Cu-Al solid solution and intermetallics on the copper-rich side of Cu-Al binary system stainless-steel were used as substrates. The duration of total processing time was varied, keeping the depositing and bombarding voltages as well as rotation intervals of the substrate constant.

3. RESULTS AND DISCUSSION

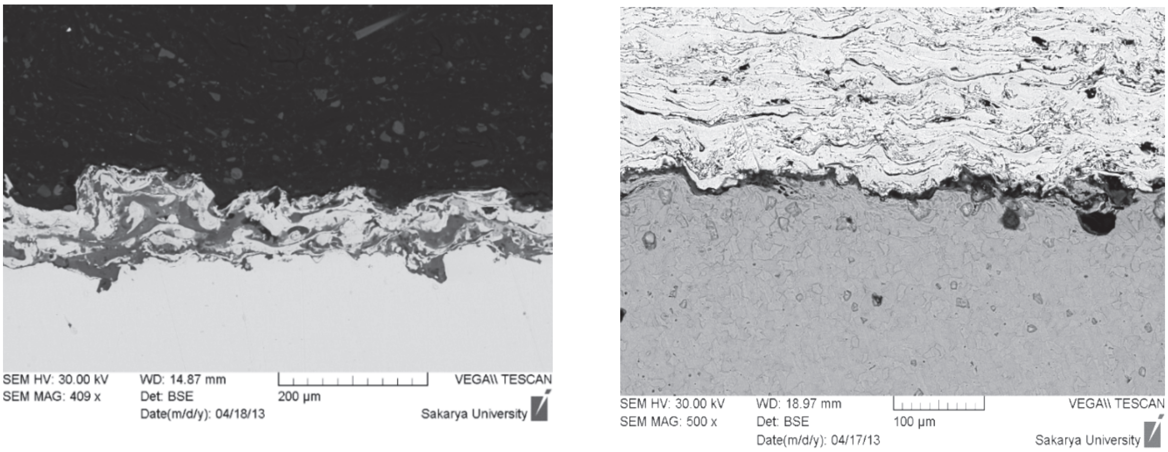
The optic micrograph of Cu-Al and Cu coating were shown in **Fig.2 (a), (b)**. The morphology of the as-received Cu powders was dendritic. The relaxation of residual stresses in such hard particles can cause the formation of microcracks perpendicular to the lamella. Some typical porosity is also observed. A particular feature of the coatings sprayed from cored wires is the rather inhomogeneous chemical composition in comparison with that sprayed from the solid wires, which can strongly influence the properties and exploitation behavior of the sprayed coatings [4,6]. **Fig. 2b**. shows Cu-Al coating. The Cu-Al coating showed dendritic structure.



(a) (b)

Fig. 2 The optic micrograph of a) Cu, b) Cu-Al coating

The SEM image of cross-section the Cu-Al and Cu coating shows a lamellar structure in **Fig. 3a**. There were a little oxides and micropores. SEM images of the as sprayed coating show that some continuous oxide films cohered on the metal splat interfaces are broken due to the intensive deformation, and that some small oxide films (particles) are immixed into the insides of metal splats. There were pores in Cu coating (**Fig. 3b**) [6-7] and the amount of pores were higher than Cu-Al coating. The Al phase was blocked to micropores in Cu-Al system [6].



(a) (b)

Fig. 3 The SEM micrograph of a) Cu-Al coating, b) Cu coating

However, microstructure of as-sprayed aluminum cupper coatings, apart from oxides, there are also lots of pore spaces in arc-sprayed coatings. It is generally agreed that the presence of open pores within the coating structure is a main drawback of arc spray. Pore spaces present in coatings allow the penetration of oxygen, which results in oxidation inside the coatings. It was found that the coatings contained more oxide after than before oxidation. When all the pore spaces closed, the oxides in the coatings would act as barriers to hinder oxygen or metal elements from diffusing to avoid inner alloy oxidizing [5-9].

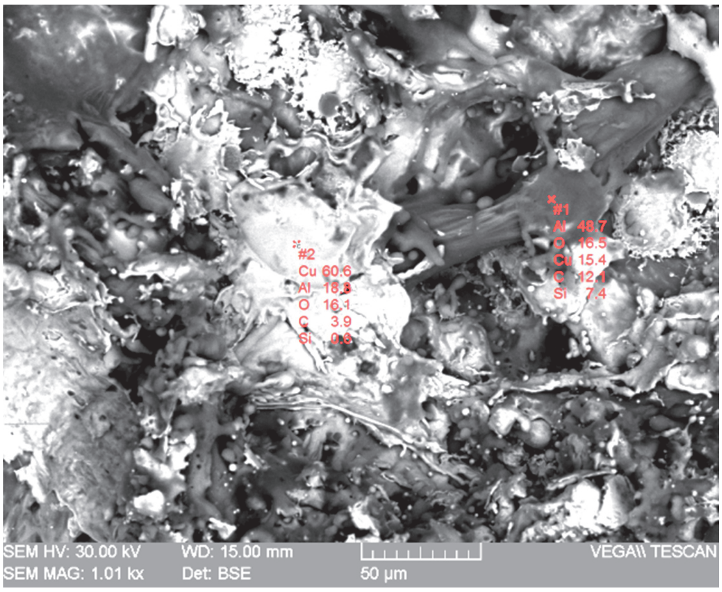


Fig. 4 The EDS analyses of Cu-Al coating

The **Fig. 4** shown us EDS analyses of Cu-Al coating. The laminar structure of the coating is mainly composed of copper splats (light areas), aluminum splats (black areas) and oxides (grey areas). Inside of the alloy layers, the content of Cu and Al also waved remarkably. The highly inhomogeneous distribution of the coating composition is presented, on the other side, from the EDS analysis; we can estimate the regions where some Cu-Al intermetallic phases maybe formed [3].

CONCLUSION

The Cu-Al coating was successfully produced by electric arc spraying. A process optimization is required for a better coating quality. The Cu-Al and Cu coating structure were different. There were micropores on surface structure. The dendritic structure formed on surface. The amount of micropores of Cu coating is higher than in Cu-Al coating.

The combination of Cu anode and Al-cathode leads to stable arc fluctuation as well as smaller droplet production. Higher gas velocity with smaller arc voltage would be desirable for preparation of better coatings. Wire arc spraying provides new attractive process for preparation of intermetallic compounds or alloys. The compounds are mainly prepared during the droplet deformation process on the substrate.

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