HVOF THERMAL SPRAYED COATINGS FOR WEAR PROTECTION IN MARINE APPLICATIONS

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1. Introduction

Applications for thermal spray processes and materials have a broad range across all industrial sectors. Thermal spray processes are easy to use, cost little to operate, and have coating attributes that are beneficial to applications in various industries. Applications include coatings for wear prevention, dimensional restoration, thermal insulation and control, corrosion resistance, oxidation resistance, lubrication films, abrasive actions, seals, biomedical environments, electromagnetic properties, etc.,

Thermal spray processes and deposited materials have resulted in attractive coating solutions in the aerospace, marine applications, industrial gas turbine, petrochemical and gas, and automotive industries [1-5]. The inherent characteristics of it's microstructure can play an important role in enhancing performance. Applications also include automotive/marine diesel components, where low-carbon steel, molybdenum, and other types of corrosion/scuff-resistant alloys are being considered for valve lifter and piston ring applications and cylinder liners [5].

Among the different thermal spray process, high velocity oxy-fuel (HVOF) spraying process is a new and rapidly developing technology, which can yield high density coatings with porosity less than 1%, having high hardness and adhesion values, and good erosion, corrosion and wear resistance properties. HVOF processes are suitable not only for applying tungsten carbide-cobalt and nickel chromium-chrome carbide systems for wear resistant coatings, but also for depositing wear and corrosion resistant alloys such as Inconel (NiCrFe), Triballoy (CoMoCr), and Hastelloy (NiCrMo) materials. HVOF MCrAlY coatings are used for high temperature oxidation/hot corrosion and TBC bond coat applications for repair and restoration of modern aero, marine and industrial gas turbines components. Low melting-point ceramics such as alumina and alumina-titania are also applied via some HVOF processes for abrasive wear and dielectric applications.

Because HVOF thermal spray coatings offer superior properties, competitive costs, and environmentally friendly processing, they are increasingly being used in place of hard chrome plating. Functional hard chrome plating is a critical process associated with manufacturing and maintenance operations on aircraft, vehicles and ships, both in civilian and military sectors, but the plating bath contains hexavalent chromium, which has adverse health and environmental effects. For this reason, the use of hexavalent chromium will be limited. Today, HVOF materials are being applied to hydraulic rods, landing gears, and the internal diameter of large bore cylinders as hard chrome replacements. The HVOF spraying of carbide materials on the landing gears of commercial airliners has been approved for use.

CrC-NiCr and WC-Co systems constitute two main carbide materials used in thermal spraying processes in order to improve the wear resistance and decrease the friction coefficient between various sliding components. Furthermore, the CrC-NiCr system coatings are widely used in high temperature-wear resistance and corrosion-resistant applications in aerospace and powder engineering industries [1, 2]. The CrC-NiCr coatings can be used in corrosive environments at service temperatures up to 800 to 900 ºC [6]. Coatings of the WC-Co system generally have a higher hardness and wear resistance than CrC-NiCr coatings, however, the decarburisation of WC into W_2C, W_3C and even metallic W phase leads to the degradation of coating properties and limits the application of these coatings to temperatures below 450 to 530 ºC [6]. The main shortcoming of CrC-NiCr coatings is a lower hardness than WC-Co system coatings [7].

2. Results and Discussion

The coatings studied in this research have been Cr3C2-25(Ni20Cr) and WC-9Co5Cr1Ni coatings, deposited on a steel substrate with a thickness of approximately 150 µm, using the HVOF thermal spray process.

SEM image of the polished cross-section of the WC-9Co5Cr1Ni coating, obtained by HVOF thermal spraying process, are shown in Fig. 1. The coating exhibits a splat pattern-like structure, which consists of islands that are elongated in directions parallel to the substrate. The coating microstructure consisted of a metallic binder Co-Cr-Ni and WC dispersed carbide phases (bright particles). During the HVOF spraying process the powder particles are accelerated and heated as they travel through the flame. The metallic matrix of the particles melts and the coating built up by the piling up of the impacting droplets that are flattened by the acceleration forces and rapidly cooled down.

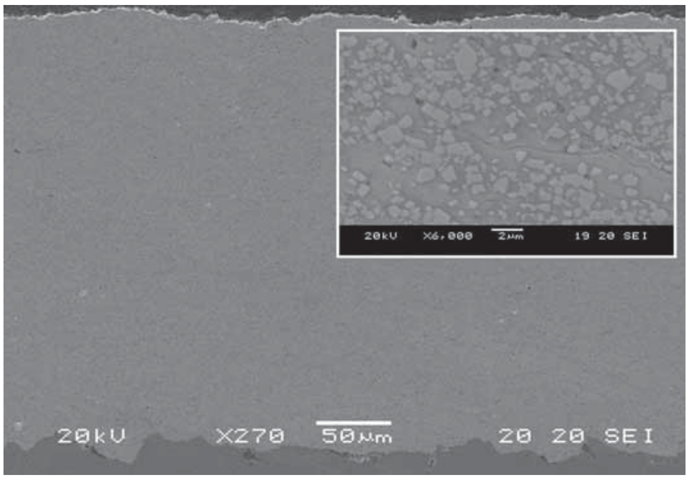

Figure 1. SEM micrograph showing the cross-section of WC-CoCrNi coating.

The coating hardness and Young's modulus have been determined with a microhardness testing system and the tribological evaluation of coated substrates was performed using a Pin on disc tribometer. The coatings sprayed from WCCoCrNi powders are significantly harder than CrC-NiCr coatings and hard chrome plating. The specific wear rate of WC-CoCrNi coating is lower than CrC-NiCr coating and hard chrome plating.

3. Conclusions

The results confirm that HVOF-sprayed coatings are a reliable alternative to electrolytic hard chrome plating. In particular, in the dry wear tests, the HVOF-sprayed coatings outperform hard chrome coatings in wear resistance. HVOF thermal spray coatings could be proposed as an environmentally-friendly, higher performance alternative to hard chrome plating. The advantage of HVOF is that it is a single technology, with a wide variety of materials that can be used to achieve just the right combination of properties for any purpose. Moreover, the HVOF coating process does not produce any hazardous waste and the greater surface characteristics of HVOF-coated components should ultimately lead to reduce the times for its maintenance.

4. References

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CORROSION RESISTANCE IMPROVE BY HARD ANODIZE A356 ALUMINIUM ALLOY BY SUBLIQUIDUS CASTING

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1. Introduction

When compared to conventional castings methods, Subliquidus Casting reduces porosity and trapped gas, allowing cast components to be heat treated without blistering and changing chemical reactivity of the surface [1].
The object of this study is to investigate the possibility to improve the corrosion resistance by hard anodizing in a component obtained by SLC with T6 heat treatment.

2. Materials and Methods

The microstructural characterisation of the A356 anodized aluminium alloy was carried out by scanning electron microscope image analysis equipped with EDS.

Electrochemical corrosion tests were used to study the corrosion resistance with and without the anodizing process. The Nyquist plots were obtained in a three electrode configuration. A saturated calomel electrode (SCE) was used as the reference electrode and a platinum plate was used as the counter electrode. Curves were performed after 30 min of immersion in an aerated 3.5% NaCl solution.

Impedance measurements (EIS) were used at frequency range from 55 kHz to 1.38 mHz, with a logarithmic sweeping frequency of 5 steps per decade and 10 mV excitation voltage amplitude.

3. Results and Discussion

Investigation regarding film formation mechanisms revealed that thickness of the anodic film was not uniform; however, after anodization corrosion resistant was improved.

Figure 1 shows A356 T6 microstructure. It can be appreciated δ spheroids typical of SLC, and globular eutectic as a result of T6 heat treatment

Figure 2 and 3 shows an anodized component cross-section. One can observe that the anodic film isn't completely uniform due to the silicon particles presence that disable the oxide layer formation [2].

Figure 4 Shows Nyquist plots for two specimens. Lower values of charge transference resistance (Rct) in the anodized components are associated with higher corrosion resistance [3].

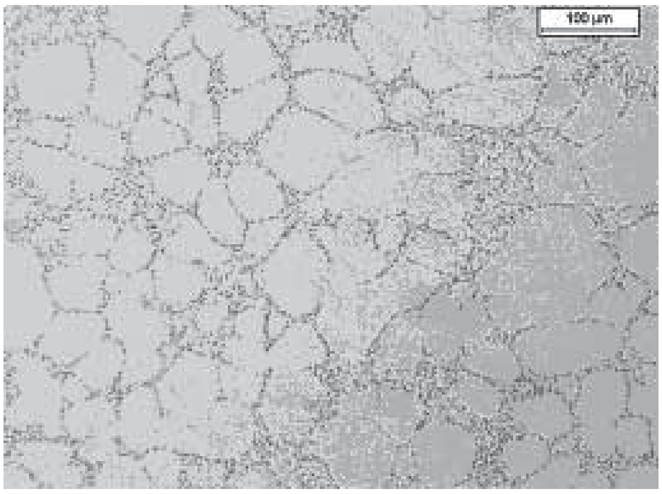

Figure 1. A356 T6 microstructure.

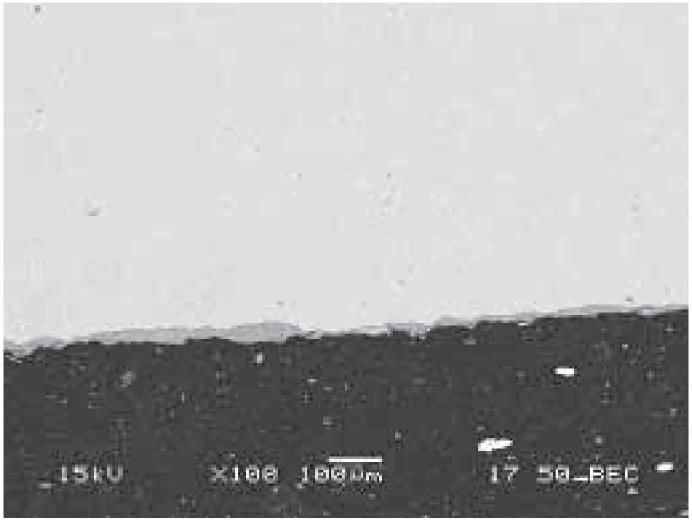

Figure 2. A356 T6 anodized