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Investigation on the corrosion behavior of the bilayered ceramic coatings deposited using atmospheric plasma spraying

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Abstract

Atmospheric plasma spraying (APS) was employed to deposit Al_2O_3, ZrO_2, Al_2O_3/ $ZrO_2$and ZrO_2/ Al_2O_3 coatings on the stainless steel substrate. Microstructural analysis of the as-sprayed coatings was carried out using scanning electron microscope (SEM). Elemental analysis of the coatings was performed using Energy-dispersive X-ray Spectroscopy (EDS) attached with SEM. The corrosion behaviors of the coatings were performed using both the potentiostat and salt spray test in 5 wt% NaCl solution. The results show that the bilayered ZrO_2/ Al_2O_3 coating possesses improved corrosion resistance when compared to the other three coatings.

Keywords: bilayered Al_2O_3- ZrO_2 coating; electron microscopy; hardness, salt spray. corrosion test

1. Introduction

Ceramic coatings are most widely used in the field of automotive, naval, industrial and biomedical sector [1-3]. Amongst all Al_2O_3 and ZrO_2 are mostly preferred for wear and corrosion resistance [4,5]. Various studies have

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revealed that alumina coatings have superior hardness, chemical stability and refractory characters are commonly utilized to resist wear caused by friction and solid particle erosion [6]. For the past few decades, zirconia coatings have been applied on nickel based super alloys as a thermal barrier coating because of its low thermal conductivity, high coefficient of thermal expansion and excellent mechanical properties [7-9].Though several surface modification techniques are available for depositing Alumina and zirconia powders, plasma spraying is considered to be superior due to its versatility, enhanced adhesion and high reliability. Jialianget. al have revealed that increase in the percentages of Alumina in the Alumina+Zirconia coating have resulted in the substantial increase in the corrosion resistance of Stainless steel substrate[10]. Furthermore, the investigations made by Gurusamy Shanmugavelayutham et.al on stainless steel substrate demonstrate that the mixing ratio of Alumina and Zirconia powders play a crucial influence on the hardness, porosity and wear resistance of the coatings[11]. Our recent work on bilayered (ZrO_2/Al_2O_3-13TiO_2) coating resulted in remarkable improvement in the corrosion and wear resistance of the biomedical Ti-13Nb-13Zr alloy [12,13].Though extensive studies were carried out on Al_2O_3 and ZrO_2 coatings for corrosion and wear resistance application, only few research works were focused on the development of bilayered coatings. Hence, an attempt has been made to investigate the effect of plasma sprayed Al_2O_3, ZrO_2, Al_2O_3/ZrO_2 and ZrO_2/Al_2O_3 coatings on the corrosion behavior of Stainless Steel substrates.

2. Experimental

2.1. Coating deposition and characterization

Conventional Al_2O_3, 7wt% yttria stabilized Zirconia (ZrO_2) and alternate layers of Al_2O_3 and ZrO_2 namely Al_2O_3/ZrO_2 and ZrO_2/Al_2O_3 were deposited on stainless steel substrate using 9 MB Metco Plasma spray system (80 kW) and the process parameters are shown intable1. It is also to be noted that the same processing parameters were used to develop (Al_2O_3/ZrO_2 and ZrO_2/Al_2O_3) bilayered coatings also. The morphologies and the cross-section the coatings were observed by JEOL JSM-6360 scanning electron microscope (SEM).Porosity measurements were carried out on the micrographs using MATERIAL-PRO Software attached with optical microscope.

Table 1.Plasma spray parameters used for plasma spraying$Al_2O_3$and ZrO_2powders

Parameters	ZrO_2 coating	Al_2O_3coating
Plasma Current (A)	700	450
Plasma Voltage (V)	55	50
Ar gas flow pressure(NLPM)	42	42
H_2 gas flow pressure(NLPM)	8	9
Carrier gas flow (psi)	58	58
Spray passes (No)	8	4
Spray distance(cm)	20	20

2.2. Salt spray test

The plasma sprayed coatings were subjected to an accelerated corrosion testing i.e., salt spray test according to ASTM B-117-9 standard at MICROLAB, Chennai, India. The salt solution containing 5wt% of NaCl is continuously sprayed as a salt mist over the coated surface of the sample at 30^o angle held on specimen table. The salt spray test was carried out for 6 hours at room temperature. The exposed surface areas of all specimens were 1 cm^2 and the remaining portion except the coated surface was waxed in order to prevent the initiation of corrosion.

2.3. Potentiodynamic polarization studies

Corrosion testing was also carried out in 5wt% NaCl solution using potentiostatconsisting of an electrochemical glass cell with three electrodes namely standard calomel electrode (SCE) as reference and a platinum foil of 10 mm