Title: Complementary Use of Electrochemical Testing Techniques to Study Corrosion Processes of HVOF Inconel 625, CoNiCrAlY and WCCoCr Coatings

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ABSTRACT

The purpose of coating is to get a blend of unique properties at low cost which is not possible from other manufacturing processes. High velocity oxygen fuel (HVOF) is one of the most commonly used thermal spraying processes to produce wear and corrosion resistant coatings. Alongside wear and corrosion resistant properties the HVOF thermally sprayed coating process also induces microstructural heterogeneities which decreased the corrosion resistant properties. Considerable research has been reported on corrosion testing of the HVOF sprayed coatings by using electrochemical techniques. Some electrochemical techniques give area average results whilst other allows the effect of different features to be determined. The complementary use of basic electrochemical techniques with more advance techniques is missing in most of the previous research. In this research work potentiodynamic polarization testing, electrochemical impedance spectroscopy and scanning electrochemical microscopy were used to see if the combined results could provide a broader picture of corrosion processes taking place at HVOF coatings. Three HVOF coatings of different microstructural complexity i.e. γ-phase Inconel 625, γ + β-phase CoNiCrAlY and WC-CoCr cermet coating were tested.

Potentiodynamic polarization results gave overall current response of the applied potential which included the current responsible for chemical reaction and current for charging and

discharging of the double layer. The general corrosion ranking of different materials was established by measuring corrosion potential, corrosion current density and passive current density from polarization curves. The analysis of the polarization curves revealed that without careful consideration of experimental details significant errors can be introduced. Improved procedures for potentiodynamic polarization testing were demonstrated by deliberately altering experimental parameters. The localized corrosion due to chloride ions and Cr-depleted regions was also studied by potentiodynamic polarization testing. The correlation between individual microstructural features and their electrochemical response was established by EIS including equivalent circuit modelling. The impedance spectroscopy results also revealed the electrochemical changes due to immersion time and polarization. The electrochemical activity at high resolution was studied by more sophisticated spatially resolved SECM. The SECM imaging and heterogeneous electron transfer rate constant studies in feedback mode pin point the regions of different electrochemical activity. The SECM imaging and SECM feedback approach curves at stainless steel and bulk Inconel showed negative feedback all over the surface. The Inconel 625 coating showed both positive and negative feedback from the surface. The positive feedback regions correspond to less electrochemically active and negative feedback regions correspond to electrochemically active regions. The comparison between SECM images and microscopy images confirmed that the splat boundaries were the most active regions in the HVOF Inconel 625 coating. The heterogeneous ET kinetic study determined higher rate constant values at positive feedback regions and lower rate constant values at negative feedback regions.