Splat-substrate interactions in high velocity thermal spray coatings

by
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A thesis submitted to the University of Auckland
in the fulfilment of the requirements for the degree of
Doctor of Philosophy in Engineering

Auckland **August 2007**

Abstract

Thermal spray coatings applied with high velocity techniques produce dense, industrial quality coatings with strong adhesion and minimal decomposition. This thesis reports on investigations of splat-substrate interactions for both solid and molten splats. Specifically, individual particles were studied to see how the particle is altered during the spray coating process, how they bond to the substrate and the role of surface oxides.

Investigations of NiCr particles high velocity air fuel (HVAF) thermally sprayed onto different materials found that soft substrates predominantly had deeply penetrating solid particles, whereas harder substrates resisted particle penetration and had a higher percentage of molten splats. This effect is caused by particle kinetic energy converted into heat during plastic deformation. The percentage of particle kinetic energy converted into heat is proportional to substrate hardness. It was also discovered that during the coating process the oxide is not removed or altered in composition, but becomes redistributed over a larger surface area due to the plastic deformation of the substrate. During this process, small scale redistribution and penetration of the oxide material by the incoming particle occurs. These results support the idea that successful bonding can occur only when the surface oxide on the substrate and on the coating material has been disturbed (for solid splats) or disrupted (for molten splats).

To date, our knowledge of solid splat bonding processes within thermal spray coatings has been very subjective where mechanical and chemical bonding has been expected to contribute. In this thesis, the splat-substrate interface was investigated with focused ion beam (FIB) microscopy, cross-sectional SEM and cross-sectional TEM. For solid NiCr splat HVAF coatings, the discovery of interfacial formations, together with no evidence of chemical bonding across the particle-substrate interface suggest that mechanical bonding is the dominant bonding mechanism for solid splat coatings; where as chemical bonding only plays a role when splats and/or substrate become molten.

Acknowledgements

I would like to thank Associate Prof Margaret M. Hyland and Dr Andreas Markwitz for the opportunity to undertake this study, as well as their support and guidance in researching and writing this thesis. I am especially grateful for their encouragement to pursue the topic when things looked grim. The results that eventually came were rewarding and the experience gained is invaluable.

I am also grateful to GNS Science and Auckland University for supporting my PhD. The first three years of this work was performed as an objective of a GNS Science research contract to the New Zealand Foundation for Research, Science and Technology (C05X0008). In the final three years of study, GNS Science and Auckland University supported travel for meetings, experiments and conferences.

A big key in the success of this thesis is due to the people and the capabilities of the Electron-microscope Unit at the University of New South Wales in Sydney. I especially wish to thank Professor Paul Munroe for taking an interest in thermal spray coatings and for being able to call upon his experience in materials research. Also thanks to Damien McGrouther for his experience with FIB, data manipulation and his role in the project. Other members of the Electron-microscope Team: Delphine Chassaing, Katie Levick, Viera Piegerova, also helped me with FIB, TEM and SEM measurements and made my visits to UNSW an enjoyable experience.

Now for a long list of “Thank yous”, to people who also helped me along the way.

- An important resource for my thesis was Pauline Muir and Maureen Coomer in the GNS Science library for sourcing many journal articles and books.
- Thank you to Steve Mathews previously of Auckland University, Ben Withy of Auckland University and Holsters Engineering in Tokoroa for assistance with HVAF thermal spray sample preparation.
- Thank you to Dr. Bryony James of Auckland University for XPS measurements;
- Thank you to Catherine Hobbis of Auckland University and Kay Card of Industrial Research Ltd for assistance with additional SEM measurements.

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