HÖGSKOLAN VÄST

Design of Thermal Barrier Coatings

NICHOLAS CURRY

AKADEMISK AVHANDLING

som med tillstånd av Forsknings- och forskarutbildningsnämnden vid Högskolan Väst för vinnande av doktorsexamen i ”Produktionsteknik” framläggs till offentlig granskning.

Friday, February 28, 2014, at 10 am in F127, University West

Opponent: Professor Matthias Oechsner, Manager of Center for Structural Materials, Technishe Universität Darmstadt, Germany

Abstract

Title: **Design of Thermal Barrier Coatings**

Keywords: Industrial Gas Turbine; Aero Turbine; Thermal Barrier Coating; Atmospheric Plasma Spraying; Suspension Plasma Spraying; Thermal Conductivity; Thermo-cyclic fatigue; Thermal Shock

ISBN: 978-91-977943-8-1

Thermal barrier coatings (TBC's) are used to provide both thermal insulation and oxidation protection to high temperature components within gas turbines. The development of turbines for power generation and aviation has led to designs where the operation conditions exceed the upper limits of most conventional engineering materials. As a result there has been a drive to improve thermal barrier coatings to allow the turbine to operate at higher temperatures for longer.

The focus of this thesis has been to design thermal barrier coatings with lower conductivity and longer lifetime than those coatings used in industry today. The work has been divided between the development of new generation air plasma spray (APS) TBC coatings for industrial gas turbines and the development of suspension plasma spray (SPS) TBC systems.

The route taken to achieve these goals with APS TBC's has been twofold. Firstly an alternative stabiliser has been chosen for the zirconium oxide system in the form of dysprosia. Secondly, control of the powder morphology and spray parameters has been used to generate coating microstructures with favourable levels of porosity.

In terms of development of SPS TBC systems, these coatings are relatively new with many of the critical coating parameters not yet known. The focus of the work has therefore been to characterise their lifetime and thermal properties when produced in a complete TBC system.

Results demonstrate that dysprosia as an alternative stabiliser gives a reduction in thermal conductivity. While small at room temperature and in the as produced state; the influence becomes more pronounced at high temperatures and with longer thermal exposure time. The trade-off for this lowered thermal conductivity may be in the loss of high temperature stability. Overall, the greatest sustained influence on thermal conductivity has been from creating coatings with high levels of porosity.

In relation to lifetime, double the thermo-cyclic fatigue (TCF) life relative to the industrial standard was achieved using a coating with engineered porosity. Introducing a polymer to the spray powder helps to generate large globular pores within the coating together with a large number of delaminations. Such a structure was shown to be highly resistant to TCF testing.

SPS TBC's were shown to have much greater performance relative to their APS counterparts in thermal shock life, TCF life and thermal conductivity. Columnar SPS coatings are a prospective alternative for strain tolerant coatings in gas turbine engines.