HÖGSKOLAN VÄST

Design of Thermal Barrier Coatings

A modelling approach

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AKADEMISK AVHANDLING

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

Fredagen den 16 januari 2015, klockan 10 i Entré AIL, Högskolan Väst

Opponent: Professor Lech Pawlowski, University of Limoges

Abstract

Title: Design of Thermal Barrier Coatings – A modelling approach

Keywords: Thermal barrier coatings; Microstructure; Thermal conductivity; Young's modulus; Interface roughness; Thermally grown oxide; Lifetime; Finite element modelling; Design

ISBN: 978-91-87531-05-7

Atmospheric plasma sprayed (APS) thermal barrier coatings (TBCs) are commonly used for thermal protection of components in modern gas turbine application such as power generation, marine and aero engines. TBC is a duplex material system consisting of an insulating ceramic topcoat layer and an intermetallic bondcoat layer. TBC microstructures are highly heterogeneous, consisting of defects such as pores and cracks of different sizes which determine the coating's final thermal and mechanical properties, and the service lives of the coatings. Failure in APS TBCs is mainly associated with the thermo-mechanical stresses developing due to the thermally grown oxide (TGO) layer growth at the topcoat-bondcoat interface and thermal expansion mismatch during thermal cycling. The interface roughness has been shown to play a major role in the development of these induced stresses and lifetime of TBCs.

The objective of this thesis work was two-fold for one purpose: to design an optimised TBC to be used for next generation gas turbines. The first objective was to investigate the relationships between coating microstructure and thermal-mechanical properties of topcoats, and to utilise these relationships to design an optimised morphology of the topcoat microstructure. The second objective was to investigate the relationships between topcoat-bondcoat interface roughness, TGO growth and lifetime of TBCs, and to utilise these relationships to design an optimal interface. Simulation technique was used to achieve these objectives. Important microstructural parameters influencing the performance of topcoats were identified and coatings with the feasible identified microstructural parameters were designed, modelled and experimentally verified. It was shown that large globular pores with connected cracks inherited within the topcoat microstructure significantly enhanced TBC performance. Real topcoat-bondcoat interface topographies were used to calculate the induced stresses and a diffusion based TGO growth model was developed to assess the lifetime. The modelling results were compared with existing theories published in previous works and experiments. It was shown that the modelling approach developed in this work could be used as a powerful tool to design new coatings and interfaces as well as to achieve high performance optimised morphologies.