CRITICAL LOCATIONS IN PLASMA SPRAYED THERMAL BARRIER COATINGS DUE TO IRREGULARITIES OF BOND COAT SURFACE

Karel Slámečka(*) , Petr Skalka, David Jech, Lenka Klakurková, Ladislav Čelko
Central European Institute of Technology, Brno University of Technology, Czech Republic
(*) Email: karel.slamecka@ceitec.vutbr.cz

ABSTRACT
In this work, critical locations in plasma-sprayed thermal barrier coatings are identified based on finite element calculations of residual cooling stresses that took into account waviness of the bond coat surface. The results are compared to microscopic observations of oxidized and thermally cycled specimens with conventional (CoNiCrAlY + Y₂O₃-ZrO₂) and novel (CoNiCrAlY + ZrO₂-Αl₂O₃-SiO₂) coatings.

Keywords: Thermal barrier coatings, plasma-spraying, thermal stresses, waviness.

INTRODUCTION
Thermal barrier coatings (TBCs) are advanced material systems used in propulsion and power generation applications to improve engine efficiency and to enhance lifetime of hot-section components such as turbine blades, vane platforms or combustion chambers (Miller, 1997). TBCs typically consist of two applied layers: an aluminium-rich metallic bond coat, often of a MCrAlY-type, where M stands either for Co, Ni, or a combination of both, and an insulating ceramic top coat (TC) of yttria partially stabilized zirconia (YSZ), or modern alternatives such as pyrochlores, hexaaluminates, perovskites or nanocoatings (Vaßen, 2010). A third thin oxide layer (TGO) gradually develops at high temperatures at the bond-coat/YSZ interface, thus resulting in a three-layer system.

In the case of plasma-sprayed TBCs, spallation frequently occurs at/near the interface at the end of cooling due to propagation of cracks under stresses originating mostly from different thermal expansion of individual layers. The geometry of the interface is thus one of the key factors influencing TBCs’ performance. Recently, the importance of the waviness component has been pointed out and the residual stresses were assessed for regular (Skalka, 2015) and irregular waviness geometries (Slámečka, 2015). In this paper, the critical locations in TBCs are discussed based on expanded calculations and microscopic observations of cracks near roughness and waviness features in specimens with conventional (CoNiCrAlY + Y₂O₃-ZrO₂) and novel (CoNiCrAlY + ZrO₂-Αl₂O₃-SiO₂) thermal barrier coatings.

RESULTS AND CONCLUSIONS
As an example, the residual stresses in the top coat and at the TGO/bond-coat interface in the TBC system with irregular interface are shown for the thickness of the TGO layer of 3 µm, Fig. 1. The colour in these figures encodes the global z-coordinate which more or less represents waviness peaks and valleys. To enhance the contrast, only the data obtained in the vicinity of the TGO layer are presented for the top coat.
Calculations show that within the top coat and at the TGO/bond-coat interface, the critical regions are located at the peak zone, which in the top coat tend to move towards the valley with further oxidation. Obtained predictions match well with the experimental evidence, e.g. Fig. 2.

Fig. 1 - Stress maps obtained for the top coat (left) and the TGO/bond-coat interface (right) for the thickness of the TGO layer \( t_{\text{TGO}} = 3 \mu\text{m} \).

Fig. 2 - Microcracks in the top coat and delamination at the TGO/bond coat interface at the roughness peaks in CoNiCrAlY-YSZ after long-term oxidation in air (200h, 1050 °C).

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REFERENCES

