Accepted Manuscript

Thermal fatigue testing and simulation of an APS TBC system in presence of a constant bending load

H. Ebrahimi, S. Nakhodchi

PII: S0142-1123(16)30371-1
DOI: http://dx.doi.org/10.1016/j.ijfatigue.2016.11.008
Reference: JIJF 4123

To appear in: *International Journal of Fatigue*

Received Date: 2 July 2016
Revised Date: 20 October 2016
Accepted Date: 8 November 2016

Please cite this article as: Ebrahimi, H., Nakhodchi, S., Thermal fatigue testing and simulation of an APS TBC system in presence of a constant bending load, *International Journal of Fatigue* (2016), doi: http://dx.doi.org/10.1016/j.ijfatigue.2016.11.008

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ACCEPTED MANUSCRIPT

Thermal fatigue testing and simulation of an APS TBC system in presence of a constant bending load

H. Ebrahimi [a], S. Nakhodchi [b,*]

[a,b] *Department of Mechanical Engineering, K. N. Toosi University of Technology, P.O.B. 1999-19395, Tehran, Iran*

* *Corresponding author: snakhodchi@kntu.ac.ir*

Abstract

Thermal Barrier Coatings (TBCs) are used as thermal insulation to protect components operating at high temperature. A multiple failure mechanism may exist in a TBC system associated with diverse in-service conditions. In this paper, Inconel 617 superalloy substrates were coated with 8% Y_2O_3 stabilized tetragonal ZrO_2 powder, deposited on top of a Ni22Cr10Al1Y bond coat by atmospheric plasma spraying (APS). In order to investigate the damage mechanism of the in-service components, experiments and numerical FE analysis were conducted to simulate the loading conditions of the TBC system in a land-based gas turbine combustor component. A specific test rig was designed and manufactured such that coated specimens were simultaneously subjected to constant bending load and thermal cycles. The temperature history was measured on both sides of the specimens and a maximum surface temperature of 1170°C on the coating surface and a thermal gradient of 500°C was obtained across the TBC system. The TBC system - failed after 82 thermal cycles. The microstructural observation showed multiple vertical and horizontal cracks confined within the top coat. By increasing the mechanical load, more extensive cracks were observed in a similar pattern. The final failure was governed by delamination at the top coat and bond coat interface. A subsequent finite element analysis confirmed that the application of external mechanical load can change the failure mechanism of the TBC. It also demonstrated that the TBC life is limited by crack propagation instead of crack initiation.

Keywords:

Thermal Barrier Coating, Thermal Fatigue , Finite Element Simulation, Cohesive Zone Model

Nomenclature

A^0	swelling coefficient ((μm/s)$^{1/n}$)
Cp	specific heat (J/kgK)
CPE8T	an 8-node plane strain thermally coupled quadrilateral, biquadratic displacement, bilinear temperature element.
d(t)	thickness of oxide layer as a function of time (μm)
d_0	initial thickness of oxide layer (μm)
E	modulus of elasticity (MPa)
E_a	swelling exponent factor
G_n	first mode strain energy (J/m^2)
G_s	second mode strain energy (J/m^2)
k	conductivity (W/mK)
M_B	bending moment (Nmm)
n	swelling exponent
P_c	midpoint of coated surface of specimen
P_s	midpoint of substrate surface of specimen
R	swelling exponent factor
S22	normal stress in direction of 2nd axis
t	time (s)
t_n	first mode traction (MPa)
t_s	second mode traction (MPa)
T	temperature (°C or K)
$T_{0,n}$	first mode cohesive strength (MPa)
$T_{0,s}$	second mode cohesive strength (MPa)
α	coefficient of thermal expansion (1/ °C)
δ	separation (μm)
δ_0	critical separation (μm)
ε^{ox}	oxidation (or swelling) strain
$\dot{\varepsilon}^{ox}$	oxidation (or swelling) strain rate
ρ	density (Kg/m^3)
ν	Poisson's ratio
Γ_0	general cohesive energy (J/m^2)
$\Gamma_{0,n}$	first mode cohesive energy (J/m^2)
$\Gamma_{0,s}$	second mode cohesive energy (J/m^2)

Download English Version:

https://daneshyari.com/en/article/5015153

Download Persian Version:

https://daneshyari.com/article/5015153

Daneshyari.com