Measurements and Numerical Simulation of Thermal and Mechanical Properties of AlSi-Polyester Abradable Coatings

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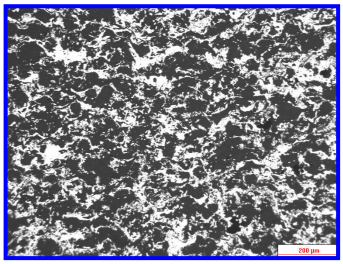
Abradable seals are used in aerospace applications to control the overtip leakages between the blades of an engine rotor and its static parts. To achieve the combination of properties required, these seals have been developed with thermally sprayed coatings generally elaborated from a range of two or three phase powder mixtures, resulting in highly porous composite materials.



AlSi-Polyester abradable material - Typical micrograph

Experimental work

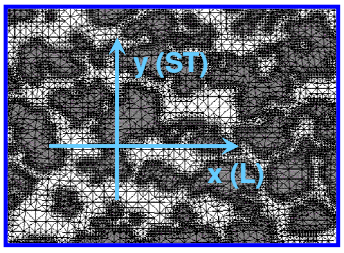
Metco 601 and Durabrade 1605 powder materials were used to provide testable coatings by plasma spraying with a Sulzer Metco 9 MB gun.

- Determined physical properties: specific heat (c_p), thermal diffusivity (a), density (ρ), thermal conductivity (λ) (calculated from c_p, a and ρ) and coefficient of thermal expansion (α).
- Mechanical properties investigated: Young's Modulus (E) in a longitudinal (L) direction and ultimate tensile strength (UTS) in both longitudinal and short transverse (ST) directions.

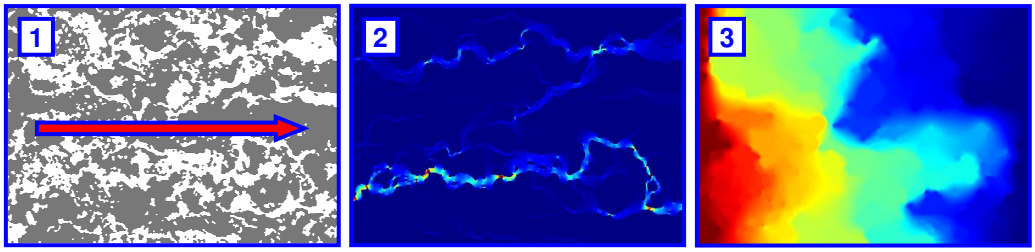
Modelling

Finite Element Methods were used to estimate some mechanical and physical properties derived from micrographs, with different magnifications.

- Elastic parameters (E_x, E_y, ν_{xy}, ν_{yx}, G_{xy} according to the orthotropic Hooke's law) were deduced from virtual tensile and shear tests.
- Coefficients of thermal expansion (α_x, α_y) were computed from the strains induced by a virtually imposed temperature increase.
- Thermal conductivities (λ_x, λ_y) were estimated from a heat transfer simulation, thanks to an in-house developed code, which directly uses the pixels as a mesh.



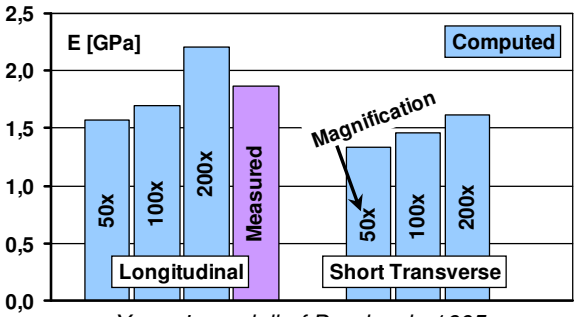
Adaptive Mesh generated by OOF (Object-Oriented Finite Element Analysis) from NIST



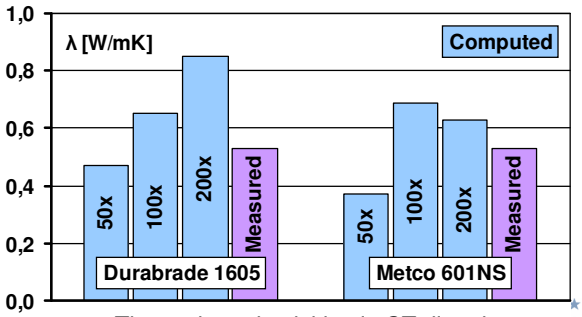
Heat transfer simulation
1 - Global heat flux
2 - Heat flux densities
3 - Temperature field

Results

The computed values are consistent with the measured ones, considering the hypotheses made (examples below). That confirms the great interest of these simulation tools for the design of new abradable materials.
Further works in progress: optimization of the magnification, statistical validations, influence of the components properties, prospective materials simulations.



Young's moduli of Durabrade 1605



Thermal conductivities in ST direction

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NEWAC new aero engine core concepts

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