High temperature oxidation resistance of thermal barrier coating systems

INTRODUCTION

The protection of certain metal parts against the effects of temperature and corrosion may require the development of complex strategies such as thermal barrier coating (TBC). These oxide coatings aim at slowing down the oxidation phenomenon but do not prevent it completely and cause other effects such as cracking of the coatings or spalling. The study of the oxidation kinetics of metallic alloys at high temperature is frequently performed using thermogravimetric analysis (TGA), which follows the mass increase of samples exposed to the desired temperature and atmosphere conditions.
THEMYS FLASH is a TGA equipment designed to best approximate the rapid and cyclic heating and cooling conditions of parts requiring TBC protection.

EXPERIMENT

- Instrument : THEMYS FLASH
- Sample: AM3 nickel-based superalloy + Thermal Barrier Coating composed of a NiPtAl bound coating and a ZrO2 top coating. Preoxidized during 20 h at 900 °C.
- Atmosphere: Air at a flow rate of 1l/h.
- The temperature profile was composed of a series of heating and cooling cycles with four phases as follows:

1. Heating at 140 °C/min up to 1100 °C,
2. A high temperature dwell time of 1 h at 1100 °C,
3. Cooling down to 200 °C at 300 °C/min,
4. A 15 min hold time at 200 °C.

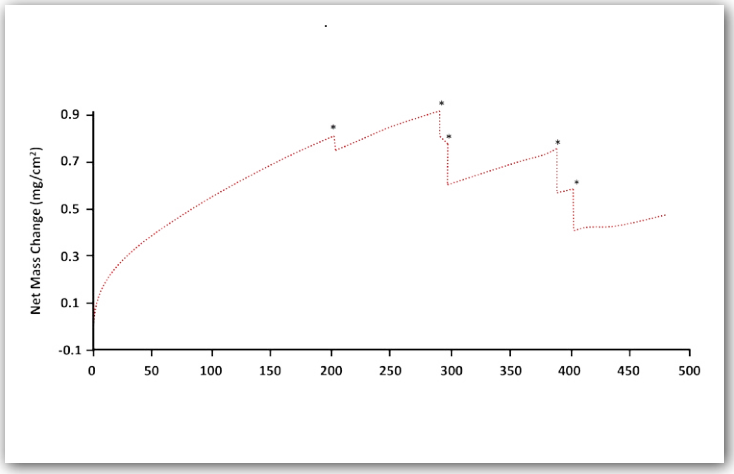


Figure 1 – Net mass change as a function of the cycle number. Stars (*) mark the cycles during which spalling effects occurred.

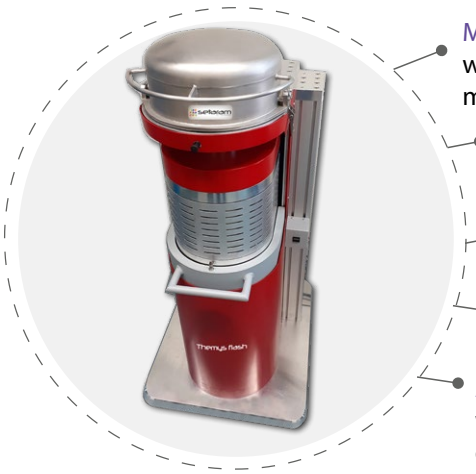
RESULTS AND CONCLUSION

The mass change due to oxidation is very small, of the order of magnitude of 30µg/cm2/cycle during the first cycles. It is still measurable thanks to the high sensitivity of the equipment. Starting at cycle 202, spalling effects were detected at various stages of the process (marked by *), but they corresponded to small percentages of the total mass of zirconia top coating (0.01–0.3%).

Reference : A. Vande Put et al., Cyclic thermogravimetry of TBC systems, Surface & Coatings Technology 202 (2007) 665–669.

INSTRUMENT

THEMYS FLASH



MULTIPLE SIMULTANEOUS MEASUREMENTS
with a flexible balance integrating up to 5 weighing modules

HIGH ACCURACY & VERSATILE
hang-down symmetrical beam balance specifically designed for TGA applications

FAST HEATING AND COOLING
thanks to its unique design of image furnace

FAST TEMPERATURE CYCLING CAPABILITY
to simulate some real materials' ageing conditions

A VARIETY OF ATMOSPHERE CONDITIONS
with the possibility of operating under oxidative gas, inert gas, or vacuum