Deposition of Fuel Impurities Within Thermal Barrier Coatings in Gas Turbine Hot Gas Paths

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For the reliable operation of modern gas turbines, Thermal Barrier Coatings (TBCs) need to withstand a wide range of ambient conditions resulting from impurities in inlet air or fuels. When analyzing deposition of detrimental hot gas constituents, previous efforts largely focus on the investigation of solid and molten deposit interaction with TBCs. Recent literature and observations in gas turbines indicate that not only liquids can penetrate porous TBCs, but the deposition from gas phase inside of pores and cracks is also an aspect of TBC degradation.

To investigate this vapor deposition process, a diffusion model has been coupled with a thermodynamic equilibrium solver. The diffusion model calculates vapor transport of trace elements through pores and gaps in the TBC, where the thermodynamic equilibrium solver calculates local thermodynamic equilibria to predict whether deposition takes place. In this work the model is applied to discuss deposition properties of calcium. In recent literature calcium has — in some cases — been reported to deposit inside of TBCs as pure anhydrite ($CaSO_4$). An actual anhydrite finding in the TBC of a stationary gas turbine blade was reproduced applying the introduced model. The vapor deposition is shown to occur within and on top of the TBC, depending on a number of factors, such as: pressure, temperatures, calcium to silicon ratio and calcium to sulfur ratio.

The successful alignment of conditions in real engines with model results will allow to address the increasing demand for more fuel- and operational flexibility of current and future gas turbines.

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