Probabilistic lifetime prediction of TBC coated parts considering design, operation and manufacturing + Thermal barrier coatings ageing mechanisms in land-based gas turbines

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PROBABILISTIC LIFETIME PREDICTION OF TBC COATED PARTS CONSIDERING DESIGN, OPERATION AND MANUFACTURING

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Last three decades, predominately the development of TBC coated parts has enabled high turbine inlet temperatures, resulting in high efficiency. Meanwhile, advanced GTs have to rely on the temperature barrier to reduce thermally activated degradation mechanisms of the metallic parts (i.e. oxidation or fatigue) to acceptable levels for guaranteed lifetime.

A lifing model has been developed based on lab testing to describe the time-temperature-dependence of TBC spallation. An extensive parameter study, using serial parts and coating processes, was done to investigate the affect of manufacturing scatter on TBC life as well as on thermal loading. The impacts of several parameters have been quantified. The transfer to part level has to consider the overall boundary conditions, i.e. increased TBC thickness will reduce on one hand the bondcoat temperature and the risk of spallation, but on the other hand, the increased thickness will increase the stresses within the TBC and the risk of spallation. The overall impact of TBC thickness can be positive or negative. It depends on the other parameters responsible for heat flux and temperatures.

Also design and boundary conditions impact the thermal loading. Heating and cooling conditions depend on heat transfer as well as hot gas and cooling air temperature. The later can vary significantly for different sites and seasons, and additionally due to the heat pick-up along the cooling passage.
In this study 12 parameters have been evaluated by Monte Carlo Simulation for risk of TBC spallation on part level. Using this model the impact of design of cooling, operational boundary conditions and the manufacturing scatter on the BC/TBC life can be assessed and optimized by focusing on those parameters that are most critical for coating lifetime.