Keynote Presentation
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Development of a Creep-Fatigue Lifing Strategy and Small Punch Creep Testing Technique for Gas Turbine Hot Gas Path Components

The requirements of the energy market are driven by an increased flexibility due to the actual economic climate and the tendency for discontinuous use of conventional resources in favour of renewable energies. Their flexibility makes Gas Turbines (GT) the main source of electrical power in this highly intermittent energy market. This makes, however, great demands on the fatigue resistance of hot gas path blades and vanes (HGPB&Vs) and in particular on their ability to withstand the interaction of fatigue, creep and environmental damage. While these effects reduce the expected life, maintenance intervals and reparability of these components, continuous cost reduction initiatives for more competitive maintenance plans oblige GT OEMs to extend the life of these critically loaded components. An understanding of the behaviour of the critical parts in this environment is therefore key for GT OEMs to quantify residual component life after service and to rejuvenate HGPBs.

A new creep-fatigue design methodology has been developed for GT blades and vanes of two Ni based superalloys. This includes the definition of an advanced constitutive model able to characterise the critical locations and conditions in HGPB&Vs by FE simulation. Creep-fatigue experiments have then been designed that reproduce the service conditions in critical locations to understand and better describe the respective damage mechanisms. The effectiveness of the methodology has been verified using service-like Thermo-Mechanical Fatigue (TMF) benchmark tests that simulate the situation at critical locations of HGPB&Vs. Two case studies will be presented for which the new procedure has been applied. These results will be underpinned by available field feedback to validate the lifing method.

The assessment of operated components has been conducted not only through microstructural evaluation but also through a miniaturised testing technique that allows the sampling of material from real critical locations. Small punch creep testing has been evaluated for Ni based superalloys and applied for the determination of the residual creep life of critical HGPB&Vs after operation.

Finally, this testing technique has been exploited for the quantification of material recovery in SX blades as obtained through a newly developed rejuvenation heat-treatment process. Thereby, various components after service have been considered with different operating regimes.