Industrial gas turbines constitute a considerable portion of global power generation. Turbine blades are subjected to high temperatures, an array of mechanical loads, and dynamic fluid fields, all contained within a non-isothermal profile, making creep and high-cycle fatigue critical aspects of turbine blade design. Improved life prediction models with even greater accuracy are needed to maintain today's product reliability under the extreme environments associated with next-generation operating conditions.

The combination of creep and high-cycle fatigue produces a synergistic interaction effect, whose explicit consequence to turbine life remains unaccounted for by current, decoupled life prediction models, which traditionally incorporated such interaction effects into design safety factors. The continued development of high fidelity analytical tools, unique cooling technologies, and advanced materials has propelled turbine design to higher efficiencies and tighter margins. Improved lifing models capable of capturing these effects are now needed in order to maintain current reliability standards in these ever-expanding, future operating conditions. Combined creep and high-cycle fatigue has been the subject of very little research; however, sufficient knowledge is available in literature to guide the formation of a comprehensive study.

This research study identifies the life-limiting aspect of a combined high-cycle fatigue and creep response in conventionally cast Ni-base superalloy CM 247 LC, and captures the interaction of the two loads in two novel candidate life prediction frameworks. A variety of temperatures, creep strains, and fatigue loading conditions are be explored to ensure that the resulting model is applicable to the myriad of potential turbine blade operating conditions. Additional tests are also be carried out to determine the contribution of high temperature aging on the combined failure and to evaluate the effect of material grain size. Rigorous metallographic assessments accompanying each test are leveraged to create the microstructurally-informed combined life prediction frameworks.

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Approved for distribution by Ali Gordon, Committee Chair, on June 16, 2020.

The public is welcome to attend.