Premature failures of vital gas turbine components, such as blades and vanes, have been the result of increasing demands of power generation facilities. As power needs fluctuate throughout the day, operators are quickly firing up gas turbines as a means of providing instant power. Traditionally, these engines would run at constant operating conditions; however, contemporary operating conditions call for these engines to be applied on an “as necessary” basis. The result of the cyclic startup and shutdown of gas turbines has led to a phenomenon known as creep-fatigue. A coupling of two primary failure mechanisms in gas turbines, creep-fatigue exacerbates the mechanisms of creep and fatigue, ultimately leading to a premature failure of components. Traditionally, independent creep and fatigue analyses are conducted to determine the limiting life factor of gas turbines. Recently, fracture mechanics approaches have been successfully used in extending the traditional analyses to include fatigue- and creep-crack growth analyses. Founded on existing approaches to creep-fatigue crack growth analyses, including experimental elastic and plastic fracture mechanics approaches, a unified creep-fatigue crack initiation and propagation model is developed.

To bring this model to fruition, the current study utilizes the development of an experimental setup capable of subjecting a modified fracture specimen to creep-fatigue conditions. With two test temperatures key to turbine components, a blunt notch compact tension specimen was subjected to trapezoidal load waveforms with various lengths of holds at maximum load. A developed direct current potential drop (DCPD) system was used to monitor crack initiation and crack lengths throughout the duration of tests. Numerical simulations on a representative specimen were conducted, to correlate and predict key fracture mechanics parameters used in the development of creep-fatigue crack initiation and propagation models. Metallurgical analysis of specimens was conducted, implementing both optical and scanning electron microscopy. From the experimental and numerical studies, a model for both the initiation and propagation of cracks on a single specimen is furnished. Through the use of elastic-plastic fracture mechanics parameters, the proposed models are observed to predict crack initiation and replicate crack propagation rates based on the experimental conditions. Assisting in the implementation of the proposed models, intended uses and applications for the models are provided, simplifying the life prediction analyses for components expected to fail due to creep-fatigue service conditions.

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The public is welcome to attend.