Anisotropic tertiary creep-damage formulations have become an increasingly important prediction technique for high temperature components due to drives in the gas turbine industry for increased combustion chamber exit pressures, temperature, and the use of anisotropic materials such as metal matrix composites and directionally-solidified (DS) Ni-base superalloys. Typically, isotropic creep damage formulations are implemented for simple cases involving a uniaxial state of stress; however, these models can be further developed for multiaxial states of stress where materials are found to exhibit induced anisotropy. In addition, anisotropic materials necessitate a fully-developed creep strain tensor. This thesis describes the development of a new anisotropic tertiary creep-damage formulation implemented in a general-purpose finite element analysis (FEA) software. Creep deformation and rupture tests are conducted on L, T, and 45°-oriented specimen of subject alloy DS GTD-111. Using the Kachanov-Rabotnov isotropic creep-damage formulation and the optimization software uSHARP, the damage constants associated with the creep tests are determined. The damage constants, secondary creep, and derived Hill Constants are applied directly into the novel formulation. Comparison between the isotropic and novel creep-damage formulations demonstrates modeling accuracy. An examination of the off-axis creep strain terms using the novel formulation is conducted. Integration of the isotropic creep-damage model provides time to failure predictions which are compared with rupture tests, and other failure prediction methods. A parametric study examining various states of stress, and materials orientations is performed to verify the flexibility of the novel formulation. A parametric exercise of the time to failure predictions for various levels of uniaxial stress and temperature is conducted.

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The public is welcome to attend.