Probabilistic Fracture Mechanics for Heavy-Duty Gas Turbine Rotor Operations in the Energy Sector

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We present probabilistic fracture mechanics methodologies and applications from an energy industry perspective. Topics include probabilistic fracture mechanics for heavy-duty rotating equipment, including gas turbine rotor disks, probabilistic modeling of forging flaw crack nucleation, modeling of non-destructive inspection capabilities, and probabilistic crack propagation from low-cycle fatigue-initiated cracks. We will present relevant new design and service applications in which reliable risk quantification and minimization are paramount. We will also illustrate how the developed Monte Carlo scheme harnesses the power of high-performance computing, including Graphics Processing Unit (GPU) utilization, to enable a fast computational turn-around time for the millions of individual fatigue crack growth calculations needed to resolve the low-risk requirements.

The presented methods pave the way for a fast and reliable robust risk quantification of power plant components and systems, including probabilistic digital twins, and support power plants' efficient, reliable operation. These methods are essential for the energy transition, including intermittent renewable energy sources such as wind turbines and photovoltaic systems, where the start-up flexibility of gas turbines is a crucial requirement.

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