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Probabilistic Damage Tolerance Methodology for Solid Fan Blades and Discs

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Abstract : Solid fan blades and discs in aero engines are subjected to high combined low and high cycle fatigue loads especially around the contact areas between blade and disc. Therefore, special coatings (e.g. dry film lubricant) and surface treatments (e.g. shot peening or laser shock peening) are applied to increase the strength with respect to combined cyclic fatigue and fretting fatigue, but also to improve damage tolerance capability. The traditional deterministic damage tolerance assessment based on fracture mechanics analysis, which treats service damage as an initial crack, often gives overly conservative results especially in the presence of vibratory stresses. A probabilistic damage tolerance methodology using crack initiation data has been developed for fan discs exposed to relatively high vibratory stresses in cross- and tail-wind conditions at certain resonance speeds for limited time periods. This Monte-Carlo based method uses a damage databank from similar designs, measured vibration levels at typical aircraft operations and wind conditions and experimental crack initiation data derived from testing of artificially damaged specimens with representative surface treatment under combined fatigue conditions. The proposed methodology leads to a more realistic prediction of the minimum damage tolerance life for the most critical locations applicable to modern fan disc designs.

Keywords : combined fatigue, damage tolerance, engine, surface treatment
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