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A SED-Based Mode-Dependent Limit Notch Radius for Multiaxial (I+III) Fatigue of Notched Components and its Effective Stress Formulation

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Geometrical discontinuities in mechanical components govern fatigue performance through stress concentrations and steep stress gradients. Classical point-based approaches are not fully consistent in capturing the full range of notch geometries, leading to the conventional distinction between blunt and sharp notches treated as separate cases. The averaged Strain Energy Density (SED) approach provides a consistent energy-based framework for notch fatigue assessment through the evaluation of the SED over a finite control volume defined by characteristic lengths associated with mode I+II and mode III loading. A key result of the present work is the emergence of a mode-dependent limit notch radius, derived within the averaged SED framework, which governs the transition between blunt and sharp notch behaviour. An analytical expression is derived for this limit radius as a function of mixed-mode loading conditions and notch opening angle. Furthermore, the limit radius under mixed-mode loading is shown to be bounded by the corresponding pure Mode I and Mode III limits, ensuring a continuous transition across loading regimes. The formulation is validated against a comprehensive experimental database of mixed-mode (I+III) fatigue results collected from the literature, comprising 142 curves for different materials. Within the derived framework, the Atzori-Lazzarin-Meneghetti diagram is extended to multiaxial loading conditions, enabling a reformulation of the averaged SED as an equivalent stress. This preserves the physical basis of the averaged SED while enabling a unified and practical fatigue assessment of notched components under multiaxial loading

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