From Uniaxial to Multiaxial Ultrasonic Fatigue Component Frequency Modulation and Experiment

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Ultrasonic Fatigue Testing *Specimen design* *Multiaxial fatigue*

Abstract Ultrasonic fatigue experiments demand meticulous monitoring, control, and precise measurement equipment, alongside rigorous design considerations for all present components. Ultrasonic fatigue testing (UTF) has continuously evolved towards proven methodology that is simpler, more reliable, and therefore standardizable. This study addresses the challenges and limitations inherent in UTF with regards to the specimen design and modulation. Analytical and computational methods prevalent in published research on specimen and ultrasonic component design are discussed. All discussed challenges are greatly enhanced when regarding multiaxial ultrasonic fatigue.

Ultrasonic machine components and specimen setup must resonate at explicit high frequencies, exhibiting the desired mode shapes that induce targeted stresses. The interconnection between components, the desired frequency and associated mode shape, and the displacement-to-strain relationship are critical to successfully execute and monitor any ultrasonic fatigue experiment.

Furthermore, this study dwells in a new proposed intricate semi-analytical formulation model for ultrasonic specimen geometries catered towards both uniaxial and multiaxial specimens. The significance of this work lies in its potential to empower researchers with a tool that enhances the design and execution of ultrasonic fatigue experiments. The proposed semi-analytical method offers a more versatile and time-efficient approach for future exploration on optimization algorithms for ultrasonic fatigue components and specimens. To showcase its capabilities, all available and applied methods are revised and compared against the model analytically and then with experimental measurement results.