Improving Cruciform Test Specimens Frequency Response for VHCF Ultrasonic Biaxial Fatigue Testing

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Abstract Very High Cycle Fatigue (VHCF) using ultrasonic machines is a subject that is receiving growing attention. Recent developments focus on biaxial stresses which are of interest to industries such as the aeronautical where plane stresses appear in the fuselage and wings. This paper aims at improving the design of biaxial VHCF cruciform test specimens that have known issues which have not yet been solved. Studies are carried out by using both numerical and experimental methods. In the first part of the study, the shape of a cruciform type specimen is improved. The main goal is to ensure the test specimen only has one mode shape in the 19.5-20.5 kHz machine's operating frequency range, since it was observed that the existence of more than one mode may affect experimental results. The final specimen confirms the theoretical discussion and the design parameters that are obtained have managed to avoid undesired mode shapes in the operating frequency range of the test machine. The second part focuses on asymmetric models, used to create non-unitary biaxiality ratios. Comparing the simulation results with the experimental data shows that the strain rates can provide acceptable prediction of biaxiality ratios. Moreover, it was observed that the biaxiality ratios obtained from stress, displacement and strain are not equal to each other and, in fact, can be correlated by an expression that was derived in the course of this research.