Fatigue strain fields comparison between Synchrotron X-Ray Diffraction and 3D Numerical computation in a bainitic steel

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ABSTRACT

Engineers prioritize resource preservation when designing lightweight materials, but fatigue can pose challenges. Although various experimental methods exist for studying fatigue cracks, some are only effective for transparent materials. For example, transmission photo-elasticity is limited in application, and post-failure metallography and micro-indentation cannot be adopted during mechanical testing. However, Synchrotron X-ray diffraction experiments can obtain valuable data from the bulk of metallic materials. A study was done on a 12mm thick Compact Tension bainitic steel sample (used in civil engineering and Wind offshore industry). A fatigue test was conducted by applying 51,000 loading cycles at a frequency of 10 Hz, ΔP=14.9KN (0.5kN to 15.4kN), followed by a 24.5 kN load. We analyzed the strain fields along the crack growth direction (εxx) and loading direction (εyy). Both experimental and Finite Element Methods data showed promising results with similar strain field shapes and values, showing as well consistency with mode I loading.

Keywords: bainitic steel, S-XRD diffraction, Finite Element Analysis, fatigue

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