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PROCEEDINGS

Quantitative Assessment of Irreversible Deformation and Fatigue Damage Based on DIC

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ABSTRACT

Digital image correlation (DIC) is an emerging non-contact optical measurement method that tracks speckle patterns on the specimen surface to obtain the deformation, providing an advanced methodology for the quantitative evaluation of full-field strain. The present work focuses on the quantitative assessment of deformation from micro to macro scales based on the DIC method and examines damage evolution in metal materials under static and cyclic loading conditions. First, an SEM-based DIC method allowing high-resolution strain measurement at subgrain scales is developed for investigating strain partitioning in dual-phase steel. The results reveal that the strain distribution at grain scales has a rather heterogeneous feature, and the influencing factors such as grain size, crystallographic texture, and mobile dislocation distribution are discussed. Second, based on the experimental results of strain partitioning between different phases, an innovative experiment-modeling combined approach that enables the quantitative determination of the strain and stress at the grain level is proposed. The method can successfully assess the weight of different phases in contributing to the macroscopic mechanical properties of multi-phase polycrystalline materials. Moreover, the full-field characterization of a fatigue crack is also investigated in this study using a multi-scale DIC method. We measured the crack opening displacements behind the crack tip and the strain field ahead of the crack tip simultaneously, and the crack closure effect as well as the local strain accumulation near the crack tip were investigated. The results provide fundamental insights into the fatigue crack driving force. Finally, we introduce a novel deep learning-based DIC approach that processes speckle images around fatigue crack tip. This advancement enables real-time prediction of deformation and crack length, thereby enhancing the capabilities of DIC for dynamic analysis.

KEYWORDS

Full-field strain; strain and stress partitioning; fatigue crack; digital image correlation

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