Explicit microstructure sensitive modeling of high cycle fatigue application to as-built additive manufactured austenitic stainless steel 316L

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ABSTRACT

With more and more industrial applications of additive manufacturing (AM) technology, the fatigue performance of AM material is now a predominant issue. Considering the great expenses for fatigue experiments, the reliable numerical simulation is often an alternative. Many fatigue prediction models have been created and validated for the conventional materials, i.e. [1]. But the AM materials require more efforts for their different microscopic properties.

This study aims at building up an explicit microstructure sensitive numerical model that considers the surface roughness and subsurface defects for the AM materials to predict the High Cycle Fatigue (HCF) performance.

The material investigated is an AM austenitic stainless steel 316L. The specimens are manufactured by Selective Laser Melting (SLM) using the powder with a grain size of 5-25 μm. Profilometry analyses are conducted to reproduce the geometrical description of the specimen surface. The realistic roughness extracted from a specimen with the as-built condition is applied in the subsequent numerical simulations. The Electron BackScatter Diffraction (EBSD) shows that the grain morphology is more similar to quadrangle than Voronoi polygon while the latter is frequently adopted in the related researches for the crystal modeling [2]. Both are used and compared in this study. The grains are found strongly textured for that the preferential direction is the building direction. These crystallographic orientations are collected and are applied to the numerical models.

Different multiaxial fatigue criteria (Dang Van, Matake, Papadopoulos) combined with a non-local method [2] are applied to the simulation results. The adoption of non-local method takes the effect of stress gradient and the effect of neighborhood into considerations. Different parameters are tested and compared. Generalized extreme value distribution analysis [3] is conducted for quantitative evaluation.

The simulations show a qualitative consistency compared with the experiments, which reveal the surface state plays a more important role in fatigue crack initiation while the effect of microstructure seems much lower.

REFERENCES

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