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M2Or2A-01: Numerical and Experimental Investigation of Deformation Induced Martensitic Transformation in Fused Filament Fabricated Austenitic Stainless Steel for Cryogenic Applications

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Cryogenic structural components, such as collars, bladders, keys for superconducting magnets, and elements of liquid hydrogen storage systems like hoses and valves, are frequently constructed from austenitic stainless steel due to its favorable properties. However, manufacturing these components using traditional methods is challenging due to their complex geometries. Additive manufacturing emerges as a promising solution, though a comprehensive understanding of the associated material behavior under extreme conditions is still developing.

This study aims to explore the deformation-induced martensitic transformation (DIMT) in fused filament fabricated (FFF) 316L stainless steel through both experimental testing and numerical simulation. The research focuses on predicting the material's response under tensile stress at ambient, 77K, and 4K temperatures. Numerical simulations employ a finite element approach to incorporate the constitutive model and its temperature-dependent phase transformation kinetics, enabling detailed investigation of stress and strain distributions at various cryogenic temperatures. These simulations are systematically calibrated and validated against corresponding experimental datasets, ensuring that the computational predictions mirror the observed microstructural evolution and macroscopic response under tensile loading. By comparing simulation results to experimental findings obtained at temperatures from room temperature down to 4K, the reliability of the model can be assessed, and its predictive capabilities can be refined.

Ultimately, the research seeks to expand the understanding of DIMT in additively manufactured 316L components, supporting the development of advanced, simulation-driven material models tailored for demanding cryogenic structural applications.

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