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ABSTRACT

Finite Element Model Updating for Rate-Dependent Plasticity: Application to Impact Experiments on Additively Manufactured Metals

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Finite Element Model Updating (FEMU) has emerged as a powerful approach for identifying material parameters by minimizing the discrepancy between experimental and numerical results. Initially applied to full-field Digital Image Correlation (DIC) data for characterizing orthotropic elasticity and elasto-plastic properties under static loading [1,2] FEMU has recently been extended to dynamic conditions, including the identification of Johnson-Cook model parameters [3]. However, the physical interpretation of Johnson-Cook parameters remains challenging, particularly in cases where strain-rate effects dominate material behavior [4,5]. In this work we demonstrate the application of a FEMU framework to identify parameters of a strain-dependent plasticity model from impact experiments (Taylor test and Direct Impact Hopkinson Bar, DIHB) on additively manufactured metals.

Numerical simulations were conducted using LS-DYNA with the isotropic, elasto-plastic material with different strain rate models considered. The specimen was represented using approximately 1500 nodes, with only one-quarter of the cylindrical geometry modeled under symmetry conditions. The experiment involved high-speed DIC measurements using a Photron Fastcam SA-Z camera at approximately 100,000 fps, capturing nodal displacements along the sample's surface outline over time. The FEMU process involved. The FEMU process involved minimizing the difference between the measured and simulated displacements, in which both nonlinear optimization and genetic algorithms were tested and the results compared.

A key aspect of our methodology is the incorporation of the covariance matrix, which quantifies uncertainty and correlation in the measured displacements. This allows for a more robust parameter identification by accounting for spatial and temporal measurement errors. Our results demonstrate that precise FEMU implementation, combined with high-resolution DIC data, significantly enhances both the accuracy and efficiency of constitutive parameter identification under dynamic loading conditions.

References

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