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# High-throughput Characterization of five DP steels Plasticity and Fracture at slow, intermediate and high strain rates

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## Abstract

Slow, intermediate and fast tensile experiments are carried out on five dual phase steel sheets, comprising DP590, DP780, DP980, DP1180 and DP1470. Each of the materials is characterized with uniaxial tension as well as notched, central hole and shear specimens in up to seven material orientations. To efficiently test the overall 675 specimens, an automated tensile testing system is used in conjunction with a novel high-throughput Split-Hopkinson Pressure Bar setup. An original specimen clamping mechanism along with fully automated bar positioning is presented. Together with a fully automated post-processing procedure this significantly decreases the testing overhead. Surface strain measurements are obtained from optical (high-speed) photography together with planar digital image correlation. High-speed infrared imaging is used to gain insight into the evolution of the surface temperature as a function of plastic deformation. To characterize the material response in a hybrid experimental-numerical manner, coupled thermo-mechanical finite element analyses are employed. The constitutive model comprises a non-associated quadratic yield function, a combined Swift–Voce strain hardening model, and a neural network-based strain rate hardening law. Integrated into a material user subroutine and calibrated using a combination of analytical formulas and a robust backpropagation algorithm, this machine-learning-enhanced plasticity model accurately predicts all experimental data, including force-displacement, local surface strain, and temperature measurements. Additionally, a neural network-based extension of the Hosford-Coulomb fracture initiation model is calibrated to capture the fracture behavior across a range of strain rates.

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