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THESE

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DOCTORAT

spécialité : Génie Mécanique

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Intitulé : Identification of the mechanical behavior of sheet metal under biaxial loading including temperature and strain rate effects

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RESUME DE LA THESE

Aluminum alloys (AA) play an increasingly role in manufacturing industries due to their contributions to lightweighting, energy efficiency, and environmental friendliness. The aim of this study is to investigate the flow behavior of AA6061-T4 sheet over a wide range of temperatures and strain rates, and to evaluate its formability with temperature under linear and nonlinear strain paths.

Phenomenological and machine learning based constitutive models are developed for AA6061-T4 sheets. Uniaxial and biaxial tensile tests are conducted to characterize material flow behaviors. Novel mathematical functions for describing temperature and strain rate sensitivities are formulated. A transition function is proposed to capture the strain hardening evolution with increasing temperature. An efficient inverse identification strategy, focusing solely on the transition function, is proposed to improve the prediction of post-necking deformation. In addition, a framework is developed for artificial neural network (ANN) learning constitutive relations on indirect data acquirable from biaxial tensile tests. The established constitutive models are further applied to formability predictions.

An experimental procedure based on biaxial tensile test is presented to determine the forming limit curves (FLC) of AA6061-T4 sheets from shear to equi-biaxial tension. A new cruciform specimen shape is designed to characterize forming limits from shear to plane strain states. A feasibility study of existing necking criteria is carried out to find proper ones for cruciform specimens. Moreover, temperature-dependent formability is studied under both linear and nonlinear strain paths. Two types of nonlinear strain paths are tested via two distinct cruciform specimens. The sensitivity of the material necking and fracture behaviors to nonlinear strain paths is discussed. Finally, coupled and uncoupled damage models are calibrated and applied to predict the necking and fracture behaviors under nonlinear strain paths.