Characterization of strain rate effects in sheet laser forming

Castillo, Javier, I; Celentano, Diego J.; Cruchaga, Marcela A.; Garcia-Herrera, Claudio M.

Abstract

This work presents numerical simulations and experimental validation of sheet laser forming processes using a single-step straight path with different laser beam powers (four levels ranging from 30 W to 120 W) and scanning speeds (four levels ranging from 5 mm/s to 20 mm/s) in graphite-coated AISI 304 stainless steel 0.6-mm-thick sheets. The numerical simulations of these cases are performed via a coupled thermomechanical finite element formulation accounting for large strains, temperature-dependent material properties and convection–radiation phenomena. Firstly, a rate-independent plastic model is used. Although this model adequately predicts the final bending angle for the cases achieving relatively low maximum temperatures, i.e. cases with low laser beam powers and high scanning speeds, it fails in describing the deformation pattern for the cases with higher maximum temperatures, i.e. cases with high laser beam powers and low scanning speeds. Secondly, in order to overcome this drawback, a rate-dependent viscoplastic model including a stress-dependent viscosity law is proposed to simulate the same cases. The final bending angles provided by this model are found to be in good agreement with the experimental measurements for the whole ranges of laser beam power and scanning speed studied in this work. Therefore, the use of this viscoplastic model in the simulation of sheet laser forming allows us to conclude that the strain rate effects, which mainly play a relevant role at high temperatures, can be adequately characterized.