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Abstract

This paper introduces a new computational scheme addressing a problem of cold recyclability of sheet–metal products based on the assessment of their post-manufacture residual formability. Formability of sheet metals has been studied for several decades, and various techniques were suggested since a Forming Limit Diagram was first introduced in the 1960s. At the same time, cold recycling, or re-manufacturing, of sheet metals is an emerging area studied mostly empirically; in its current form, it lacks theoretical foundation. In order to address the challenge of residual formability for sheet-metal products, a reformability index is introduced in this study. The proposed method takes advantage of the latest developments in the area of evaluating multiple-path formability and introduces a quantitative reformability index for the manufactured material. This index represents possible levels of strains for deformation along different paths, based on Polar Effective Plastic Strain (PEPS). PEPS provides robustness against non-linear strain-path effects, thus making a reliable basis for such analysis. Based on residual formability, a predictive model was sought to assess a degrading effect of the flattening process. Taking advantage of extensive numerical simulation, a wide range of geometrical parameters in an unbending process, as a predominant mechanism in flattening, was studied.

The reformability index alongside prediction of degradation in flattening allows evaluation of prospective re-manufacturing. The significance of this research is its advancement towards recycling of sheet-metal products without melting them by facilitating design for sustainability. The proposed scheme also provides a subroutine friendly framework for numerical simulations.

Keywords: Remanufacturing, sheet metal, residual formability, reformability index, flattening