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Utilizing a Ductile Damage Criterion of Steel for Finite Element Analysis of a Deep Drawing Process of a Rectangular Cup

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Abstract

Sheet forming process involves material and stress non-linearities, making it difficult to explore the generation and propagation of fracture analytically. This work focuses on the numerical simulation of deep drawing operation of a rectangular cup made with mild carbon structural steel (SS275) for the purpose of process optimization. The simulation employs the ductile damage criterion, which accounts for the nucleation, growth, and coalescence of microvoids within the material. The necessary damage parameters for the steel are obtained from experimental tensile test data. Numerical simulation of the deep drawing operation was performed with the use of the ABAQUS FE software using the dynamic Explicit algorithm. The design of the different tools is obtained based on the geometry of the finished product and is performed using the software. The computed damage evolution curves for a given set of process parameters are compiled following simulation to determine suitable forming conditions. It can be noted that by increasing strain rate, crack initiation changes location. Punch force and damage evolution with displacement is plotted along with plastic strain distributions as an indicator of the fracture zone. The accurate prediction of fracture during the deep drawing process is critical for optimizing manufacturing parameters and reducing production costs. The results successfully predict the onset of fractures at the punch radius, which aligns with known failure locations in industrial settings. The findings are essential for a predictive analysis of deep drawing process for formability limits and optimizing process parameters to mitigate fracture.

Keywords

Ductile Damage Criterion, Steel, Finite Element Analysis, Deep Drawing Process ans Rectangular Cup.