 ICCES, vol.16, no.2, pp.37-37

A Novel Constitutive Equation for Inverse Analysis Method and its Application in Sheet Metal Forming

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Summary

Bending movements will be caused when elements passing by die entrance radius. The classical inverse analysis method (CIAM) uses the constitutive equation based on deformation theory of plasticity. Based on the assumption of the proportional loading, Hencky deformation theory is adopted. The secant modulus is obtained from uniaxial tensile curve and the plastic strain rate can be directly integrated to obtain a total plastic strain expression. The CIAM of sheet metal stamping has the shortcomings of no consideration of the effects of deformation history on stress prediction. Therefore, there is some discrepancy between the stress calculated with CIAM and that of actual situation. An updated inverse analysis method is proposed based on the final workpiece in Euler coordinate system. The principle of the virtual work is adopted to obtain the equivalent equations. The updated inverse analysis method uses the constitutive equation based on flow theory of plasticity to consider the loading history. In order to avoid numerous iterations to ensure the numerical stability in Newton-Raphson scheme to obtain plastic multiplier , the equation in unknown stress vectors is transformed into a scalar equation using the notion of the equivalent stress. Thus a scalar equation of two orders and only one unknown factor is obtained. The difficulty of the direct resolution is to have the unknown factor in the inverse matrix. A simple transformation matrix is introduced to reverse this matrix, so that the multiplier can be solved explicitly. Results obtained with the classical inverse analysis method based on deformation theory of plasticity and the updated one based on flow theory of plasticity are compared with those of the incremental forward finite element solver LS-DYNA. The comparisons of blank configurations, Forming Limited Diagram (FLD) and the effective strain distribution show that the proposed constitutive equation is effective and reliable.