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Combined Hardening Behavior for Sheet Metal and its Application

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About this Monograph
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Preface

Modeling the material behavior accurately in tension-compression and compression-tension load is essential to sheet metal forming simulation, failure and springback prediction, especially when the material points experience cyclic loadings. The combined linear hardening model proposed previously is modified to model the transient behavior more realistically by describing the scalar parameter β as a function of equivalent strain when compressive and reversed stress occurred.

This book proposed modification hardening model to account for the expansion (isotropic) and translation (kinematic) of the yield loci in terms of the hardening model. The capability of the model is demonstrated by showing two characteristic effects of tension-compression and compression curves: crossing and Bauschinger effects. Only modification of the scalar parameter β is added to describe the evolution of cyclic curves, which can be identified from tensile-compression tests and curve fittings. The proposed model is applied to sheet metal forming, fracture and springback predictions at room and elevated temperature. Tension-compression tests are firstly simulated and compared with available experimental data in order to fit and make the functions of scalar parameter β. The corrected data are then applied for complicated forming process e. g predict the fracture and improve the press formability of door hinge, the incremental sheet metal forming for complicate shape, and rotational incremental sheet forming for magnesium alloy sheets.

In order to predict the ductile fracture, a modification of combined kinematic and isotropic hardening law is implemented and evaluated from the histories of ductile fracture value (I) by means of finite element analysis. Here, the criterion for a ductile fracture, as developed by OYANE, (*Journal of Mechanical Work. Technol*ogy, 4 (1980), pp. 65–81), is carried out via a user material, using finite element code. To improve press formability and secure a safe product without any failure, the finite element method (FEM) simulations are coupled with Taguchi's orthogonal array experiment.

To improve press formability of a door hinge, three design variables – the die corner radius, declination of the bead punch, and peak angle of the bead punch – are selected to be improved. The numeric simulations reveal that the die corner radius is the most important variable, and its modification is most effective in improving the press formability for a door hinge. The simulation results are confirmed with experimental ones.

To simulate incremental sheet forming process for the product of complex shape (e.g. human face), a combination of both computer-aided manufacturing (CAM) and finite-element modelling (FEM) simulation, is utilized. Here, the results, using ABAQUS/Explicit finite-element code, are compared with forming limit curve at fracture in order to predict and improve the forming conditions by changing process variables of tool radius, tool down-step, and friction coefficient. First, the CAM simulation is used to create cutter location data. This data are then calculated, modified, and exported to the input file format required by ABAQUS through using MATLAB programming. The FEM results are implemented for negative incremental sheet forming and then investigated by experiment

To simulate the effect of the large amount of heat generation at elements in the contact area due to friction energy of the rotational tool-specimen interface on equivalent stress-strain evolution in incremental forming, Johnson-Cook model was applied and also compared with equivalent stress-strain curves obtained by tensile test at elevated temperatures. The (FE) simulation results of ductile fracture was then compared with the experimental results of 80 mm × 80 mm × 25 mm square shape with 45 °, 60 °, and 80 mm × 80 mm × 20 mm square shape with 70 ° wall angles. The trend of (FE) simulation results were quite good agreement with experiment results. Finally, the effect of process parameters e. g tool down-step and tool radius on the ductile fracture value and forming limit curve at fracture (FLCF) were investigated using (FE) simulation results.

Dr. Nguyen Duc Toan