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Adaptive integration for accurate springback prediction

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Introduction

Error due to numerical integration in thickness direction is yet another reason of common inaccuracy of springback prediction [1]. During the finite element solution procedure well-known numerical schemes like Newton-Cotes rules or Gauss quadrature are commonly used for the through-thickness integration of shell elements. When a material is in the elastic regime, the integration error is negligible for any scheme, using a limited number of integration points. The situation changes when the material is in the elastic-plastic regime. Even for a simple problem up to 50 points through the material thickness may be needed to minimize the influence of the integration error on the accuracy of springback prediction. However, in simulations of sheet metal forming, increasing the number of integration points places high demands on computational costs and is very undesirable.

Components of adaptive strategy

An adaptive through-thickness integration strategy is developed [2]. To improve the accuracy, it utilises the integration points more efficiently. The integration strategy consists of two parts: interval manager and interval processor. If one considers the implicit finite element solution procedure, in the end of every successfully converged incremental step the interval manager evaluates the integrand's profile. Based on this information, the location and number of the integration points is adapted and the internal variables are updated. Within an incremental step the points are not adapted, to minimise the risk of divergence of the iterative solution process. The actual integration is performed by the interval processor, which uses the numerical schemes that can cope with unequally distributed sampling points. Adapting the integration points in the end of every loading step ensures more accurate stress resultants, hence, a more accurate springback prediction.

Results

The performance of the adaptive integration strategy is evaluated using several tests. Simulations of the unconstrained cylindrical bending problem (NUMISHEET'02 benchmark) show that the traditional Gauss quadrature requires at least 20 integration points to minimise the numerical integration error. At the same time, to achieve similar accuracy the adaptive Simpson's rule uses twice as less integration points and, thus, improves springback prediction at minimal costs.

Acknowledgements

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References

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[2] I.A. Burchitz, T. Meinders. Adaptive through-thickness integration for accurate springback prediction, submitted for publication.