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Adaptive through-thickness integration for shells

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Introduction

In the automotive industry finite element (FE) software is used in the design process of new sheet metal parts. During this process the amount of springback is numerically predicted. This information is used in the tools design to guarantee the desired product shape. Low accuracy of the numerical prediction of springback makes the information unreliable.

Figure 1: Sheet metal parts.

Objective

The project goal is to improve the predictability of springback to meet industrial requirements.

Adaptive integration

Error due to numerical integration in thickness direction of shell elements is one of the reasons of the inaccuracy of springback prediction. Even for a simple problem traditional schemes with a fixed location of integration points (ip's) may require up to 50 ip's for high accuracy of springback analysis [1].

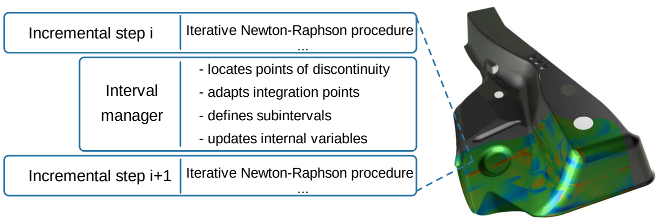

Figure 2: Adaptive integration in FE solution procedure.

An adaptive through-thickness integration strategy can be a good alternative. The strategy defines abscissas and weights depending on integrand's properties and, thus, can adapt itself to improve the accuracy of integration. It consists of two groups of components: an interval manager and an interval processor. The interval manager is employed in the end of every incremental step of the FE solution procedure (figure 2). It uses algorithms to adapt integration points and to update their internal variables. The interval processor performs the actual integration. For high flexibility, it uses numerical schemes that can cope with unequally spaced points.

Results

The adaptive strategy was tested using a simple problem. A moment resulting from bending of a beam under tension was calculated numerically and compared to the analytical solution. As shown in figure 3, the error obtained with the traditional rule oscillates and reaches high levels when using less than 10 integration points.

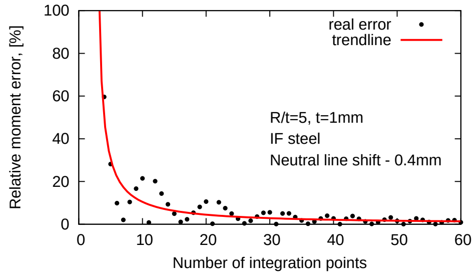

Figure 3: Performance of the trapezoidal rule.

In contrast, the adaptive integration helps to obtain a very low and smooth error using a limited number of the integration points (figure 4).

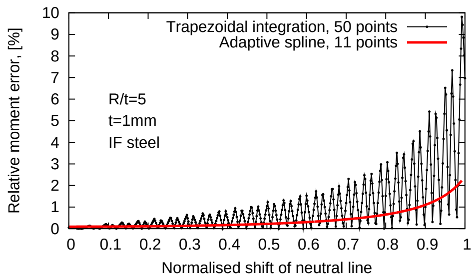

Figure 4: Advantages of the adaptive integration.

Future work & Valorisation

The advantages and potential of the adaptive integration were demonstrated. The strategy will be implemented for the Kirchhoff triangular elements and tested using a number of representative examples.

References

[1] Wagoner, R. H. and Li, M. Simulation of springback: Through-thickness integration. Int. J. Plasticity, 2006.

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