NUMERICAL MODELLING OF SHEAR CUTTING IN HIGH STRENGTH SHEETS.

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The use of advanced high strength steel (AHSS) has given the automotive industry possibilities to produce high performance lightweight structures at affordable costs. The strength and wide applicability of AHSS have made them the preferred choice over conventional steel in both crash-, Body-in-white and chassis parts. However, the low ductility of AHSS makes them sensitive to edge cracking at sheared edges subjected to stretching. Edge cracking significantly controls the forming behaviour of the part and can cause costly disturbances in the manufacturing process. Several publications show the correlation between damage inflicted by shear cutting and limited forming properties of the sheared edge [1, 2, 3, 4]. One way of quantifying the cut edge damage from shear cutting is by considering the final cut edge morphology, where certain cut edge compositions are more prone to edge cracking than others [5]. The use of numerical modelling can therefore serve as aid by foreseeing the cut edge damage through predicting the cut edge morphology and thus the subsequent edge cracking.

Numerical modelling of the shear cutting process requires damage- and failure modelling that covers a wide range of stress states, ranging from uniaxial compression to biaxial tension [6]. The damage modelling should also address both compressive shear failure of undamaged material as well as crack initiation and propagation following the shearing process. This study describes a method of calibrating a damage- and failure model for high strength sheet steel that additionally uses local calibration of the fracture locus. A recently published article by the present authors show how cracks affect the damage-and failure modelling accuracy in high strength metal sheets [7]. The local calibration of the fracture locus aims to include the effect from crack initiation following the shearing process and circumvent the numerical inaccuracy caused by the crack initiation.

The presented calibration technique enabled numerical modelling of the shear cutting process such that the model could reproduce the cut edge shapes for a wide range of cutting clearances. The authors of this study thus considers the presented modelling method as an effective tool for edge damage assessment, which can aid in estimating the edge cracking in subsequent forming operations.

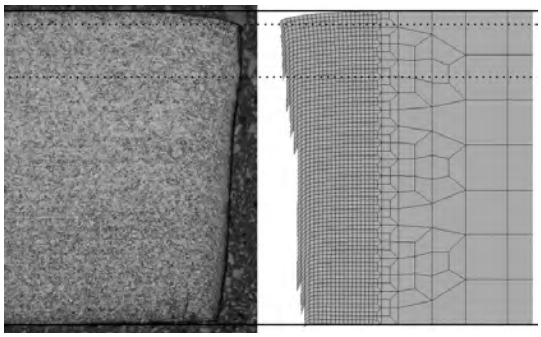

Figure 1: Comparison of experimental vs. numerical cut edge morphology of complex phase AHSS steel with 9% clearance.

References

[1] Konieczny, A. and Henderson, T., On formability limitations in stamping involving sheared edge stretching. SAE Tech. Pap. 2007.

[2] Shih, Hua Chu and Chiriac, Constantin and Shi, Ming F., The effects of AHSS shear edge conditions on edge fracture. ASME 2010 Int. Manuf. Sci. Eng. Conf. MSEC 2010, 1, 599–608. 2010.

[3] Thomas, D. J., Understanding the effects of mechanical and laser cut-edges to prevent formability ruptures during automotive manufacturing, J. Fail. Anal. Prev., 13, 451–462. 2013.

[4] Frómeta, D. and Tedesco, M. and Calvo, J. and Lara, A. and Molas, S. and Casellas, D., Assessing edge cracking resistance in AHSS automotive parts by the Essential Work of Fracture methodology, J. Phys. Conf. Ser., 896. 2017.

[5] Sigvant, M. and Falk, J. and Pilthammar, J., Experiments and FE-simulations of stretch flanging of DP-steels with different shear cut edge quality, J. Phys. Conf. Ser., 896. 2017.

[6] Gutknecht, F., Steinbach, F., Hammer, T.,Clausmeyer, T., Volk, W., Tekkaya, A. E., Analysis of shear cutting of dual phase steel by application of an advanced damage model. Procedia Structural Integrity, 2, 1700-1707. 2016.

[7] Sandin, Olle and Jonsén, Pär and Frómeta, David and Casellas, Daniel, Stating Failure Modelling Limitations of High Strength Sheets: Implications to Sheet Metal Forming, Materials, 14, 7821. 2021.

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