# Smoothed Particle Galerkin method applied to punching of metals

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## ABSTRACT

Metal cutting processes such as punching and trimming, are widely used in the manufacturing industry. Depending on the conditions, cutting can induce damage and fractures in the trimmed edge zone. There is however, a need to better understand the cutting process to improve mechanical properties of the final product. Optimizing cutting operations to minimize damage and improve fatigue life are essentials and numerical simulations of cutting operations can be of good assistance. One of the main challenges in modelling metal cutting is to capture the large deformation occurring in the cutting zone, and a second challenge is to find suitable failure models working at these conditions. An interesting method to treat large deformations and still use continuum based constitutive models are the smoothed particle Galerkin (SPG) method, see [1].

In this work, the punching process is modelled with a combination of SPG and finite element method (FEM), also presented in [2]. Plasticity behaviour of the material was modelled with an elasto-plastic model and a Modified Mohr-Coulomb (MMC) failure criterion to model the material failure. Both models were calibrated against experimental data. Laboratory punching tests with different clearance values were carried out using sheets of different fracture strengths. All experimental cases are numerically modelled. Validation is conducted by comparing numerical results with experimental measurements of punch force and displacement. Also, morphology of the final cutting edges from both real and virtual are compared. The numerical results show good agreement against experimental measurements. Furthermore, the combined method gives robustness and stability as it can handle large deformations efficiently. Results from the SPG-simulation corresponded very well with the results from punching experiments, and it can be concluded that the model was able to capture the material behaviour of the sheet in a highly detailed level. When the punched edge profiles from the simulations were compared to the experiments, there was an almost exact match for all the cases studied. The force-displacement behaviour of the punch from simulations was in great consistency with experimental results as well. It was also concluded that the combination of a stress state dependent failure criterion together with the SPG-method shows significant possibilities to cope with three dimensional problems where large deformations in combination with difficult material failure occurs.

## REFERENCES

[1] C. T. Wu, Y. Guo, and W. Hu., “An Introduction to the LS-DYNA Smoothed Particle Galerkin Method for Severe Deformation and Failure Analysis in Solids”. In: 13th International LS-DYNA Users Conference. (2014).

[2] A. Svanberg, *Numerical Methods for Simulating the Metal Shearing Process*, Degree work, Luleå University of Technology, (2019).