Thesis title: Sheet metal forming simulation using a shell based micromechanical SPH method: application to functionally graded materials

This thesis deals with the development and extension of an original method [1] called "Shell Smoothed Particle Hydrodynamics" (SSPH) for the numerical modeling of sheet metal forming processes, namely deep drawing and hydroforming [2]. Since its development by the research team in 2014, the SSPH method has been extended to the analysis of isotropic and composite structures undergoing large displacements and impact [3], to the optimization [4] and more recently to the thermomechanical behavior of functionally graded materials [5].

It is proposed here, to develop a new shell SPH model based on the Discrete Kirchhoff theory suitable for the metal forming of thin metallic sheets using a single layer of particles in the mid-plane of the shell contrarily to the standard continuum SPH method. The numerical developments in the framework of the present PhD thesis will concern the review and alleviation of numerical locking phenomena encountered in the classical SPH method such as non-consistency and instability in tension.

The developed Discrete Kirchhoff shell SPH model will be extended to large elastoplastic strains and coupled to a recent micromechanical ductile damage model to predict necking and fracture risk of thin functionally graded metallic sheets during the hot forming process due to a non-optimal calibration of pressure and stroke feedings. This micromechanical damage model has been already implemented by the research team within a finite element for biomechanics modeling and has shown to be efficient [6]. The strong form of resulting shell equilibrium equations will be discretized directly by the improved shell based SPH method and solved by an explicit dynamic type scheme.

The developments in this thesis will be done starting with Python coding, and then will be implemented in the open source software CalculiX (www.calculix.de). Indeed, this software offers numerous advantages such as contact algorithms and various time integration schemes.

For the validation of the SSPH model, several benchmarks from the NUMISHEET and NUMIFORM international conferences will be evaluated and the results compared to those obtained by the classical finite element method.

This thesis subject is original and has never been addressed by the international scientific community of metal forming; hence the developments in this thesis will surely allow the publication of several articles in peer-reviewed international journals.

Keywords: Sheet metal forming; SPH modeling; micromechanics; damage; large strains.

Background of candidate: Expected candidate should have basic knowledge of sheet metal forming, finite element modeling and basics of programming.

References

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