Success Story
COMET

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AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Amoree
Aluminium and magnesium processing optimisation with special respect to resource and energy efficiency
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K-Projects

Improved process knowledge through efficient numerical methods for massive forming processes.

Efficient numerical methods for simulating complex metal forming processes, such as extrusion, are developed. The aim is a simulation of industrially relevant tasks in maximum one day. The study of such processes could make an essential contribution to the improvement of process control as well as for tool development. Minimizing waste material and improved product quality can also be a target.

Methods for the efficient calculation of massive-forming processes

In the numerical simulation of metal forming processes such as solid-extrusion and rolling, many nonlinear effects such as large deformations, non-linear material behavior, thermal effects, friction, etc. have to be modeled. The consideration of these physical effects of prolonged processes with standard methods (Lagrange FEM) is numerically consuming and limited by extremely long computing times. To be able to find application in the industry, the calculation time must be reduced to about one day

Some scientists have already dealt with ways to speed up calculations and have applied methods such as ALE (Arbitrary Lagrangian Eulerian) FVM (Finite Volume Method) and particle methods. These were, however, mostly applied in self-developed software packages, using simple examples.

Even commercial software packages, such as LS-DYNA™ from LSTC®, now offer such alternative calculation methods. To proof the functionality, again simple examples are used by the manufacturer.

In project Amoree work package 3.2 it was possible to apply the Multi-Material-Arbitrary-Lagrangian-Eulerian (MMALE) method to industry relevant examples in the semi-industrial scale. Specifically, the simulation of the production of a pipe section by extrusion and a Friction-Stir Welding (FSW) process has been performed.

The MMALE method was chosen after an intensive literature research and experiments with particle and fluid mechanics methods, because it represents a good compromise between the ability to include all the necessary effects and the necessary computing time.

Although methods of fluid mechanics (Computational Fluid Dynamics, CFD) are able to handle these conditions very well, they need to be adapted for the consideration of metallic materials.

The well-established Finite Element Method (FEM) is currently used in the process simulation with large deformations, but in order to maintain the integrity of the spatial discretization, frequent re-meshing has to be performed. This process is numerically consuming and can lead, after several revisions, to large errors.

bmwfw Federal Ministry of Science, Research and Economy
bmvit Austrian Ministry for Transport, Innovation and Technology

Arbitrary Lagrangian-Eulerian Method Between liquid and solid

The Arbitrary Lagrangian Eulerian (ALE) Methode now provides a blend of the most frequently used methods for fluids (Euler) and the usually in the solid mechanics used method (Lagrangian). These two methods separates a fundamentally different way of looking at activities in space.

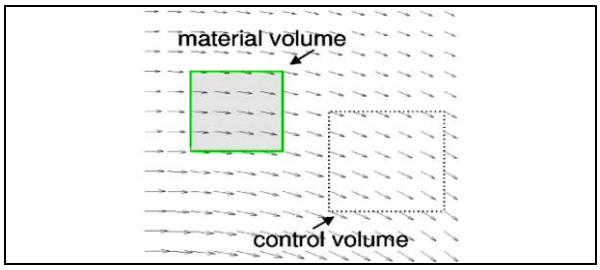

Fig. 1: Comparison: Lagrange-Euler (J. F. Price, Lag-rangian and Eulerian Repr. of Fluid Flow, 2006)]

In the Lagrangian method, a material particle is followed through space and the forces acting on it as well as external influences and thereby triggered state changes in the particles are tracked.

In the Euler method, a control volume is determined within which the changes in the internal state due to external influences are accounted for. The spatial discretization is thus generally separated from the material so that the correction by large deformations is omitted. However, free surfaces are hard and rough determined.

Impact and effects

Being able to simulate forming processes efficiently without greatly sacrificing accuracy, is a prerequisite to the development of tools to assist with complex geometries. To calculate, for example, filling of a complex extrusion tool, effects such as heating due to deformation, friction, material-separation and welds as well as large-deformations must be considered. The local flow behavior in turn depends largely on the speed and temperature. A consideration of other effects such as the development of the microstructure can be added for industrially interesting issues only for fast and efficient calculation models.

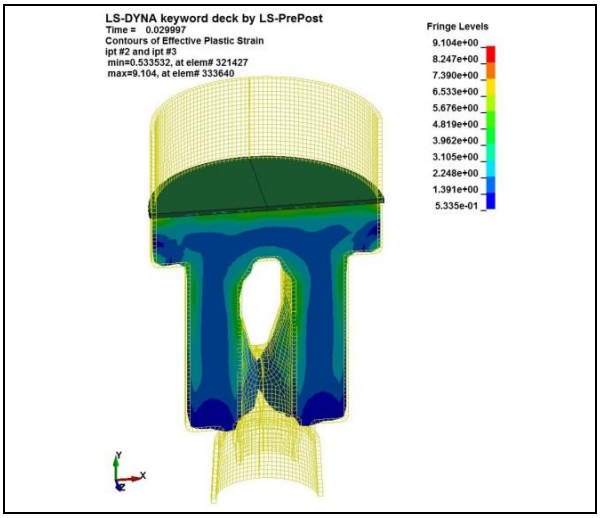

Fig. 2: Strain results for an extrusion simulation of a pipe.

The results of previous simulations show good agreement with reference-methods and experimental studies. The possibility of very strong parallelization and time scaling allows a significant acceleration of the calculations. In future, this method could probably be an attractive possibility for industrial daily routine.

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