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Meshless methods in aluminium extrusion

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ABSTRACT

Introduction

The finite element method (FEM) is nowadays the main tool to model forming processes. Whenever deformations in these processes are large, distortion of finite elements is likely to occur. Accuracy and convergence of the simulations will decrease.

To overcome this problem, an Eulerian formulation, arbitrary Lagrangian-Eulerian (ALE) formulation or remeshing procedure can be adopted to keep mesh distortion acceptable. These methods can introduce numerical problems like diffusion or instabilities. Meshless methods are presented by various authors as a possible way to circumvent these phenomena. A Lagrangian formulation can be maintained without introducing mesh distortion.

In this research, the Eulerian-FEM method and two meshless methods (SPH and EFG) are compared on a 2d aluminium extrusion process. A summary of previous research on aluminium extrusion and meshless methods can be found in the article of Alfaro *et al.* [1].

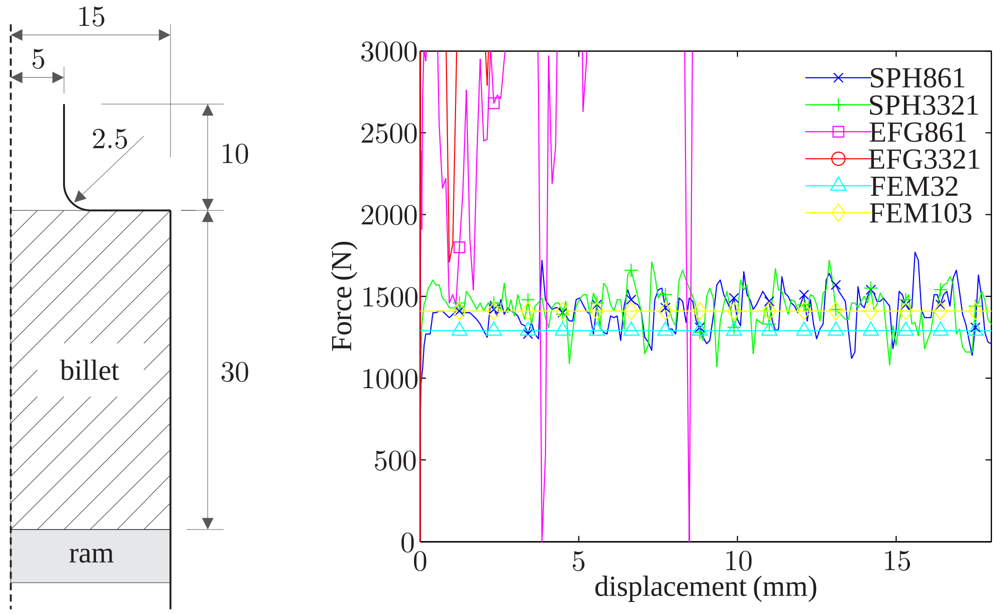
Modeling

The finite element package DIEKA developed at the University of Twente is used for the FEM calculation. LS-DYNA is used for SPH and EFG. The test set-up is displayed in Figure 1(a). Only half of the geometry is modeled due to symmetry. Dimensions are in millimeters. An incompressible rigid-viscoplastic material model is used with a Sellars-Tegart hardening rule. This sample process is considered isothermal and plane strain. The finite elements used are 4-node quadrilaterals with B-bar formulation to alleviate volume locking. The upwards velocity of the ram is 1 mm/s.

Preliminary results

Figure 1(b) shows a graph of the force-displacement of the ram for six simulations. In the legend, first three letters indicate the method used, the last set of numbers indicate the amount of nodes used.

Since the FEM simulations solve a steady-state problem, the ram force is displayed independent of the punch displacement. The EFG method seems to be suffering of volume locking and ‘cell’ distortion.



(a) setup

(b) ram force-displacement

Figure 1: extrusion model

The ram force resulting from the SPH simulation corresponds to the Euler-FEM calculation quite reasonably. The ‘oscillations’ on the force are most likely to be due to the explicit time integration scheme in LS-DYNA.

Examining the field quantities of the meshless simulations reveals some numerical deficiencies. The SPH shows node clustering and pressure wave patterns [2]. The hydrostatic pressure in the EFG nodes is of a non-physical magnitude due to the locking [3]. The extensive distortion of the integration cells gives incorrect patterns in field quantities.

Despite the drawbacks of the SPH method, the ability to simulate the process with a Lagrangian approach is interesting. Die filling behavior, shearbands and the dead metal zone can be simulated in a natural way.

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