PennState

- Example in Abaqus

ALE Mechanics in Abaqus

- The adaptive meshing technique in Abaqus combines the features of pure Lagrangian analysis and pure Eulerian analysis. This type of adaptive meshing is often referred to as Arbitrary Lagrangian-Eulerian (ALE) analysis. The Abaqus documentation often refers to “ALE adaptive meshing” simply as “adaptive meshing.”

- ALE adaptive meshing is a tool that makes it possible to maintain a high-quality mesh throughout an analysis, even when large deformation or loss of material occurs, by allowing the mesh to move independently of the material.

- ALE adaptive meshing does not alter the topology (elements and connectivity) of the mesh, which implies some limitations on the ability of this method to maintain a high-quality mesh upon extreme deformation.

- ALE adaptive meshing is distinct from the pure Eulerian analysis capability in Abaqus/Explicit.

http://dsk.ippt.pan.pl/docs/abaqus/v6.13/books/usb/default.htm

ALE Mechanics in Abaqus

- The pure Eulerian capability supports multiple materials and voids within a single element, which allows effective handling of analyses involving extreme deformation (such as fluid flow).

- In contrast, ALE elements are always 100% full of a single material; while this formulation limits the deformation of material in the model to the deformation of the elements, it allows more precise definitions of material boundaries and more complex contact interactions.

- Although the adaptive meshing techniques and the user interface are similar in Abaqus/Explicit and Abaqus/Standard, the use-cases and the level of functionality are different.

- Adaptive meshing in Abaqus/Explicit is intended to model large-deformation problems. It does not attempt to minimize discretization errors in small-deformation analyses.

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ALE Mechanics in Abaqus

Features of ALE adaptive meshing

ALE adaptive meshing:

- can often maintain a high-quality mesh under severe material deformation by allowing the mesh to move independently of the underlying material; and
- maintains a topologically similar mesh throughout the analysis (i.e., elements are not created or destroyed).

In Abaqus/Explicit ALE adaptive meshing:

- can be used to analyze Lagrangian problems (in which no material leaves the mesh) and Eulerian problems (in which material flows through the mesh);
- can be used as a continuous adaptive meshing tool for transient analysis problems undergoing large deformations (such as dynamic impact, penetration, and forging problems);
- can be used as a solution technique to model steady-state processes (such as extrusion or rolling);
- can be used as a tool to analyze the transient phase in a steady-state process; and
- can be used in explicit dynamics (including adiabatic thermal analysis) and fully coupled thermal-stress procedures.

In Abaqus/Standard ALE adaptive meshing:

- can be used to solve Lagrangian problems (in which no material leaves the mesh) and to model effects of ablation, or wear (in which material is eroded at the boundary);
- can be used to update the acoustic mesh when structural preloading causes significant geometric changes in the acoustic domain; and
- can be used in geometrically nonlinear static, steady-state transport, coupled pore fluid flow and stress, and coupled temperature-displacement procedures.

http://dsk.ippt.pan.pl/docs/abaqus/v6.13/books/usb/default.htm

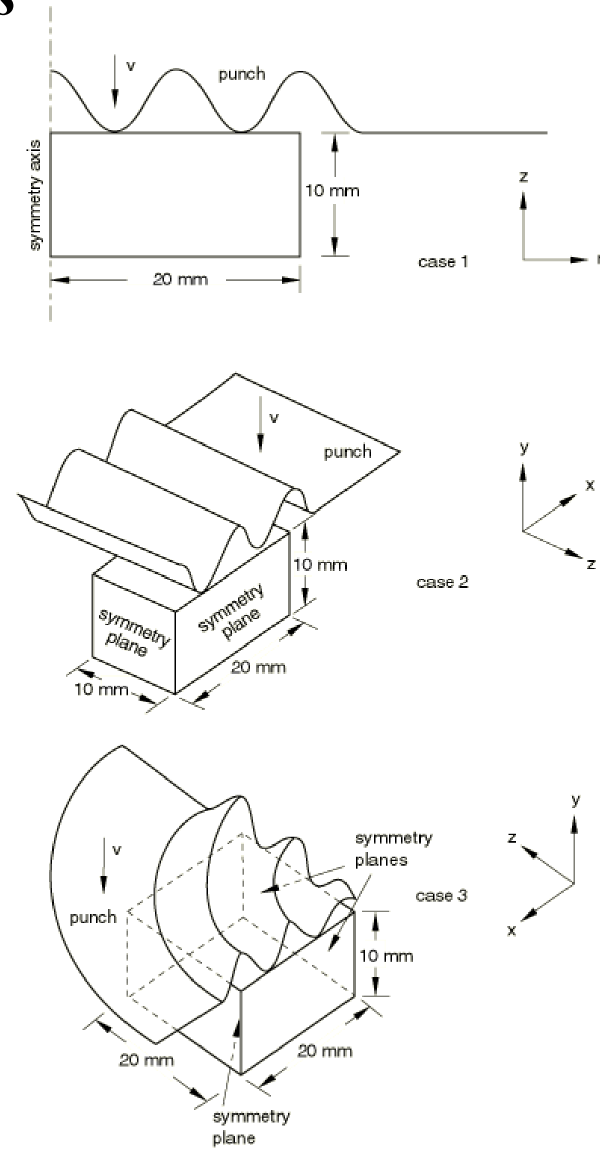
ALE Mechanics in Abaqus

Forging with sinusoidal dies

This example illustrates the use of adaptive meshing in forging problems that incorporate geometrically complex dies and involve substantial material flow.

Problem description

- Three different geometric models are considered.
- Each model consists of a rigid die and a deformable blank.
- The cross-sectional shape of the die is sinusoidal with an amplitude and a period of 5 and 10 mm, respectively.
- The blank is steel and is modeled as a von Mises elastic-plastic material with a Young's modulus of 200 GPa, an initial yield stress of 100 MPa, and a constant hardening slope of 300 MPa. Poisson's ratio is 0.3; the density is 7800 kg/m^3.
- In all cases the die is moved downward vertically at a velocity of 2000 mm/sec and is constrained in all other degrees of freedom.
- The total die displacement is 7.6 mm for Case 1, 6.7 mm for Case 2, and 5.6 mm for Case 3.
- Although each analysis uses a sinusoidal die, the geometries and flow characteristics of the blank material are quite different for each problem.



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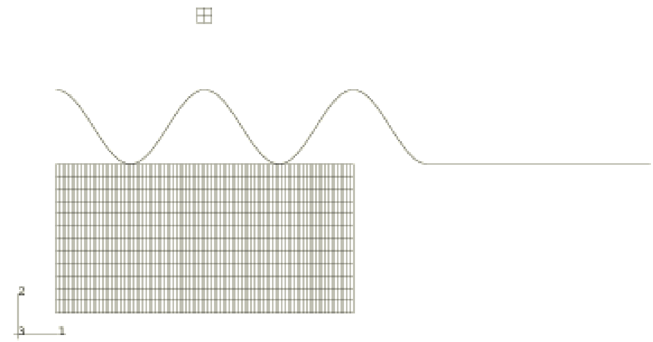
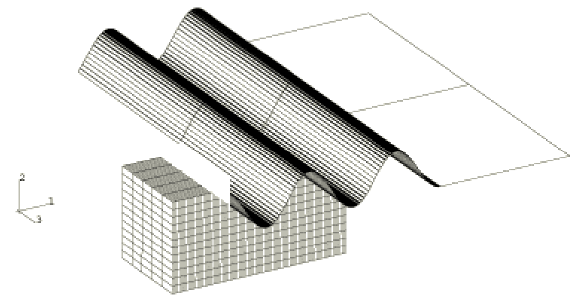
Forging with sinusoidal dies

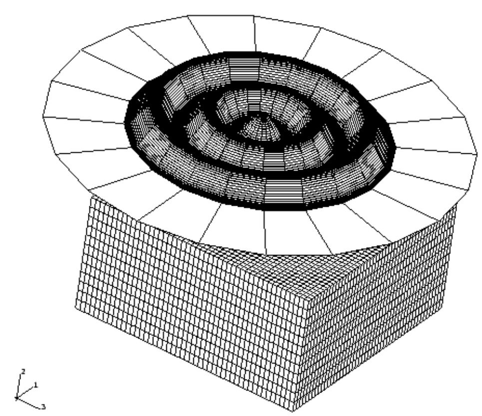
Case 1: Axisymmetric model
The blank is meshed with CAX4R elements and measures 20 × 10 mm. The dies are modeled as analytical rigid surfaces comprised of connected line segments. The bottom of the blank is constrained in the *z*-direction, and symmetry boundary conditions are prescribed at *r*=0.



Case 2: Three-dimensional model
The blank is meshed with C3D8R elements and measures 20 × 10 × 10 mm. The dies are modeled as three-dimensional cylindrical analytical rigid surfaces. The bottom of the blank is constrained in the *y*-direction, and symmetry boundary conditions are applied at the *x*=0 and *z*=10 planes.



Case 3: Three-dimensional model
The blank is meshed with C3D8R elements and measures 20 × 10 × 20 mm. The dies are modeled as three-dimensional revolved analytical rigid surfaces. The bottom of the blank is constrained in the *y*-direction, and symmetry boundary conditions are applied at the *x*=0 and *z*=10 planes.



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Forging with sinusoidal dies

Adaptive meshing

- A single adaptive mesh domain that incorporates the entire blank is used for each model. Symmetry planes are defined as Lagrangian boundary regions (the default), and contact surfaces are defined as sliding boundary regions (the default).

- Because the material flow for each of the geometries is substantial, the frequency and the intensity of adaptive meshing must be increased to provide an accurate solution.

- The frequency at which adaptive meshing is to be performed is reduced from the default of 10 to 5 for all cases. The number of mesh sweeps is increased from the default of 1 to 3 for all cases.