Automatic & Robust Meshing in Fluids

2011 ANSYS Regional Conferences
This is just a taste...

Note that full 14.0 update webinars of an hour per product will be scheduled closer to the release... This presentation is really a condensed overview of one segment of ANSYS Meshing.
Automatic & Robust Meshing – Assembly Meshing

Saves time by eliminating the tedious geometry clean-up

Top-down approach to mesh all parts at once

• Virtual Bodies (material points) automatically extract internal regions from assemblies

• Supports:
  – Meshing solids from sheet bodies forming a roughly “closed” domain
  – Conformal mesh between parts without requiring multibody parts or shared topology
  – Overlapping bodies, small gaps, etc.
  – Tet (linear) and CutCell (hex-dominant) mesh types
  – Program Controlled Inflation

Do Not Need:
Volume fill or sew, Pinch, Booleans, Multibody parts or shared topology
Agenda

1. The Customer Problem
2. Assembly meshing overview
3. New Features
   1. Flow Volume Extraction
   2. Sharp Angle, Thin Sections
   3. Contacts and Leak closing
4. Demo: Mixing Tank
5. Miscellaneous features
6. Summary
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The Customer Problem
Assembly Meshing Motivation

CFD users need a quick way to generate the fluid volume mesh from complex assemblies of geometric solid parts.

- The parts may not be in contact with each other, and they may contain sharp angles, thin sections and gaps.
- Poor CAD models that don’t form watertight solid geometry.

By combining the flow volume extraction and meshing operations, the overall meshing time and efficiency of the meshing workflow can be improved.

Solution:
- Assembly meshing
The overall meshing process can often get elongated if the geometry is complex:
Assembly Meshing: Process Compression

Assembly meshing combines the flow volume extraction and meshing operations to reduce overall meshing time.

Part Meshing:
- Geometry Prep
- Mesh Setup
- Mesh Generation

Assembly Meshing:
- Geometry Prep
- Mesh Setup
- Mesh Generation

Note: Mesh Generation time is slightly longer, but overall time is significantly reduced.
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Assembly meshing:
Flow Volume, Inflation, Sharp Angle, Thin Sections
R14 Assembly Meshing: Characteristics

• Maintains characteristics from CutCell at R13
  – High fraction of hex and prismatic cells
  – Supports global size functions, feature capture, tessellation, etc. controls
  – Operates on parts, multi-body parts, etc. with new option to define virtual bodies
  – Patch independent:
    • Eliminates the need for pinch control and VT operations

• Creates conformal meshes across parts
  – Eliminates the need for multi-body part generation in CAD

• Ability to create flow volumes from a “closed” set of bodies (sheet or solid)
  – Eliminates the need for Boolean/Fill operations in CAD

• Supports both CutCell and Tetrahedral meshes
  – Tetrahedral meshes supported by CFX and Mechanical solvers (but Assembly meshing is not exposed for those physics yet)
Flow volume extraction:
Three simple steps

1. Define Coordinate system inside the Fluid Void
2. Insert a Virtual body
3. Assign the proper Coordinate System to the Material Point
4. Done
R14 Assembly Meshing: Keep Solid Mesh

In the Assembly Meshing panel, you can choose to keep or discard the mesh in all solids.

Parts can be marked as Fluids/Solids.
R14 Inflation Improvements

Speed and Flexibility of inflation:
- Better quality during stair stepping
- Better handling of high aspect ratio inflation
- Improved Speed of inflation creation ~30-100%

Industrial Example:
- 68 Million cells, 5 inflation layers
- Total Mesh Time:
  - R13: 6 hrs 39 mins
  - R14: 3 hrs 38 mins

Assembly Meshing Flexibility
- Cutcell: Full support of 2-stage inflation
  - CutCell and inflation in two separate steps
- Tetrahedron: Uses pre-inflation
  - Faster, more layers, and better quality
R14 Assembly Meshing: Automatic Inflation

Also supported for Virtual Bodies

- Program controlled inflation acts only on Fluid Bodies
R14 Assembly Meshing:

Sharp angle tool

• A special cell cutting algorithm has been developed to properly capture sharp 3D angles
• Can be used to improve feature capturing in general
• Insert a “Sharp Angle” and pick adjacent faces
CFD users often need to extract the flow volume from CAD using Fill, Stitch or Boolean operations.

Because of missing rubber seals, bad CAD, imposed tolerances, etc., gaps appear in the model and creation of the flow volume might fail.

Finding and closing these gaps in CAD can be tedious.

Solution:

Assembly meshing solves this problem in several ways:

1. **Tolerances only need to be resolved to level of discretization of mesh**

2. **Gaps that are still too large can be visualized through leakage identification**

3. **Tools to guide mesher in resolving gaps**
Find leaks using material points:

- Any time you are using material points (for internal flow), and it is leaking to the outside, you can automatically see the leak-path together with the surface mesh.

There is a small gap between the valve plug and the valve seat.
R14 Assembly Meshing Leak Handling: Contact (Interface) Regions

Using Contacts for Assembly meshing:

• Workbench has extensive capabilities to detect contact (interfaces) between parts

• Until R14, that contact information was of little use to FLUENT users

• Contacts have several purposes for Assembly Meshing:
  – Closing of small gaps using contact sizing
  – Find thin sections
  – Find Contacts
    • Features at contact pairs are preserved
    • Contacts are also used in Fluid Surface picker helper

For example, in this image the circled edges would be removed without contact defined since the feature angle is below the default (40 degrees)
Closing a leak: Three simple steps

1. Define a Contact between the entities that are leaking
   - Edge/face or Face/Face
2. Drag and drop the contact on top of the Mesh Icon
   - Creates a Contact sizing
3. Adjust Contact sizing
   - Use roughly 1/5 of min-size
4. Go to Assembly Meshing
Why locate thin sections (3D bodies)?

- The assembly meshing method produces better quality meshes if thin baffles and fins are well resolved.
- By using the Find Thin Sections tool, these can be found in advance and appropriate sizing can be applied.
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Assembly meshing: Mixing Tank Demo
R14 Assembly Meshing

Miscellaneous features:

• Size Function improvements
  – Separate Min size for Curvature and Proximity
  – Less mesh clustering
  – Support for Body of Influence

• Add the Fluid Surfaces to the Virtual Body
  – Needed when creating fluid regions from surface bodies only
  – More memory/speed efficient when Keep Solid Mesh is off
    • Uses Connections and Extend to Connection picker helper to pick all the boundaries of the fluid body
    • Allow for adding property to fluid body (curvature angle)

• “Mesh Unite” Fluid or Solid bodies using Mesh Groups
  – To simplify setup and improve quality of the mesh
SUMMARY
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Assembly Meshing Advantages:
• Improved turnaround time
  – Fewer manual steps
  – Fewer geometry cleanup operations
  – Avoids fluid extraction and other Boolean operations
• Cell count reduction of 50%
  – CutCell vs. Patch Conforming tet
• High fraction of Hex cells
• Can find and close gaps in the model
• Supports 2-stage inflation
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THANK YOU

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