Adaptive Mesh Refinement for Overset

15th Symposium on Overset Composite Grids and Solution Technology

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Content

- Basic Concepts & Background Refinement
- Initialize Solution
- Gap Refinement
- Overset Region Refinement
Motivation

**Basic Overset requirement:**
- Ensure similar cell sizes at the Overset interfaces
- Provide sufficient mesh resolution in Gaps

**Overset refinement components in STAR-CCM+:**
- Refine the background regions according to the overset regions
- Refine the overset regions according to the background regions
- Ensure minimal resolution in gaps ( > 5 cells in the gap width)
- Coarsen inactive cells
Motivation

Overset Mesh Refinement Criteria

Refine or coarsen regions of lower priority (e.g. Background region) in order to match the cell sizes of all higher priority regions at the Overset interfaces.
Loose and Tight Overset Boundaries

- Loose Overset Boundary **without** AMR
- Tight Overset Boundary with Overset AMR
- Variable Background Mesh Size with Overset AMR
Loose and Tight Overset Boundaries

Loose Overset Boundary without AMR

- Timestep
- Result Accuracy
- Cell Size Mismatch

Tight Overset Boundary with Overset AMR

- Ease of Use
- Runtime

Variable Background Mesh Size with Overset AMR

- Cell Size Match
- Result Accuracy

General Recommendation:

- Uniform background mesh
- Variable background mesh
When to use AMR due to Overset

Some suggestions for the decision process:
- Ignore refinement due to physics.
- Only consider initial mesh and mesh motion.

<table>
<thead>
<tr>
<th>When are cell sizes matching at the Overset interface?</th>
<th>New Overset user or user with focus on setup time</th>
<th>Experienced user with focus on performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>Use Overset refinement criteria</td>
<td>If possible, coarsen regions with higher priorities at the interface. Otherwise see action below.</td>
</tr>
<tr>
<td>Initial Mesh Only</td>
<td>Use Overset refinement criteria</td>
<td>Use Overset refinement criteria or adjust refinement in motion path</td>
</tr>
<tr>
<td>During Full Mesh Motion</td>
<td>No actions required</td>
<td>No actions required</td>
</tr>
</tbody>
</table>
Overset Mesh Refinement: Graphical User Interface
Interface Refinement Width

Initial Regions

Intersected Regions without AMR
**Interface Refinement Width**

**Interface Refinement Width**: Additional width
Relative parameter, Multiples of acceptor size diameters

![Image of mesh refinement with different widths](image)

- **Refinement width: 0**
- **2 (default)**
- **4**
Handling Overset errors (initialize Solution)

If an Overset error occurs within the initial intersection:
Ignore the error and try to resolve it by using the Overset Mesh Refinement Criterion (if added)
Handling Overset errors (initialize Solution)

If an Overset error occurs within the **initial intersection**:
Ignore the error and try to resolve it by using the *Overset Mesh Refinement Criterion* (if added)
General Gap Refinement

Simcenter STAR-CCM+

No Refinement

Simcenter STAR-CCM+

Gap Refinement
Overset Small Gap Modeling

Overset Prism Layer Shrinkage
- Moving previously inactive prism layer cells into the gap ("specialized morphing")
- Anisotropic refinement
- Cheap (no additional cells)

Adaptive Mesh Refinement
- Refining cells inside the gap
- Isotropic refinement
- No prism layers required
Prism layer refinement & prism layer shrinkage

Non-isotropic refinement:
- Normal direction
- Tangential direction

Isotropic refinement
Prism layer refinement & prism layer shrinkage
Oil jet lubrication for high speed gears
Gap Refinement Strategy

Unwanted refinements

Successfully prevented refinements
Overset Small Gap Modeling

Combination of AMR and Overset Prism Layer Shrinkage

Step 1: AMR

Step 2: Prism Layer Shrinkage

Shrinkage may not be possible, since prism layers are no longer fully intact!

Possible remediation
• Leave default Continua > Adaptive Mesh > Prism Cell Refinement: None
• Use Uniform Gap Refinement
Overset Uniform Gap Refinement

Parameters
- **Gap Zone Width**: Specifies a gap distance in order to identify a cell to be located within a gap.
- **Gap Refinement Level** (only available for Specified Level): Target refinement level within all gaps.

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# Simulating Oil Jet Lubrication of High Speed Gears

**AMR vs static mesh**

<table>
<thead>
<tr>
<th></th>
<th>AMR setup</th>
<th>Static mesh setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesh count</td>
<td>~9M after ½ revolution</td>
<td>~90M</td>
</tr>
<tr>
<td>Number of cores</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>Elapsed time per time step</td>
<td>~28s after ½ revolution (on average)</td>
<td>~177s</td>
</tr>
<tr>
<td>Elapsed time for ½ revolution</td>
<td>50h</td>
<td>300h (estimated)</td>
</tr>
</tbody>
</table>
Example: Oil jet lubrication for high speed gears
Gap Refinement Strategy (by Klaus Wechsler)
The initial meshes (left) as well as the refined meshes (right) do have matching cell sizes. Hence, only having consistent cell sizes between overset and background region is not sufficient to provide an unique refinement.

An additional constraint is necessary to avoid repeated refinement or refinement oscillations in time!
Example: Refinements in the Overset Region

- Background Region Refinement
- Overset Region Refinement
Conclusion

How Adaptive Mesh Refinement can help to
- Keep Overset interfaces refined
- Simplify Overset setup