Adaptive Mesh Refinement for Overset

15th Symposium on Overset Composite Grids and Solution Technology

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Content

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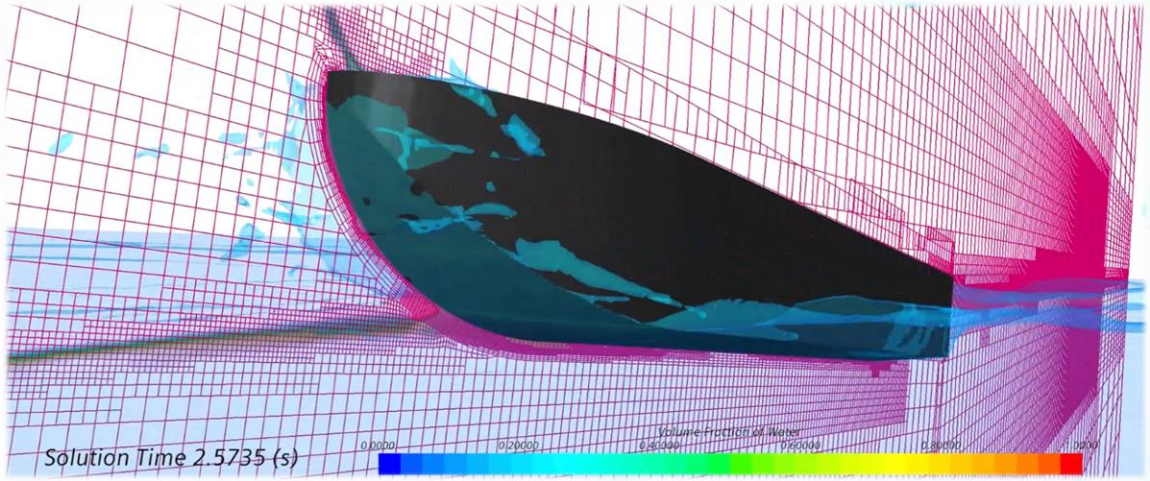
- Initialize Solution
- Gap Refinement
- Overset Region Refinement



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Motivation

Basic Overset requirement:

- Ensure similar cell sizes at the Overset interfaces
- Provide sufficient mesh resolution in Gaps

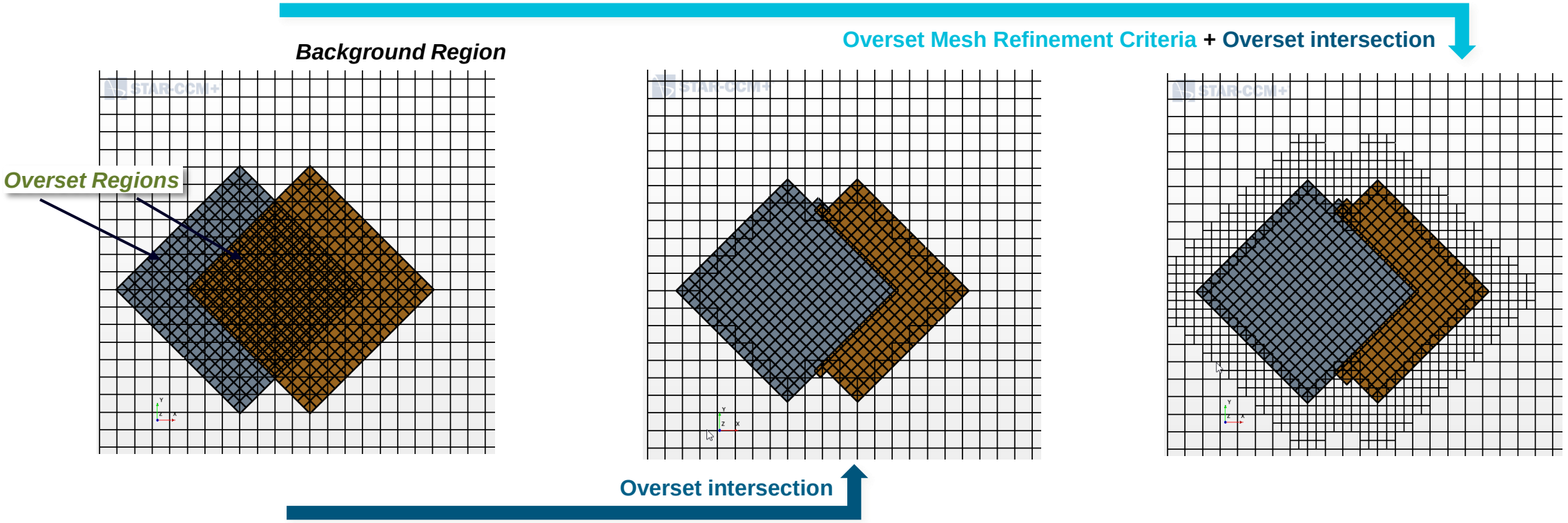
Overset refinement components in STAR-CCM+:

- 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.



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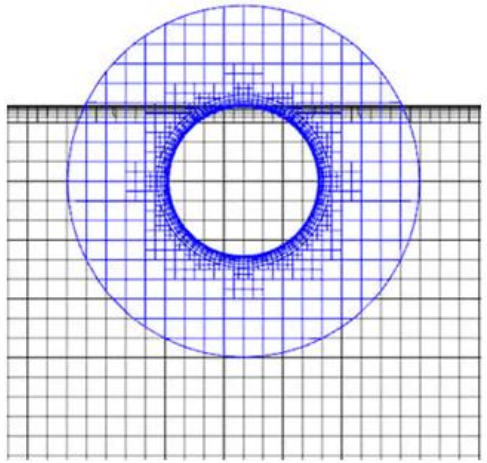
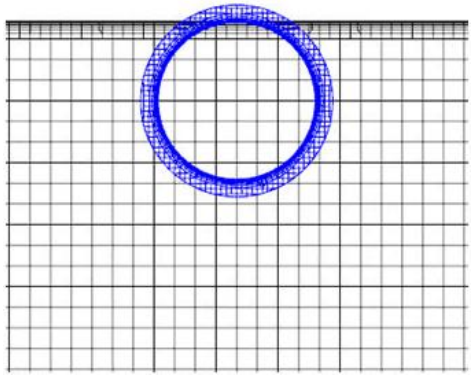
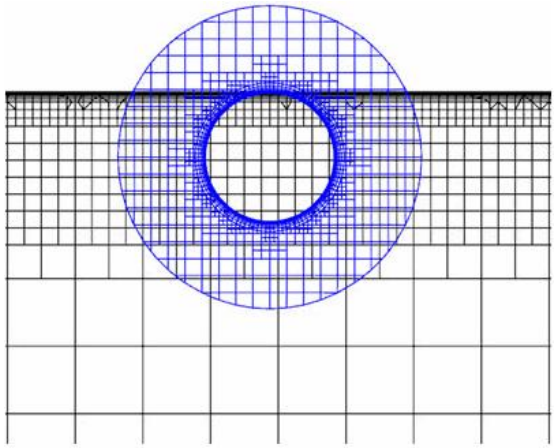
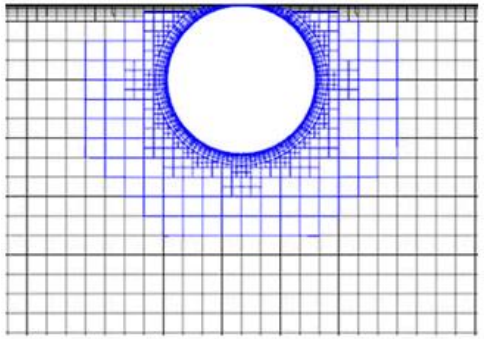
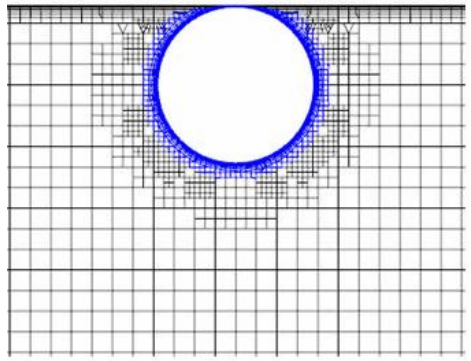
Loose and Tight Overset Boundaries

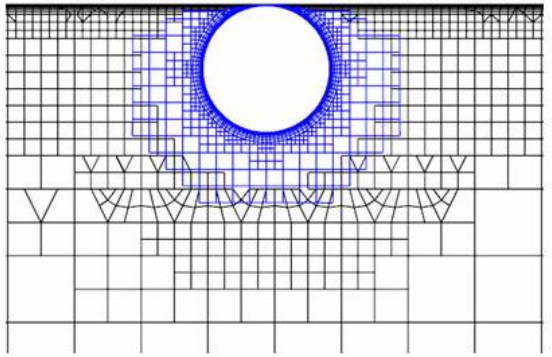












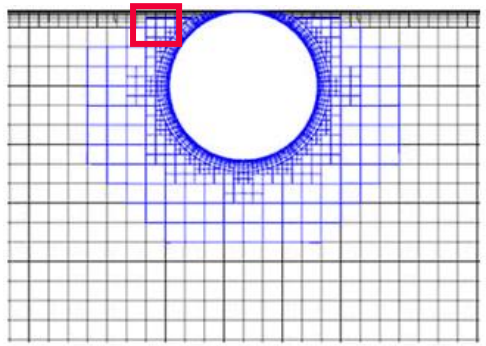
Loose Overset Boundary **without** AMR

Tight Overset Boundary with Overset AMR

Variable Background Mesh Size with Overset AMR

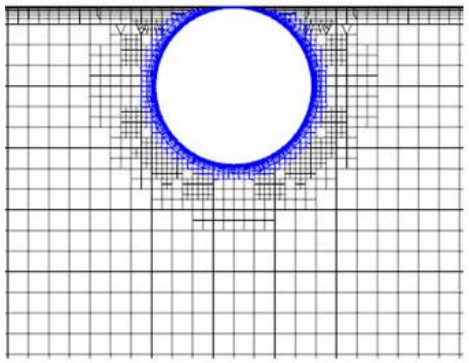
Loose and Tight Overset Boundaries

Loose Overset Boundary **without** AMR



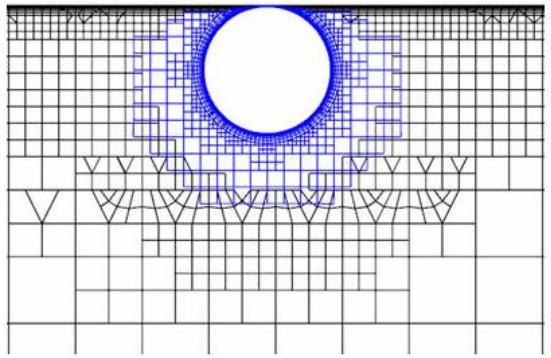
- ⊕ Timestep
- ⊕ Result Accuracy
- ⊖ Cell Size Mismatch

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

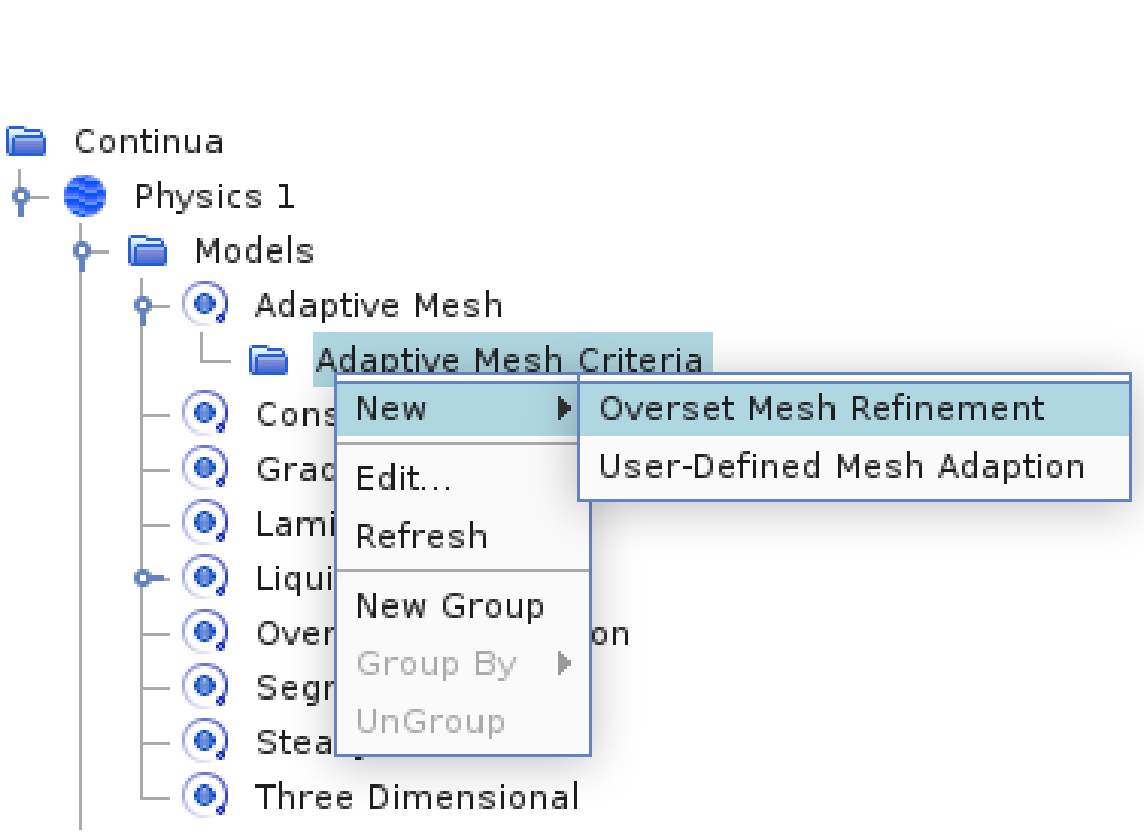
When to use AMR due to Overset

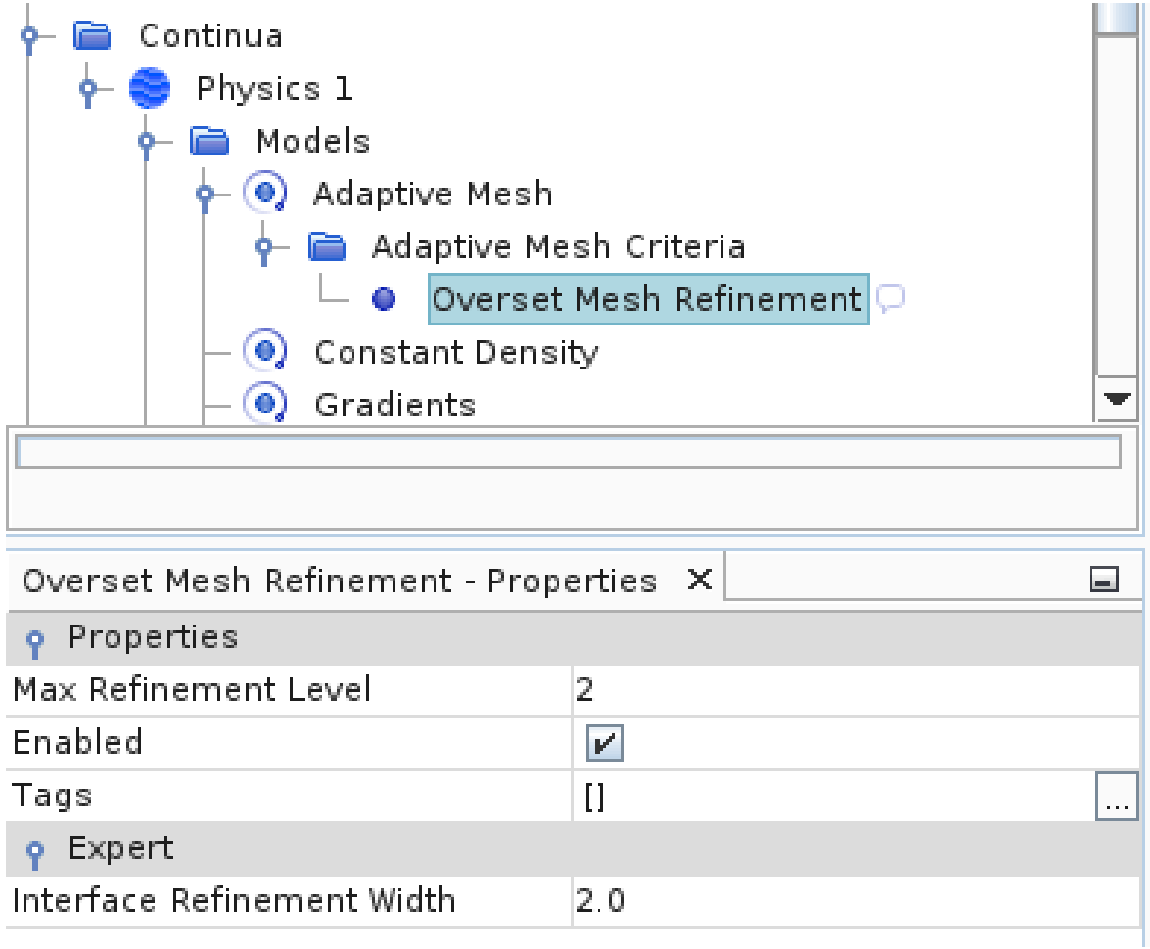
Some suggestions for the decision process:

- Ignore refinement due to physics.
- Only consider initial mesh and mesh motion.

When are cell sizes matching at the Overset interface?	New Overset user or user with focus on setup time	Experienced user with focus on performance
Never	Use Overset refinement criteria	If possible, coarsen regions with higher priorities at the interface. Otherwise see action below.
Initial Mesh Only	Use Overset refinement criteria	Use Overset refinement criteria or adjust refinement in motion path
During Full Mesh Motion	No actions required	No actions required

Overset Mesh Refinement: Graphical User Interface





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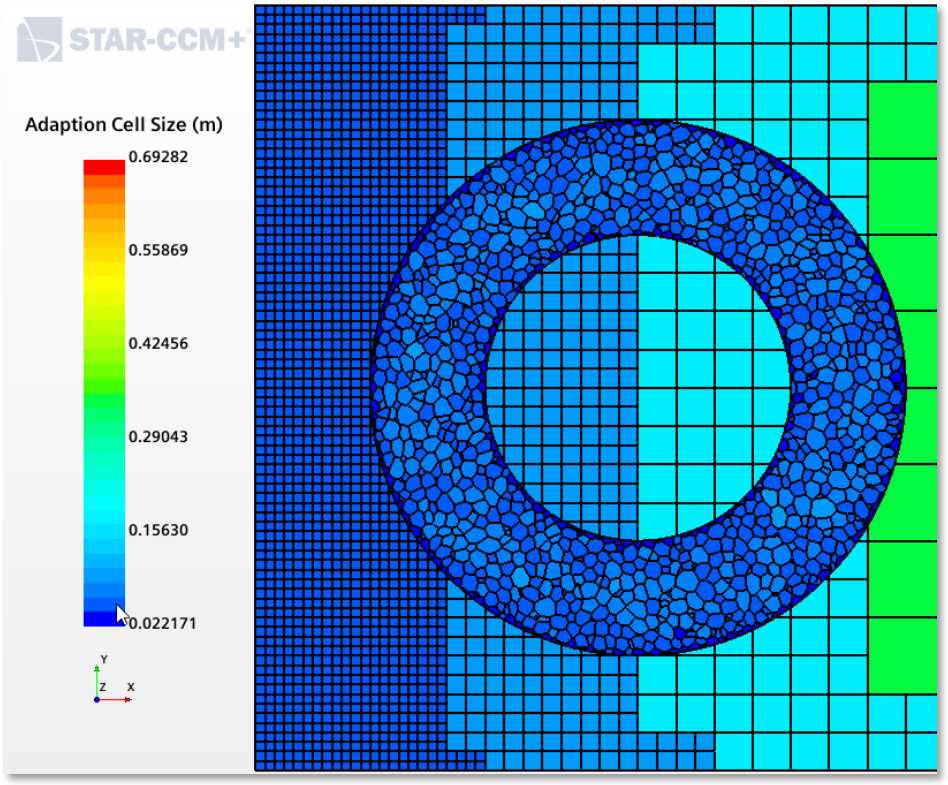
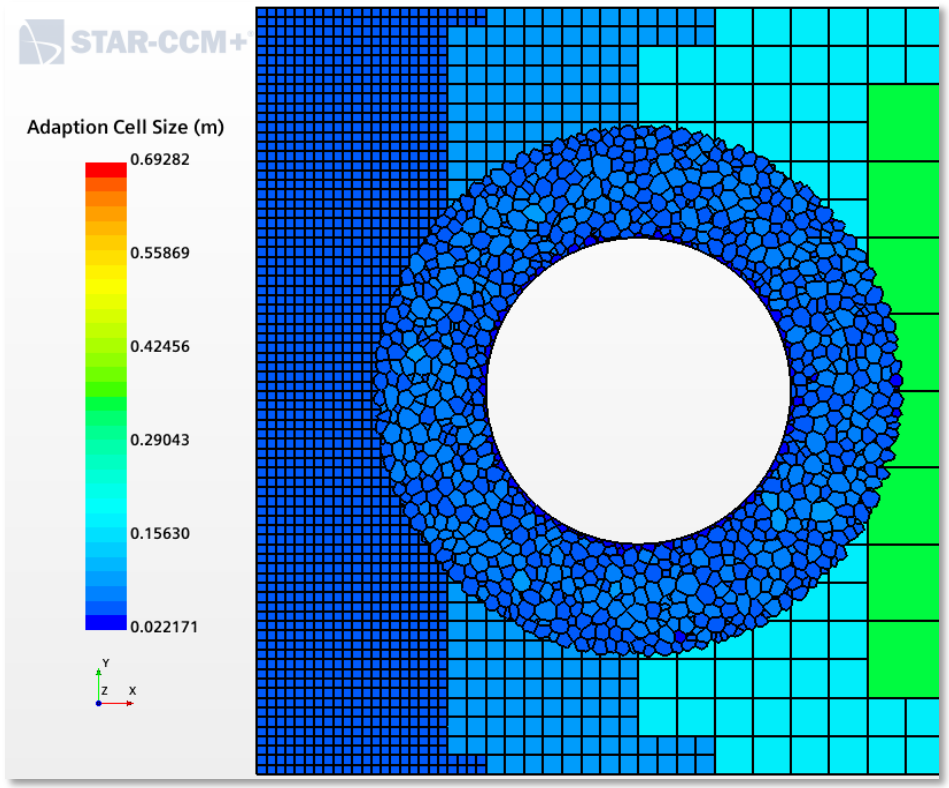
Interface Refinement Width



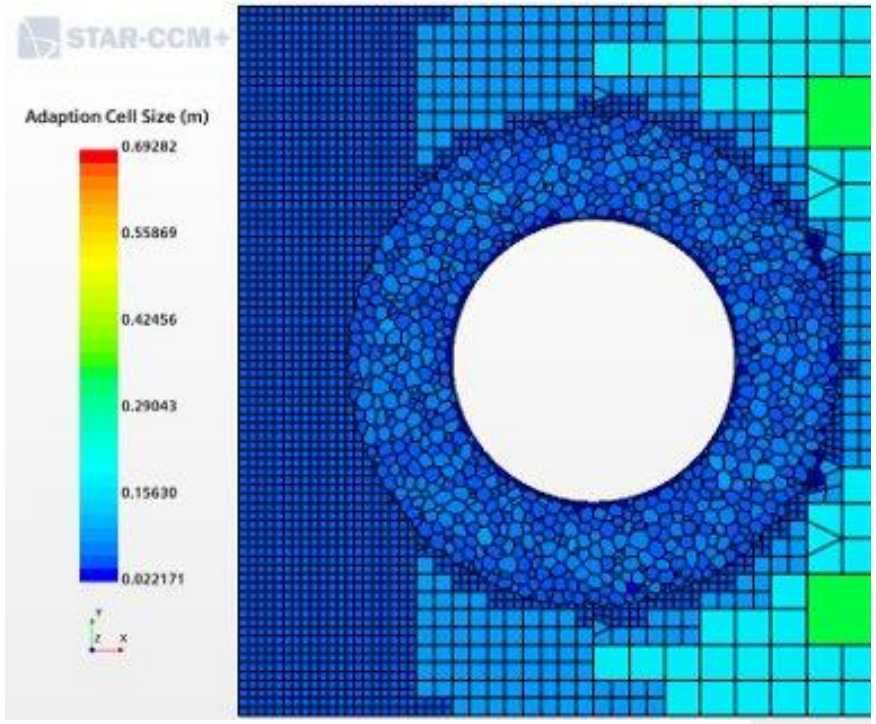
Initial Regions

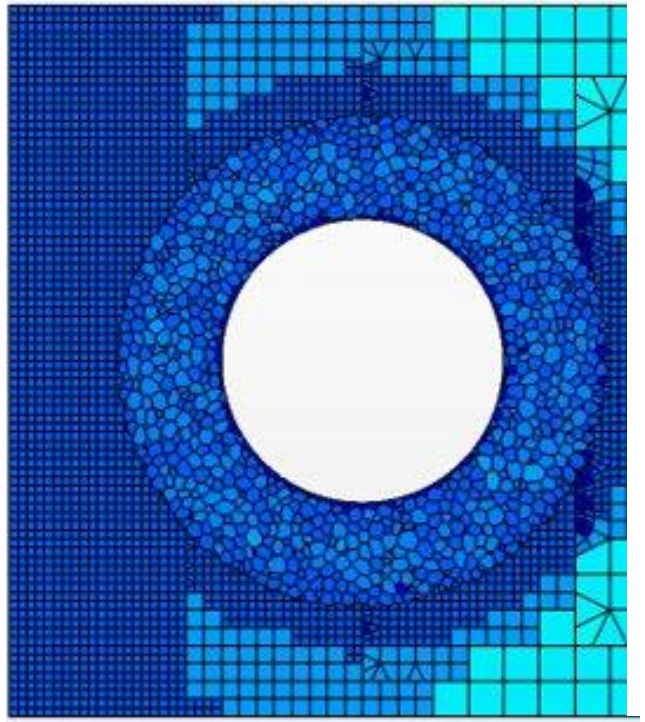


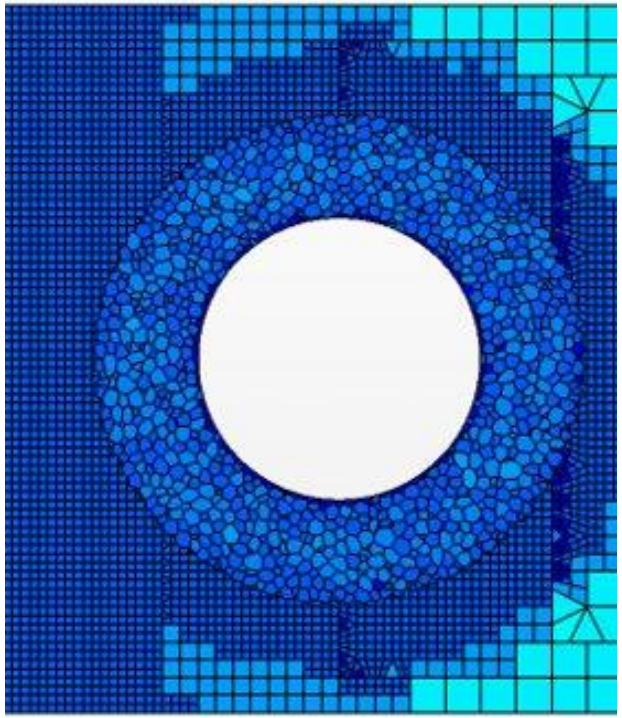
Intersected Regions without AMR

Interface Refinement Width

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







Refinement width: **0** **2 (default)** **4**

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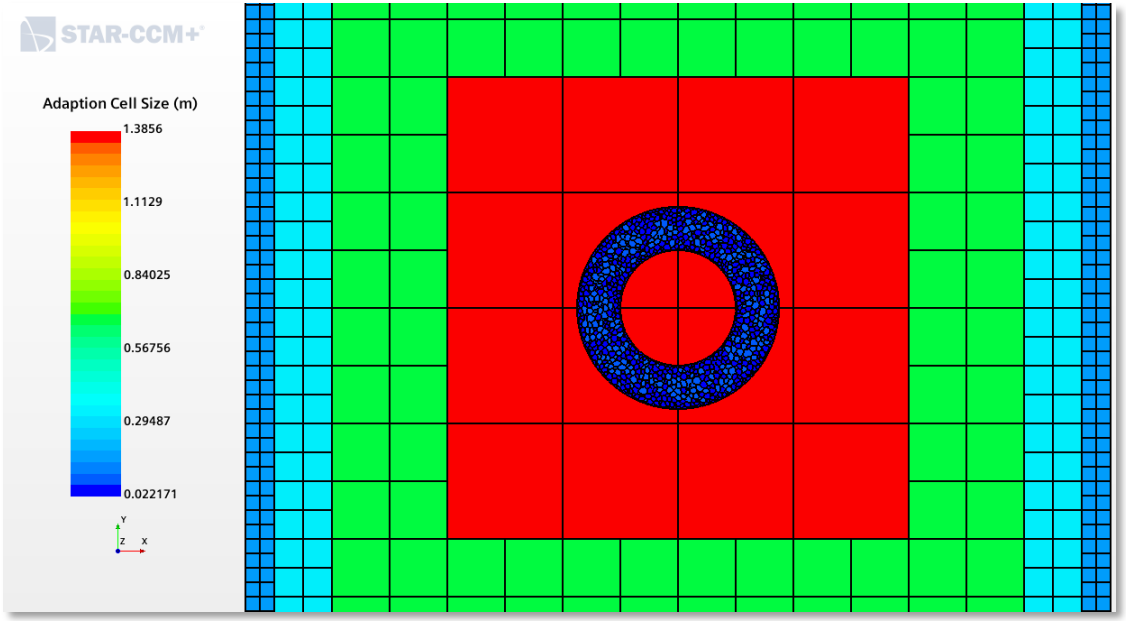
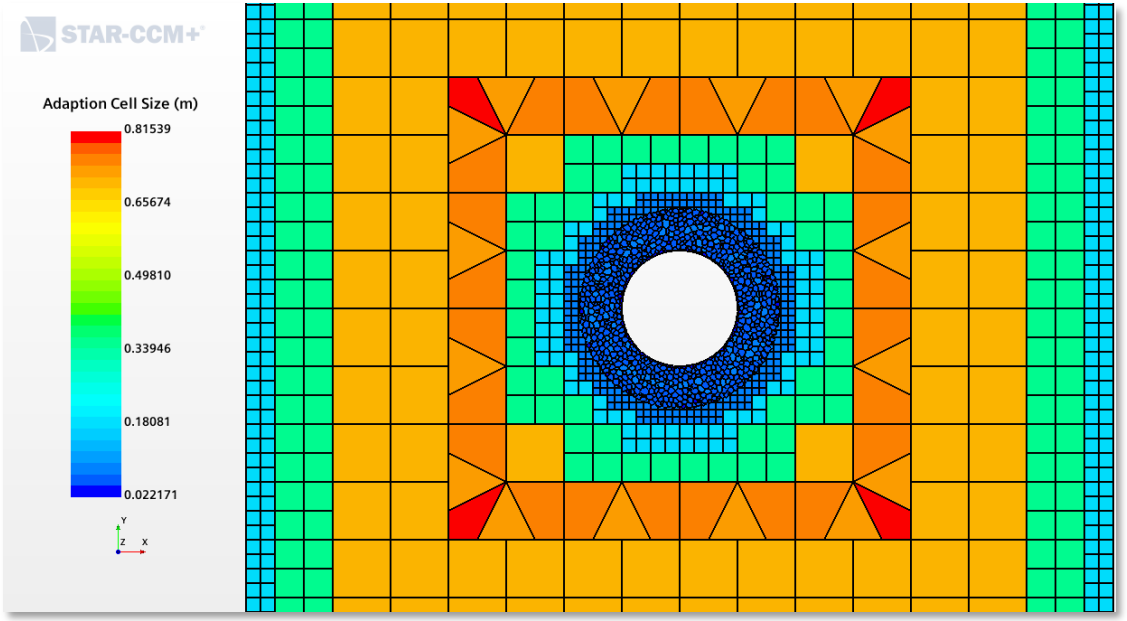
Handling Overset errors (initialize Solution)

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)





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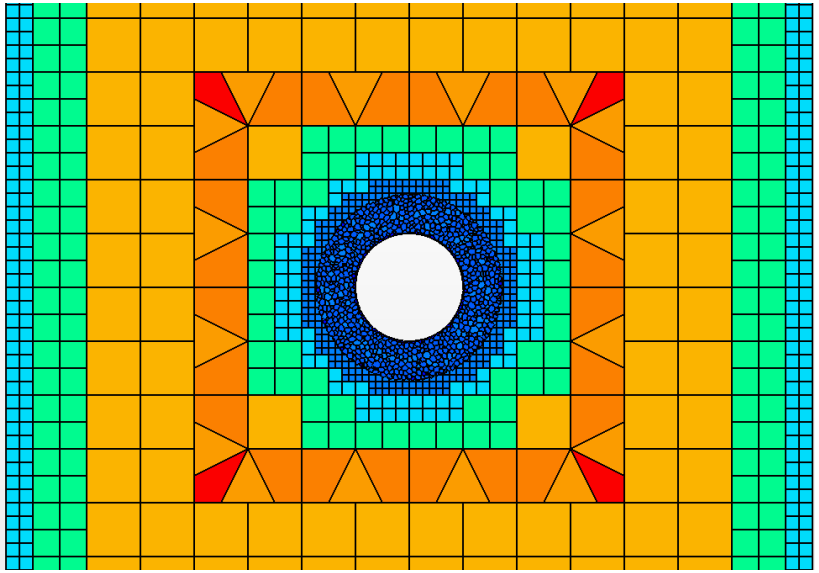
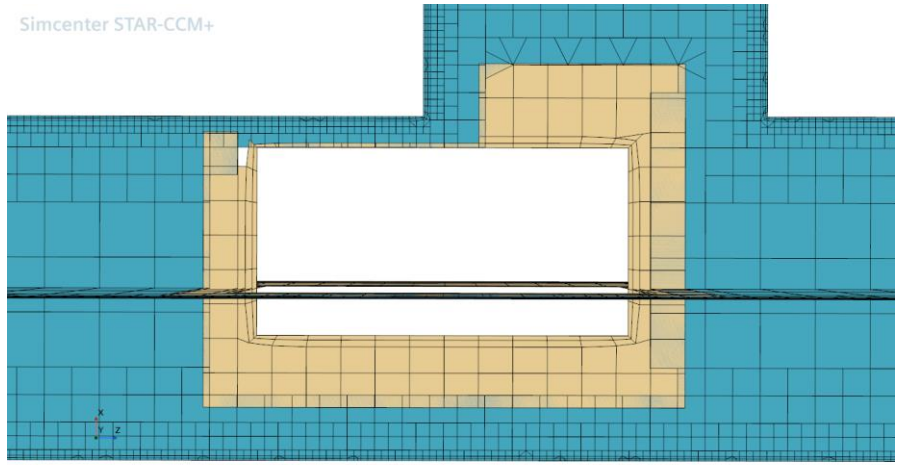
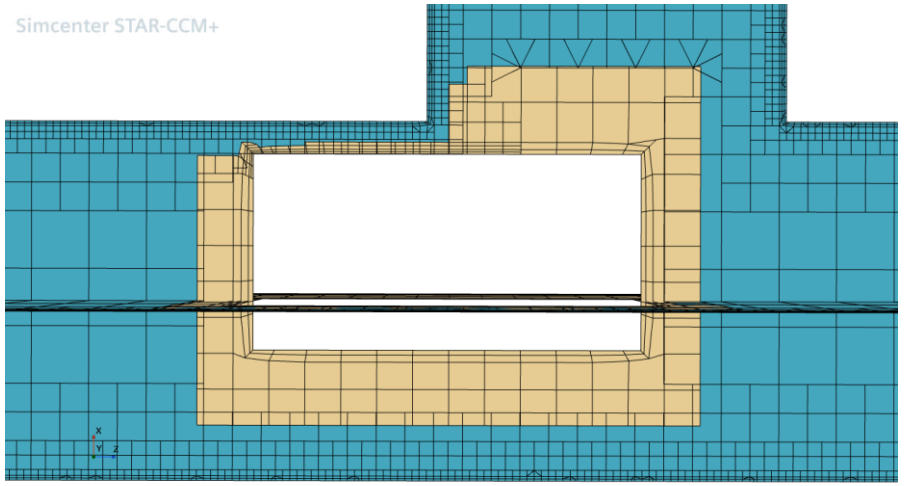
```
Initialization of star.segregatedenergy.SegregatedEnergySolver requires an additional pass...
Overset Mesh 1 needs update

Updating two-level indirect region interface Overset Mesh 1 between Overset and Background.

Error 1 of 1: Failed to cut hole in region "Background".
 This might be due to an overlapping of overset regions or due to invalid mesh configuration!
Scheduling region for Adaption: Background
Resetting interfaces
Region: Background, Added primary mid side vertices: 28, Added halo mid side vertices: 0
Region: Background, Added primary mid face vertices: 17, Added halo mid face vertices: 0
Region: Background, Added primary mid cell vertices: 2
Total AMR statistics: # refined: 2361 # coarsened: 0 # copied: 53031
AMR Timing: Pre-processing 1: (0.02, 0.00184703)  Vertex creation: (0.18, 0.025399)  Data prepa
Mesh of the region Background adapted.
AMR time: (1.58,0.201232) Total SIM time: (537.65,259.994) % AMR time (2.1036,0.551804)
Hexes #: 66767 Tets #: 0 Wedges #: 0 Pyramids #: 0 Poly #: 5248
Overset Mesh 1 needs update

Updating two-level indirect region interface Overset Mesh 1 between Overset and Background.

Re-partitioning
Initialization of star.segregatedflow.SegregatedFlowModel requires an additional pass...
```

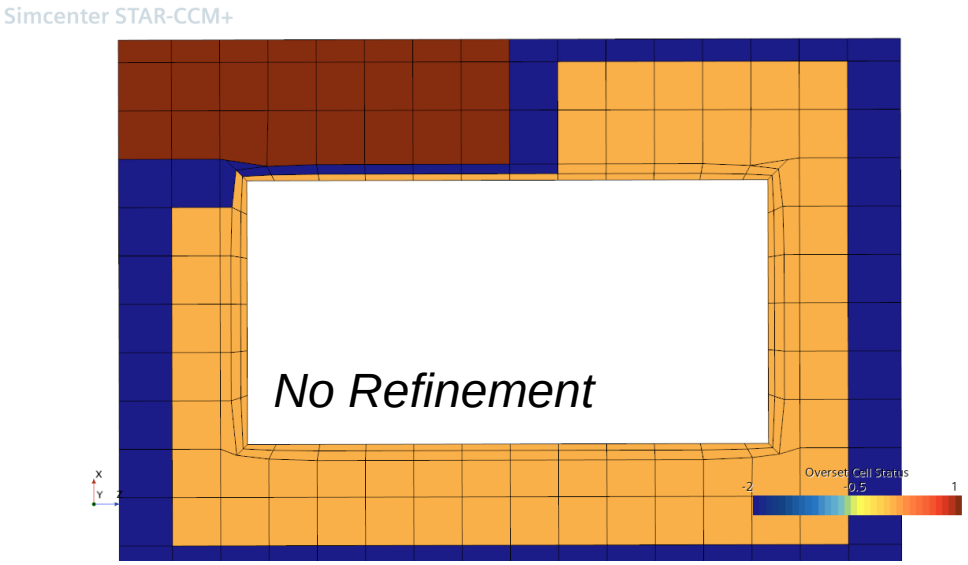
Adaption

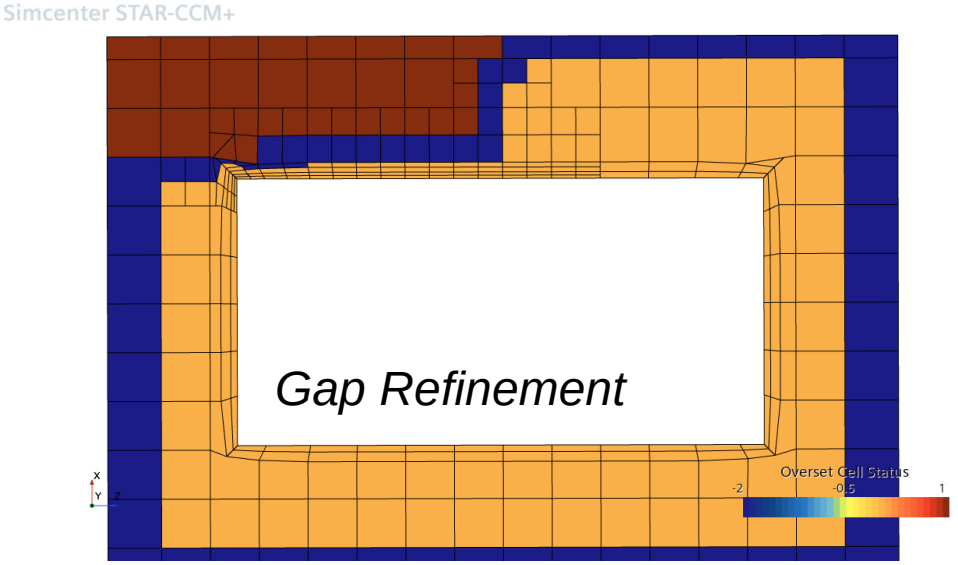


General Gap Refinement









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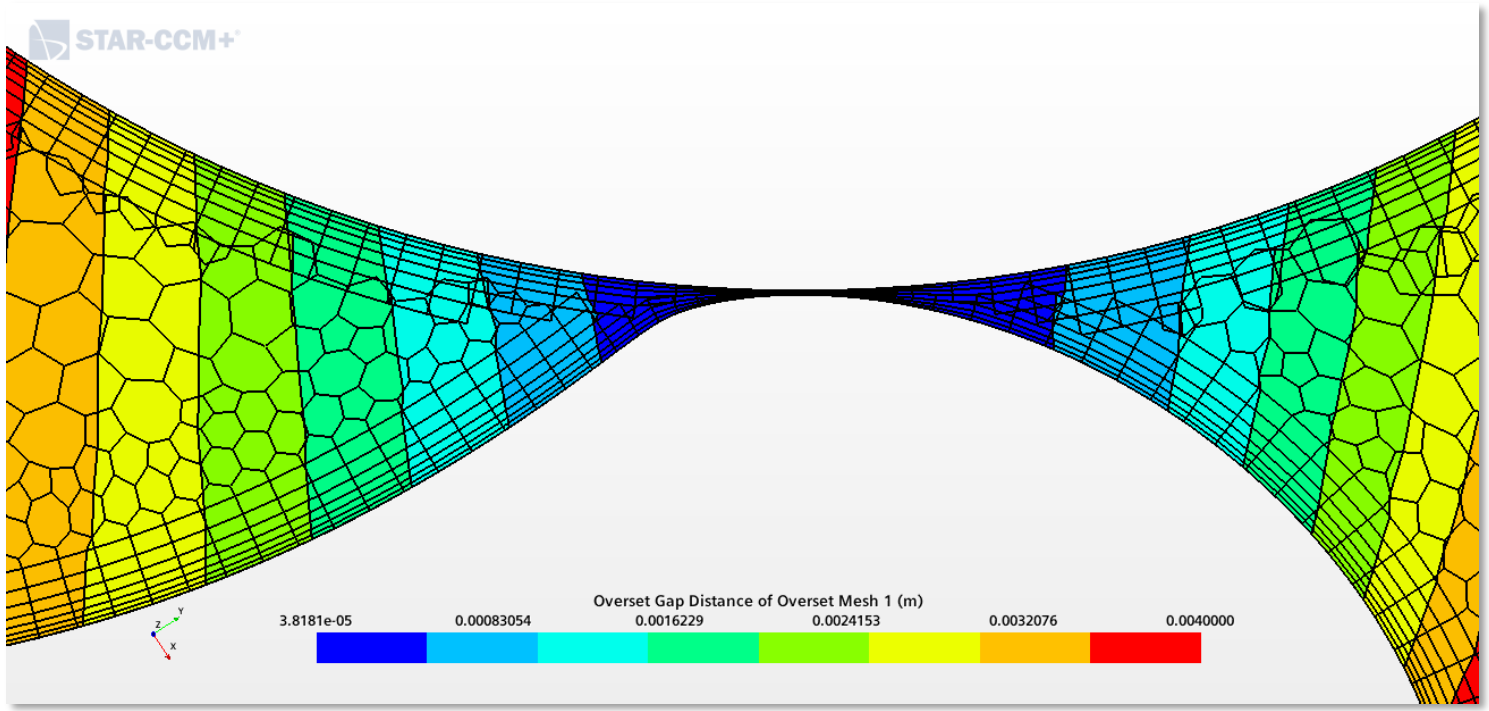
Overset Small Gap Modeling

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



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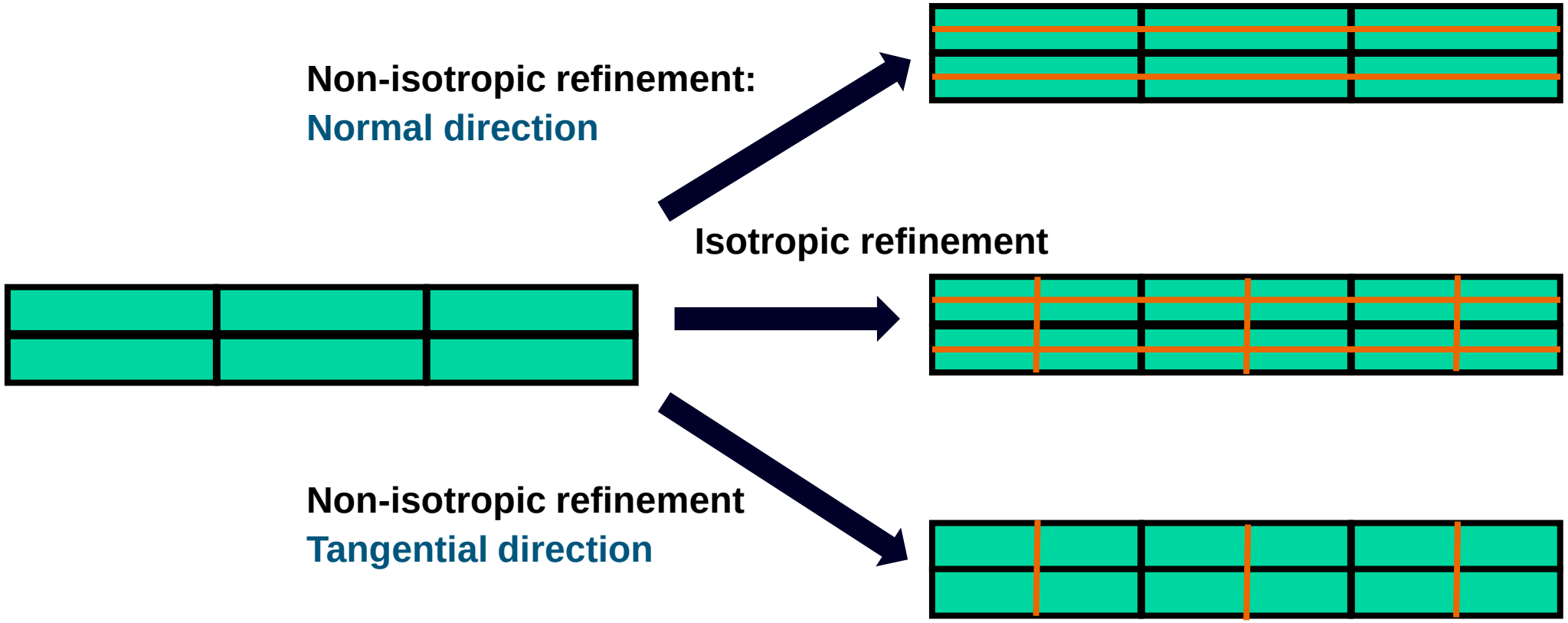
Prism layer refinement & prism layer shrinkage



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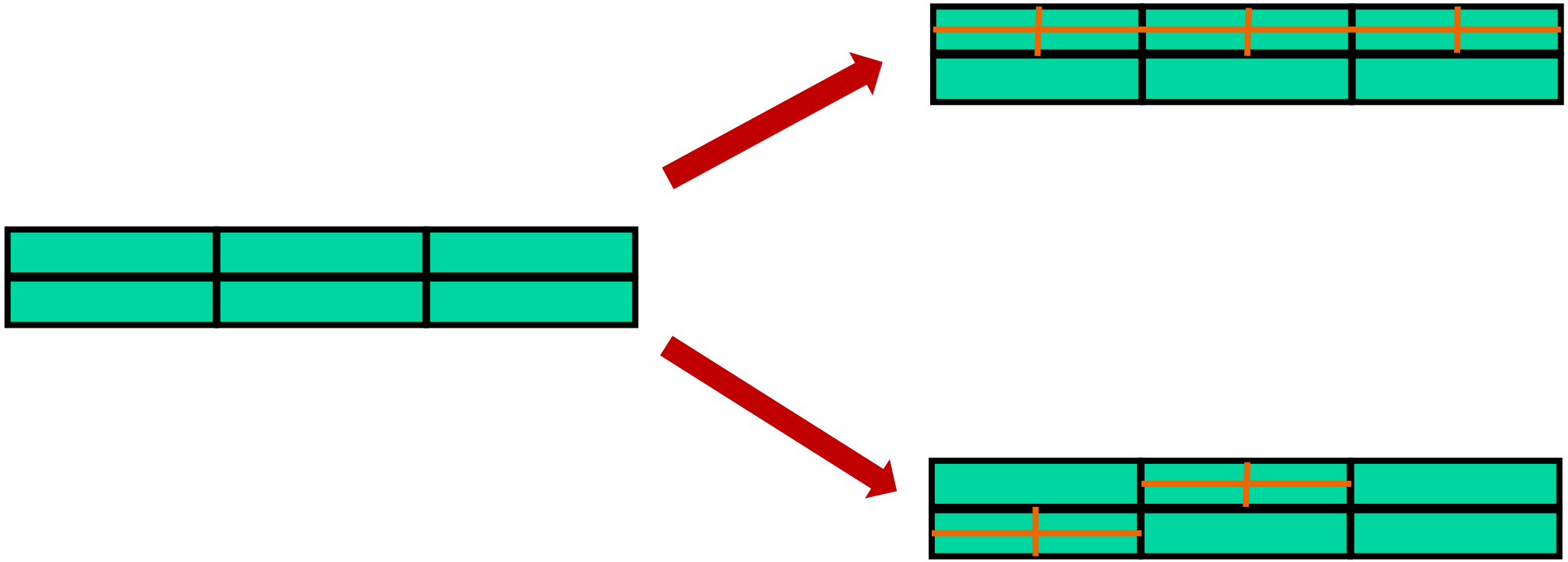
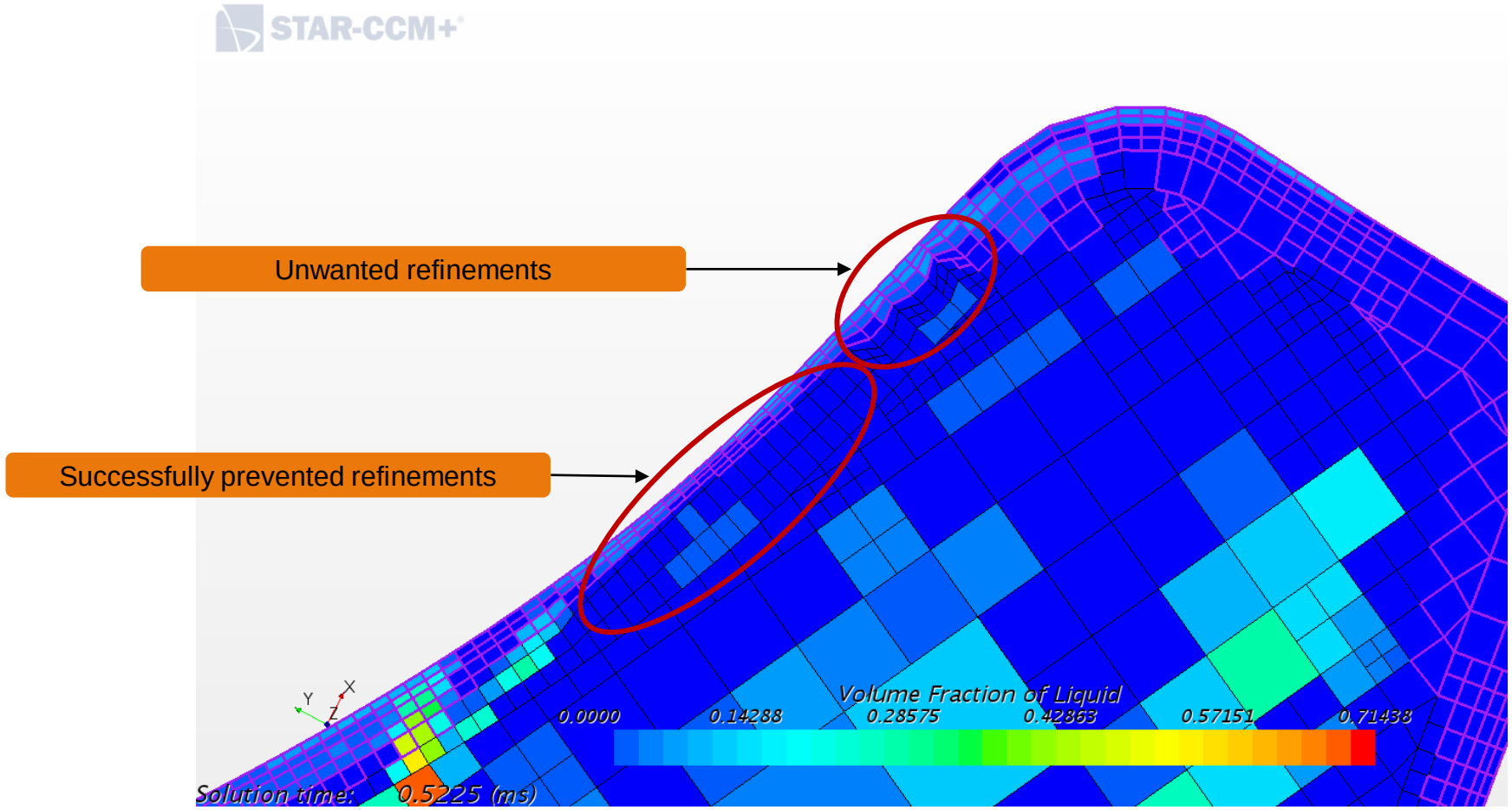
Prism layer refinement & prism layer shrinkage



Oil jet lubrication for high speed gears
Gap Refinement Strategy



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Overset Small Gap Modeling

Combination of AMR and Overset Prism Layer Shrinkage

Step 1: AMR

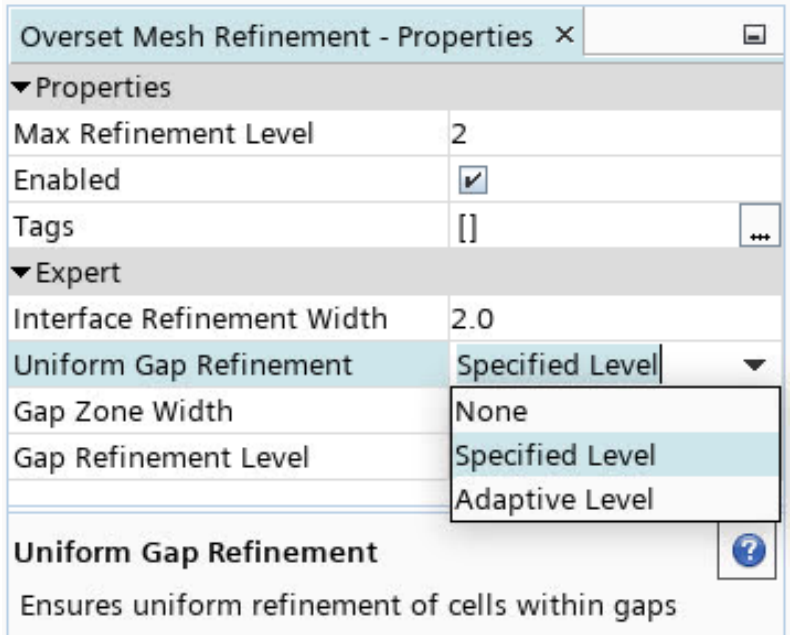
Step 2: Prism Layer Shrinkage

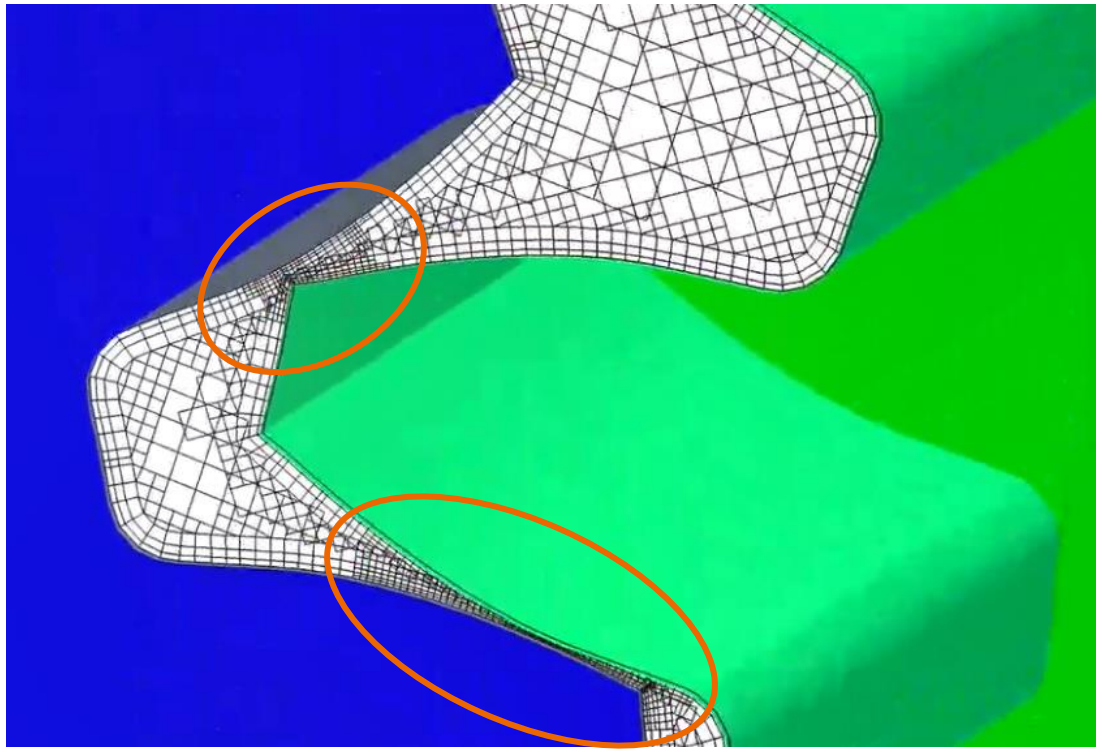
Shrinkage may not be not possible, since prism layers are no longer fully intact!

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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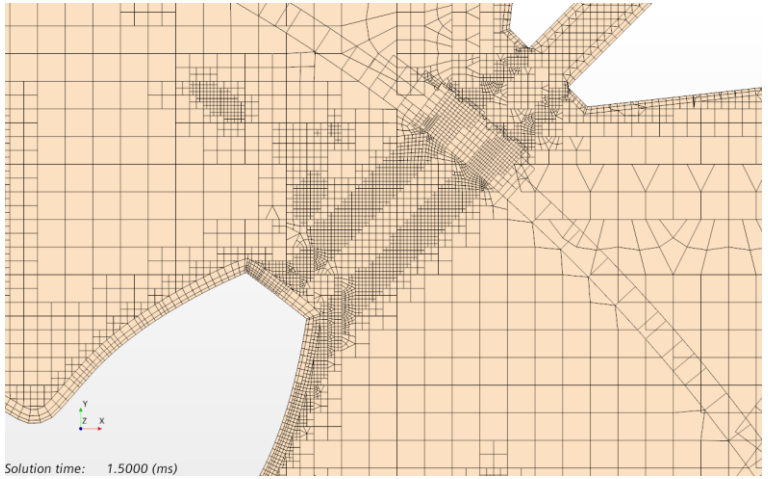
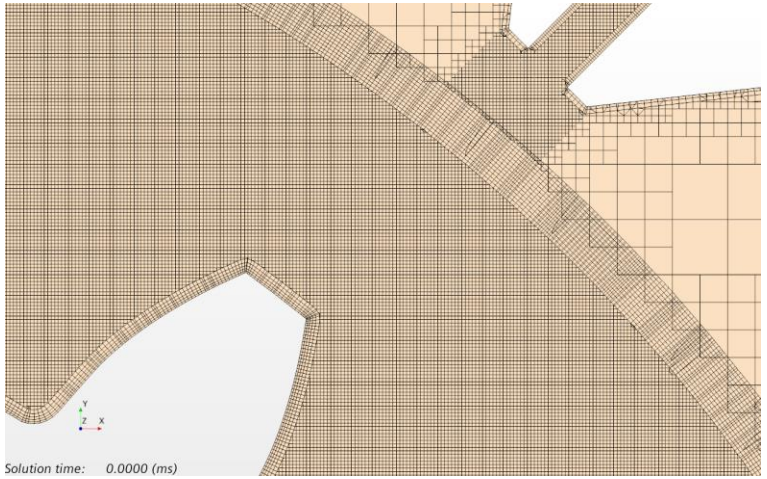
Simulating Oil Jet Lubrication of High Speed Gears

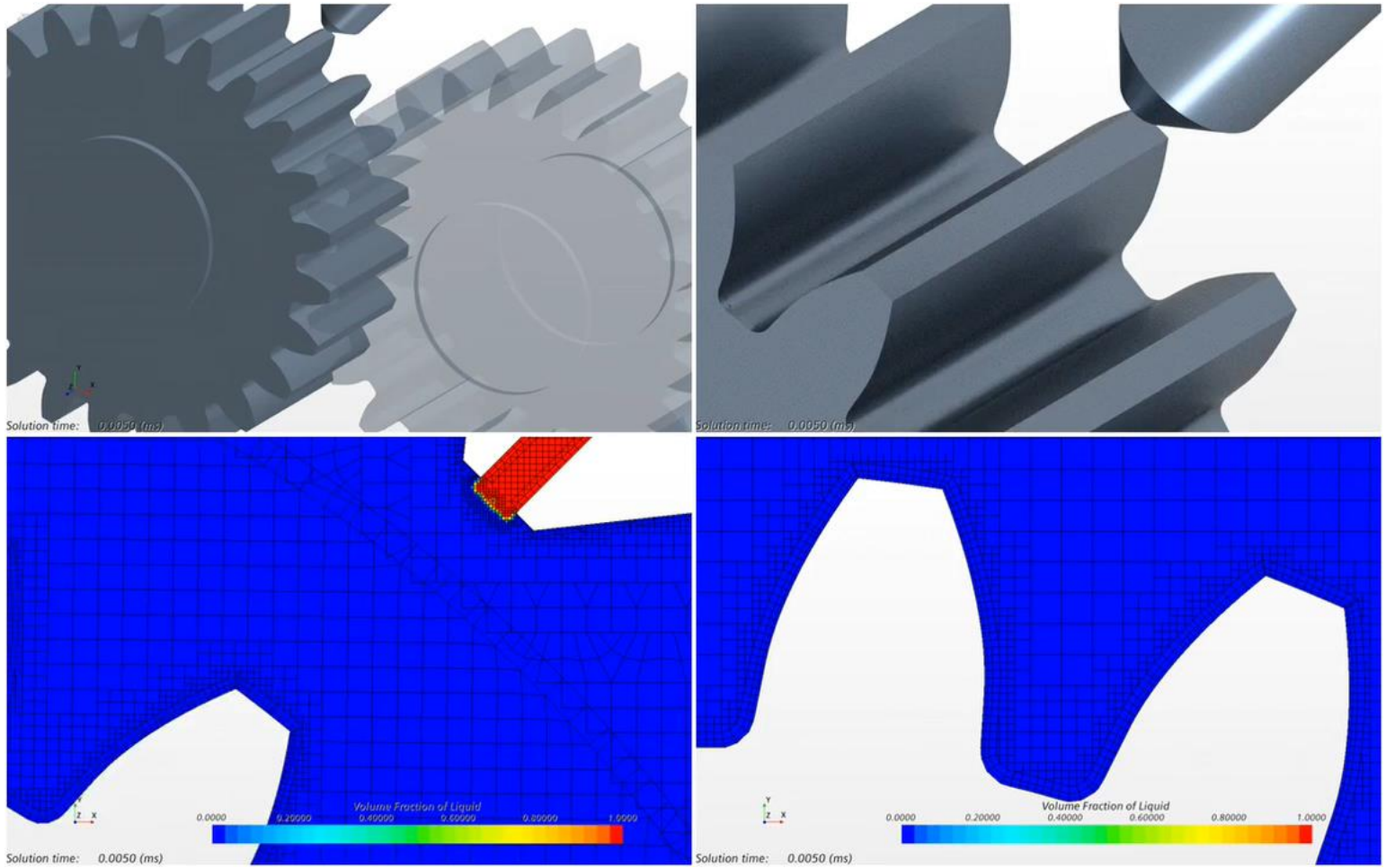
AMR vs static mesh

	AMR setup	Static mesh setup
Mesh count	~9M after ½ revolution	~90M
Number of cores	216	216
Elapsed time per time step	~28s after ½ revolution (on average)	~177s
Elapsed time for ½ revolution	50h	300h (estimated)





Example: Oil jet lubrication for high speed gears
Gap Refinement Strategy (by Klaus Wechsler)



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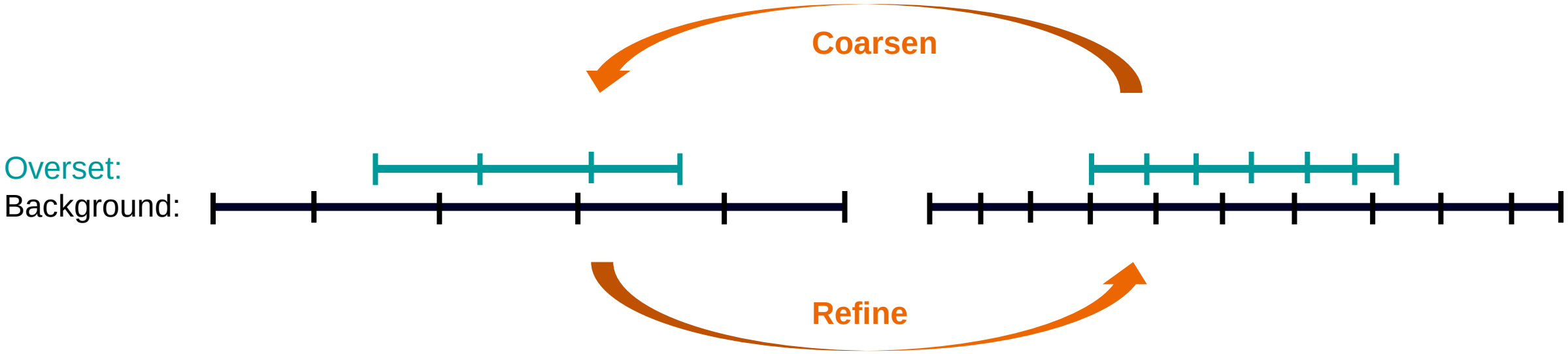
Overset Region Refinement



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!

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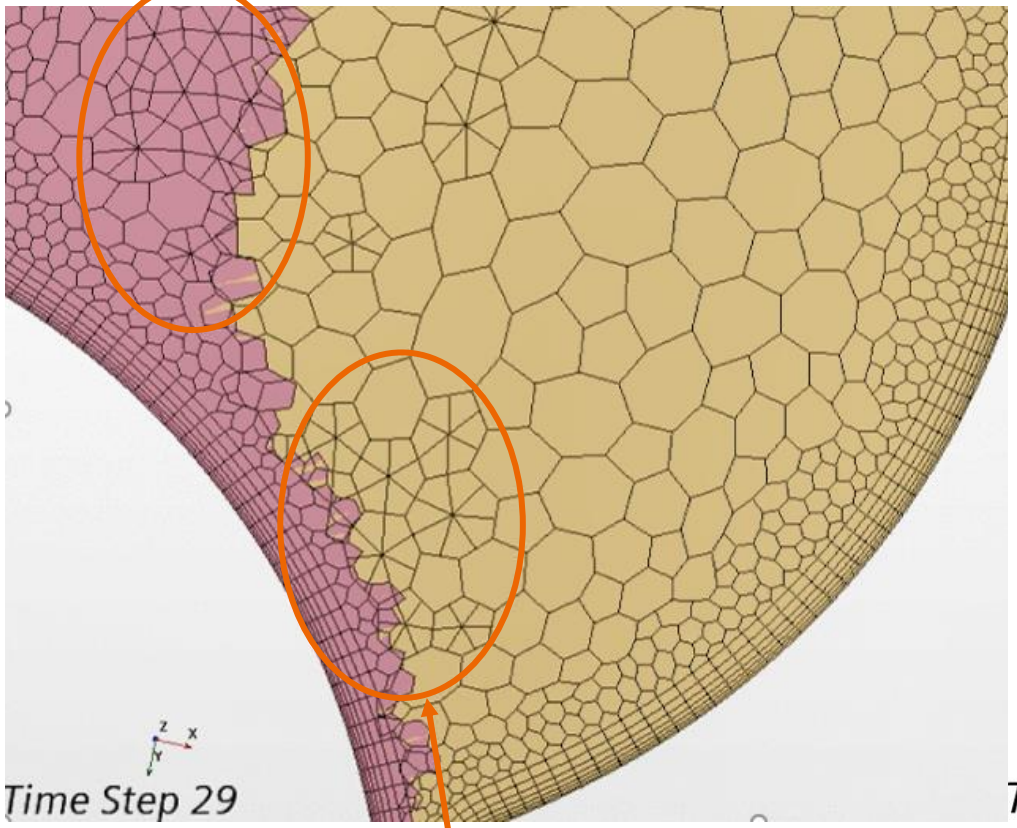
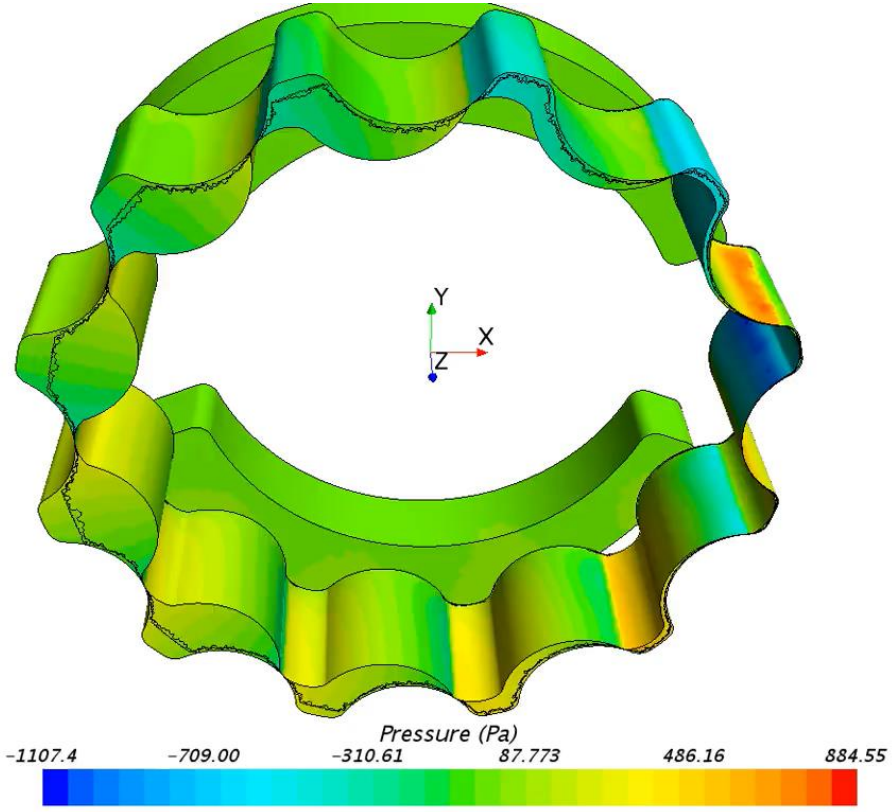
Example: Refinements in the Overset Region

Background Region Refinement



Overset Region Refinement



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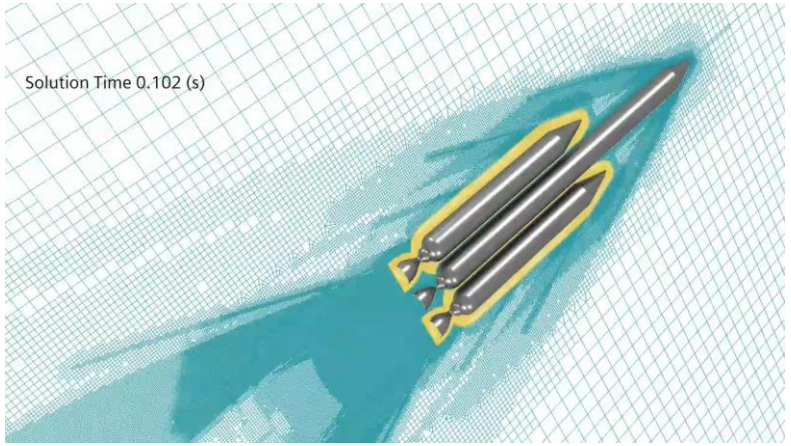
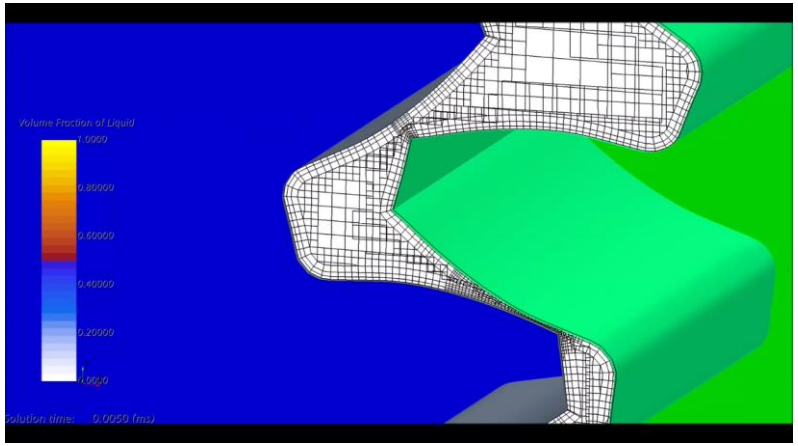
Conclusion

How Adaptive Mesh Refinement can help to

- Keep Overset interfaces refined
- Simplify Overset setup





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