Meshing in STAR-CCM+: Recent Advances
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Outline

- **STAR-CCM+: a complete simulation workflow**
  - Emphasis on pre-processing technology

- **Recent advances in surface preparation and meshing**
  - Continue to enhance flexibility, control, automation, ease-of-use...

- **Future direction**
STAR-CCM+: a complete simulation workflow...

Complex model import and preparation

Automated surface and volume meshing

Wide variety of physics

Meaningful visual and numerical analysis
STAR-CCM+: a complete simulation workflow…

- Provide a streamlined workflow for engineering analysis
- Complete the loop to enable design optimization studies
- Achieve the most optimal design…
Surface preparation and meshing – a key enabler...

-Ability to take arbitrarily complex, “unclean” geometry as input
-Hierarchical data organization
-Automatic and interactive tools to prepare geometry for meshing
-Wide variety of volume mesh types to optimize based on your need
-Complete control on mesh size and distribution
Surface preparation

- Surface wrapper – the ability to make unclean geometry ready for meshing
- Surface repair and imprinter – interactive tools in an intuitive interface
- Surface remesher – high quality

Import

Wrapped and Remeshed
Volume meshing

- Trimmed
- Polyhedral
- Prismatic
- Thin
- Directed
- Advancing layer
- ...

...
Recent advances in surface preparation and meshing

Each new release continues to build on our theme of
- Automation
- Flexibility
- Control
- Ease-of-use
- Accuracy
- Innovation
- ...

Continue to push the envelope on the workflows we are able to pipeline and automate
New gap closure option
- User specifies seed points to specify volumes to exclude
- No need to know gap closure size a-priori
- Works in conjunction with existing size-based gap closure
- Localizes the effect of gap closure
Surface remesher

Edge proximity mesh control

- Provides the ability to specify number of triangles across a part surface – refines based on size of CAD face…
- Optionally specify number of triangles between feature edges or patch perimeter edges internal to part surface
- Eliminates the need to split the surface out for local refinement
- Especially useful for wing trailing edges, geometries with widely varying length scales, etc.
Surface remesher

**Proximity Ceiling**
- Surface proximity now has a “ceiling” option to limit the distance for which proximity is searched
- Provides more control on precise placement of mesh density
- Useful in meshing of thin structures
Local growth rate specification

- Ability to specify surface mesh growth rate on a per-part surface basis in addition to globally
- Can also specify at a sub-assembly level in parts based meshing
- Provides complete control on transition rate from small mesh sizes to

Constant growth rate (1.3)
**Surface remesher**

*Aligned meshing*

- First introduced in v6.02
- Numerous improvements in every version since then to increase the number of aligned meshable surfaces
- v8.06 provides the ability to align mesh CAD faces even if they are not logically four sided

Smooth transitions from aligned to non-aligned regions

Remeshed surface preserves directionality
Surface repair

- Boolean operations within repair panel
  - Unite
  - Intersect
  - Subtract
Surface repair

**Enhancements to split by patch tool**
- Ability to grow and shrink patch sets for easier selection
- Options to invert selection set, clear selections, do multi-grows, etc.
- Includes “smart selection” – double click on patch to stop at next “break” point
Surface repair

-New plane specification option for project to plane and intersect faces features
  - Can either specify vector or three points to define plane
  - Points can be specified by coordinates or picked in scene
Surface repair

🌟 Mixed-mode hole fill
  - Enhances hole filling option to fill open and closed loops within same selection set
  - Options to control interactions between edge chains

🌟 Directional smoothing option
  - Allows user to constrain smoothing direction
  - Also allows the use of local coordinate systems
Parallel polyhedral mesher introduced a couple of years ago

Parallel trimmer
- Officially introduced in v8.06
- Speedups of up to 3x on eight processors
- Equivalent mesh count and quality
- No more cell count ceiling – successfully generated over 1 billion cells!

Each version in v9.xx will continue to improve on the scalability and work on parallelizing more meshers…
Prism layer mesher

- Ability to visualize only prism layer cells using cell sets
- Allows user to see surface of transition from prisms to core mesh
**Directed mesher**

- Introduced in v7.04
- Numerous user requested enhancements in every release since then
  - Repeated distribution patterns
  - Create patch vertex at user specified location
  - Split curve at specified parameter value
  - Split curve evenly multiple times
  - Ability to deal with “stacked” parts

...
Automatic source mesh creation
- User can invoke remesher to triangulate complex source mesh surface
- Optionally convert triangles to quadrilaterals
- Pipelined approach automates entire procedure
Directed mesher

- Ability to mesh looped geometries
  - Source/target is same surface
- Continued improvements to robustness and quality
  - Dramatically varying cross-sections
  - Highly non-planar source/target surfaces
Parts based meshing

- Introduced in v8.02 – surface preparation and meshing done at parts level
- Decouples meshing from physics
- Preserves model assembly hierarchy during meshing phase
- More natural, compact mesh control specification on individual surfaces, parts or entire assemblies
- Much more flexible pipeline – facilitates easy design modification studies

- A framework for all future surface preparation and meshing…
Parts based meshing – a flexible pipeline…

A few clicks, and you are ready to go!
Parts based meshing

Combine geometry actions, mesh operations, mesh types in any combination

Facilitate quick design studies
Parts based meshing

- Continue to add more functionality with every release
  - Copy/paste of mesh controls – automatically handles part inheritance, etc.
  - Only modified parts are remeshed in per-part meshing mode
  - Better association with upstream 3D-CAD bodies
  - Split part surface by contact
  - Priority indexing in imprint panel
    - User selects parts to imprint
    - Pick parts with higher priority, reorder as needed
    - Priority order dictates direction of imprint
Future direction

Continue to broaden our scope in each of the key areas of:
- Geometry import/preparation
- Meshing
- Multi-disciplinary physics
- Visualization/analysis

Volume rendering: Convection of soot from a fire source
Future direction - meshing

- **Partial wrapping**
  - Wrap only the small portion of a complex geometry that is unclean

- **Pipelined 2D meshing**
  - Works within the pipeline to be able to do 1000’s of design modifications quickly and seamlessly

- **Continued emphasis on parallel meshing**
  - Improve scalability of current parallel meshers
  - Parallelize more meshers (wrapper, remesh, etc.)

- **More investment in parts based meshing**
  - Continue to migrate all meshers to parts environment
  - Add new operations to promote more workflows

- **Continue to innovate with new meshers**

- **Local remeshing**
Future direction – local remeshing

Useful when user has large initial mesh and wants to do minor design modifications

- User would specify changed components and workflow would seamlessly regenerate only the local mesh in the vicinity…
Conclusion

- The tool of choice for engineering analysis and simulation
- We continue to make strides in each facet of the simulation workflow

Integrated engineering solution for solving multidisciplinary problems