Walk-in Slide: AU 2014 Social Media Feed

1. Click on the link below, this will open your web browser

http://aucache.autodesk.com/social/visualization.html

2. Use “Extended Display” to project the website on screen if you plan to work on your computer. Use “Duplicate” to display same image on screen and computer.

Purging Old Misconceptions: Best Practices for Meshing in Simulation Moldflow Insight

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Class summary

There have been a significant number of improvements made over the last several years on the meshing capabilities within Simulation Moldflow. Because of this, many of our previous “best practices” are no longer relevant and even have caused issues with preparing and understanding meshing. This presentation will look at those old best practices and breakdown why many are no longer applicable and what is now recommended for the best mesh representation as well as time and hardware efficient.

Key learning objectives

At the end of this class, you will be able to:

- Understand the need for proper mesh representation and configuration
- Discover the ideal use of mesh types, options and mesh configuration
- Discover the influence of improper mesh use
- Learn how to incorporate other tools to improve quality

Agenda

- Model quality influence and tools
- Mesh type determination
- Mesh refinement
- Feature definition
- Material impact
- Solver impact

Model Quality Influence and Tools

Why is Source Model Quality so Important?

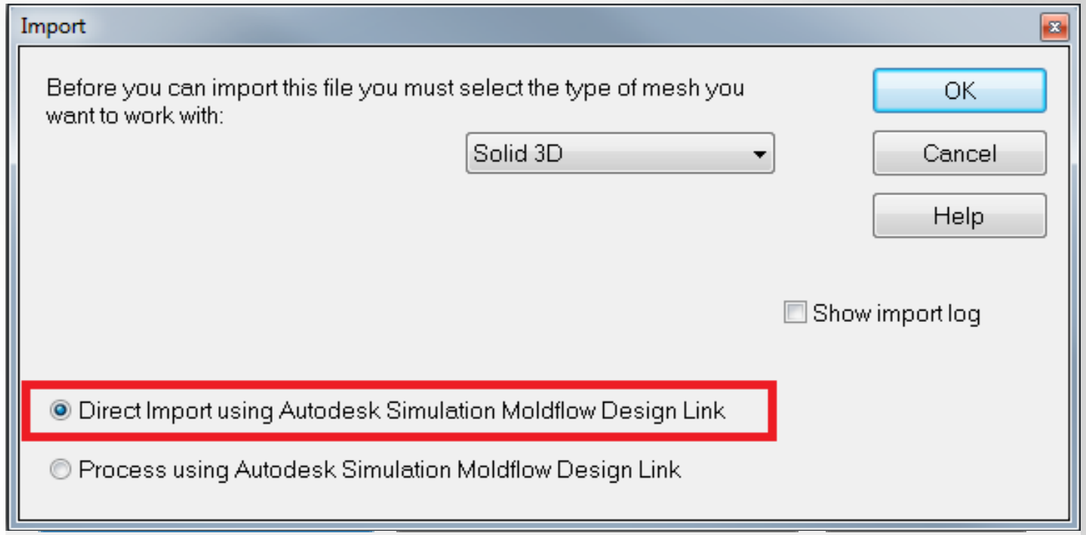
- Geometric representation
- Improved model setup
  - Mesh preparation ease
  - Mesh quality
- Reduced time to analysis
  - Preparation is faster
- Reduced time to analyze
  - Analyses run faster
  - Lower potential for analyses failure
- Need for Moldflow specific mesh
  - External meshes may not be configured to correctly capture plastic behavior
- Most importantly improved accuracy

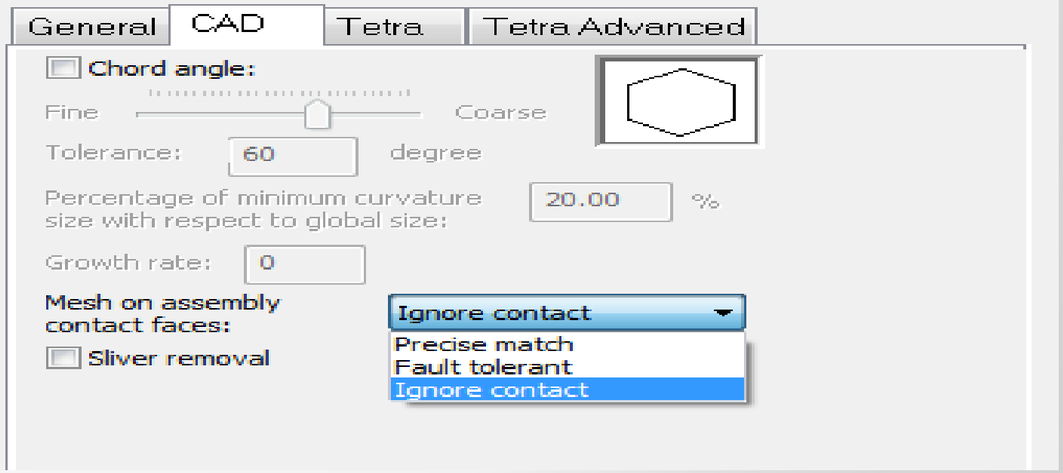
What Tools Are Available: Autodesk

- Moldflow Design Link
  - Now uses Synergy license (essentially free)
  - Full access to most native CAD files
  - Full geometric and topology representation
- CAD Doctor
  - CAD repair and modification tool
    - Address quality issues such as free edges, overlaps, etc.
    - Remove or modify unnecessary features (bosses, rounds, etc.)
- Inventor Fusion
  - Desktop version still provided (no longer being actively developed in that iteration)

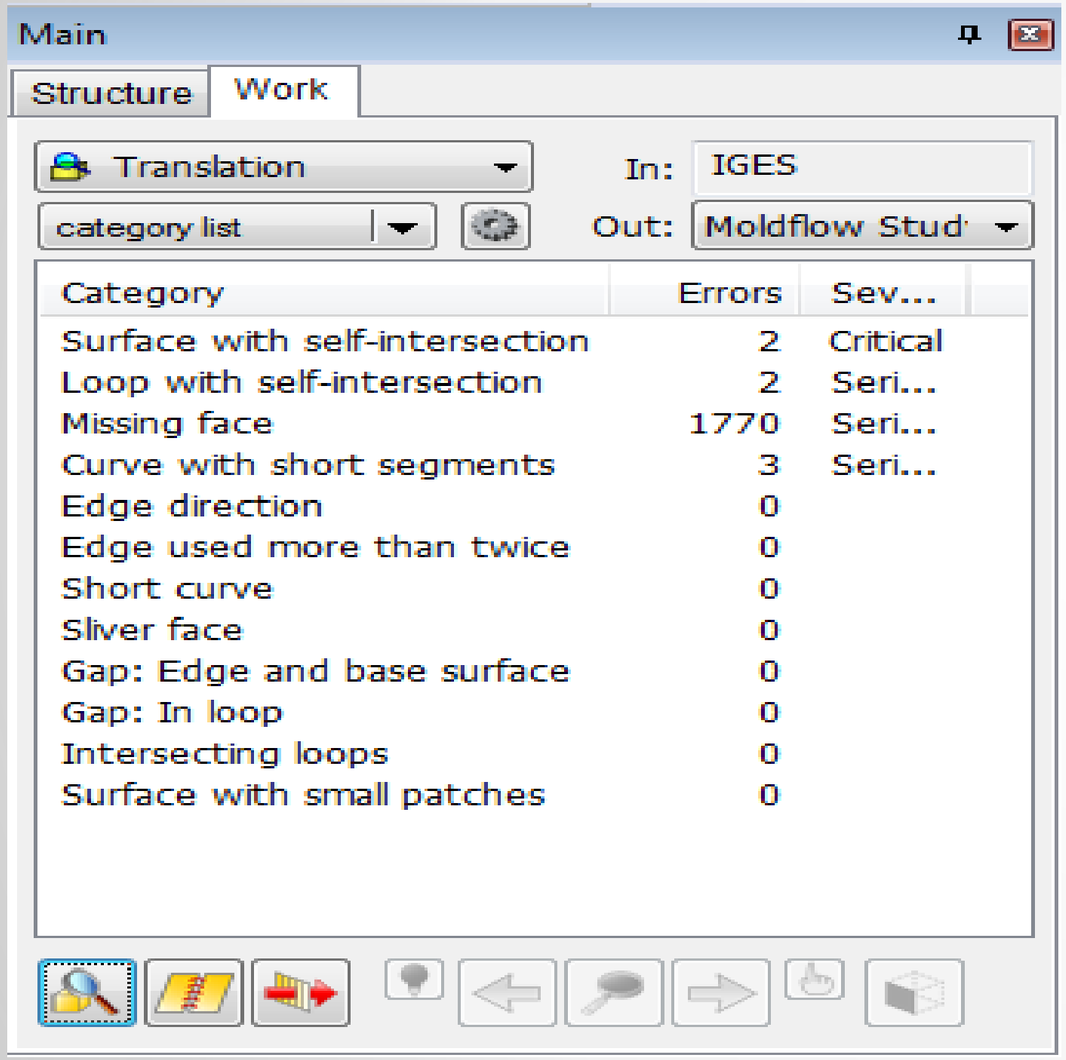
What Tools Are Available: Autodesk Moldflow Design Link

- CAD geometry stored in study
- CAD topology retained
  - Translated to ASM kernel
  - No translation to only NURBS
- Kernel-based meshing
  - Robust meshing capabilities
  - Improved matching
  - Higher geometric fidelity
- Read Only





What Tools Are Available: CAD Doctor

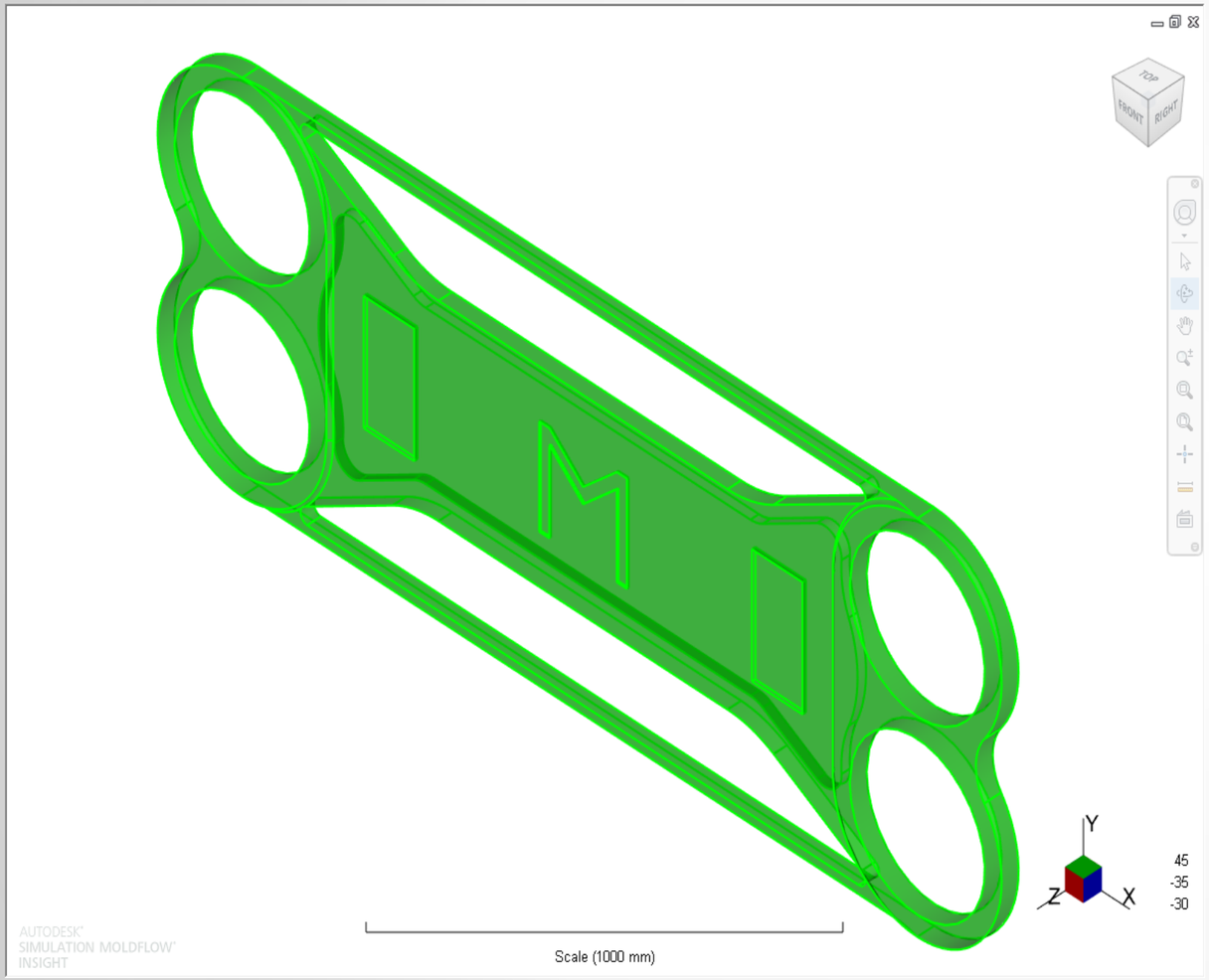


- Identifies issues with CAD geometry
- Fix capabilities
  - Specific
  - Broad (heal)
- Neutral files
  - Inherently have more substantial issues
- Native files can be used as well
- Direct Moldflow study export

What Tools Are Available: External

- Primarily explicit modeling and meshing tools
- Altair Hypermesh
  - Unique in ability to generate *.udm file
    - Bypasses Moldflow mesh flagging to remesh 3D geometries
- BETA CAE Systems S.A. ANSA
- Mesh specific tools often give more control on meshing
  - Can help improve and ensure quality representation
  - Reduce time for preparation due to workflow, ease of use, etc.
- Interoperability varies

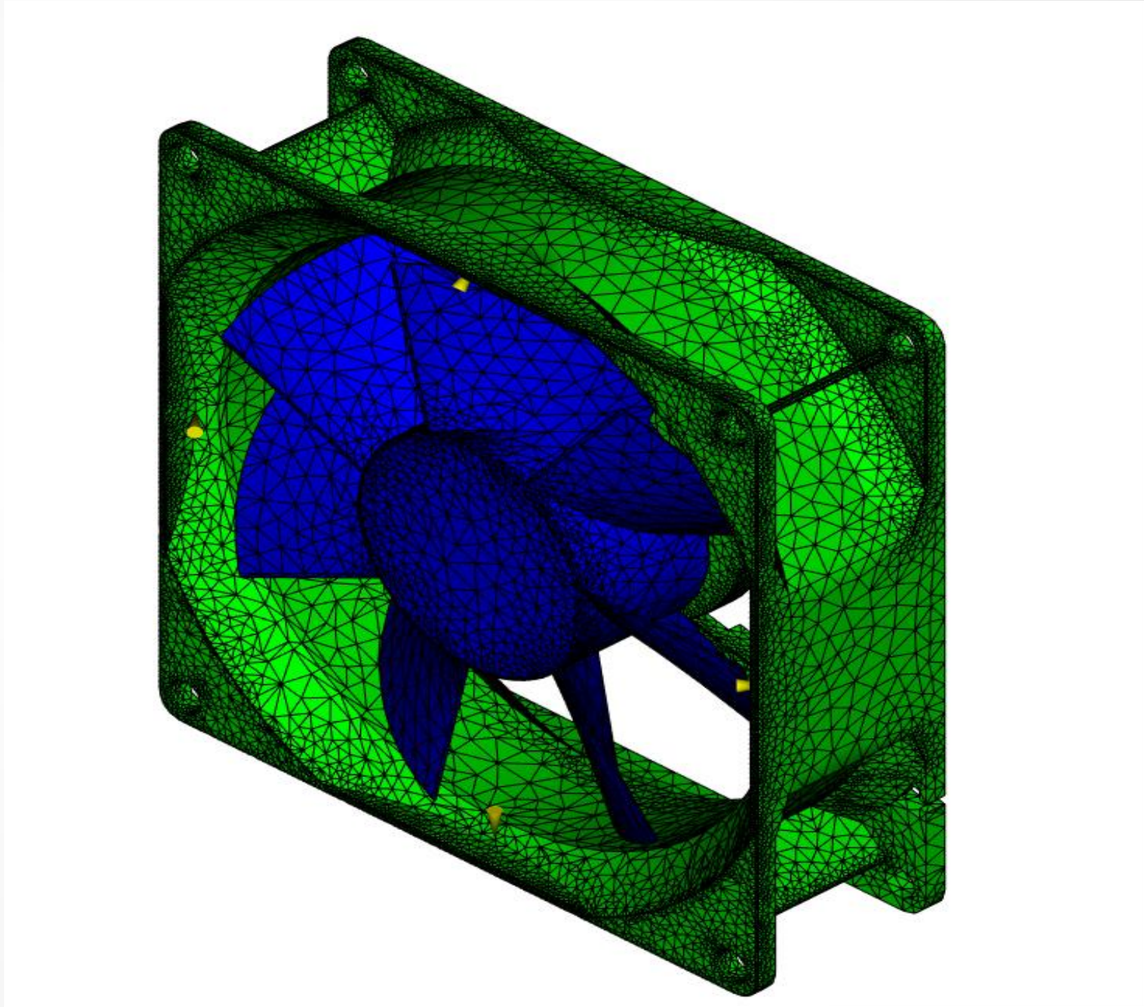
CAD Source Influence: Overview



- Ability to import native representation ideal
  - Maintains correct geometric representation
- Additional model translations
  - Increases potential of problems
    - Incorrect representation
    - Quality degradation

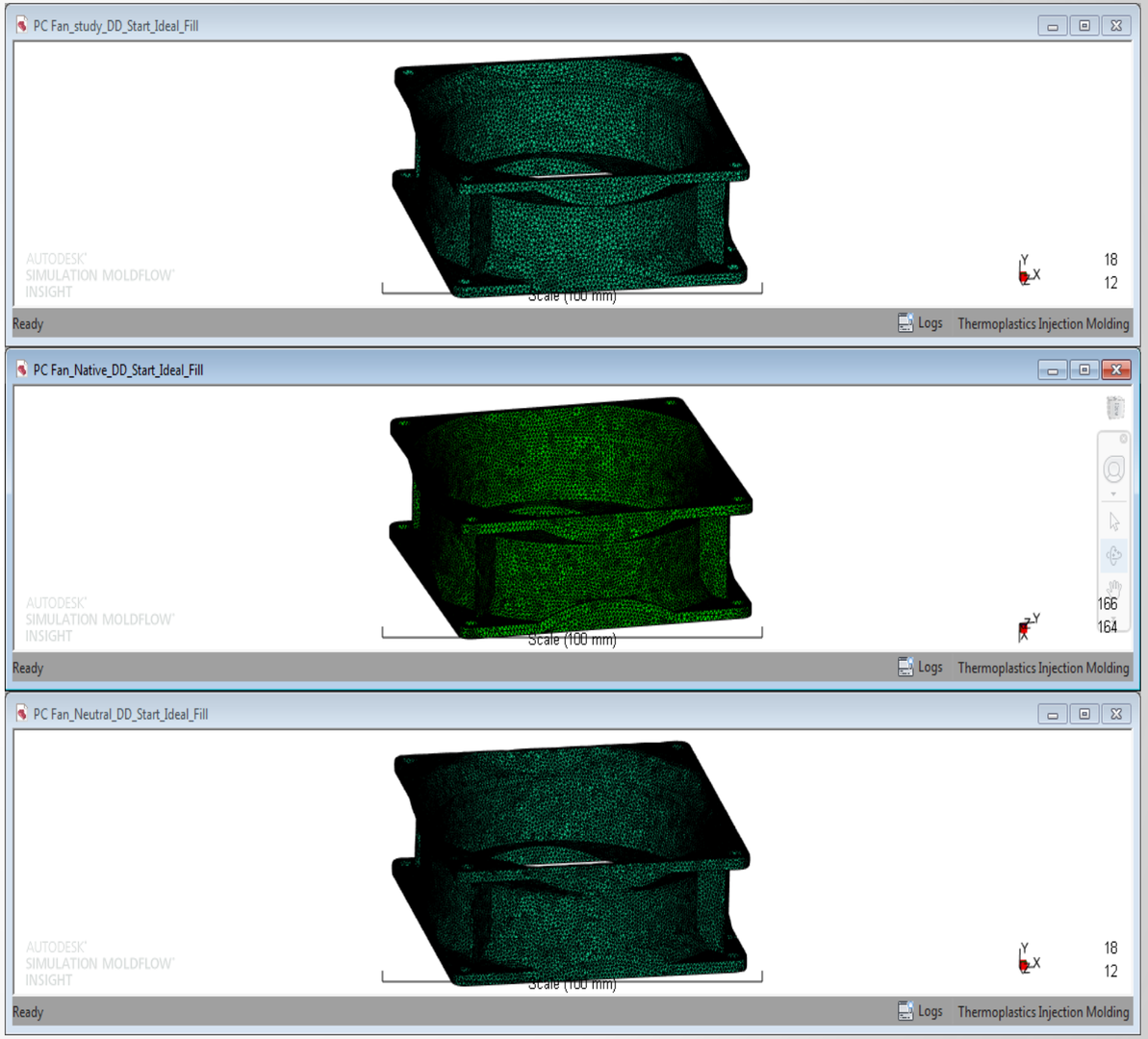
CAD Source Influence: Computer Fan Example

- 3 component assembly
- Highlight source model influence
  - 3 different file representations
- Final parts meshed to 3D
- Compared several areas
  - Time in several areas of interest
  - Quality

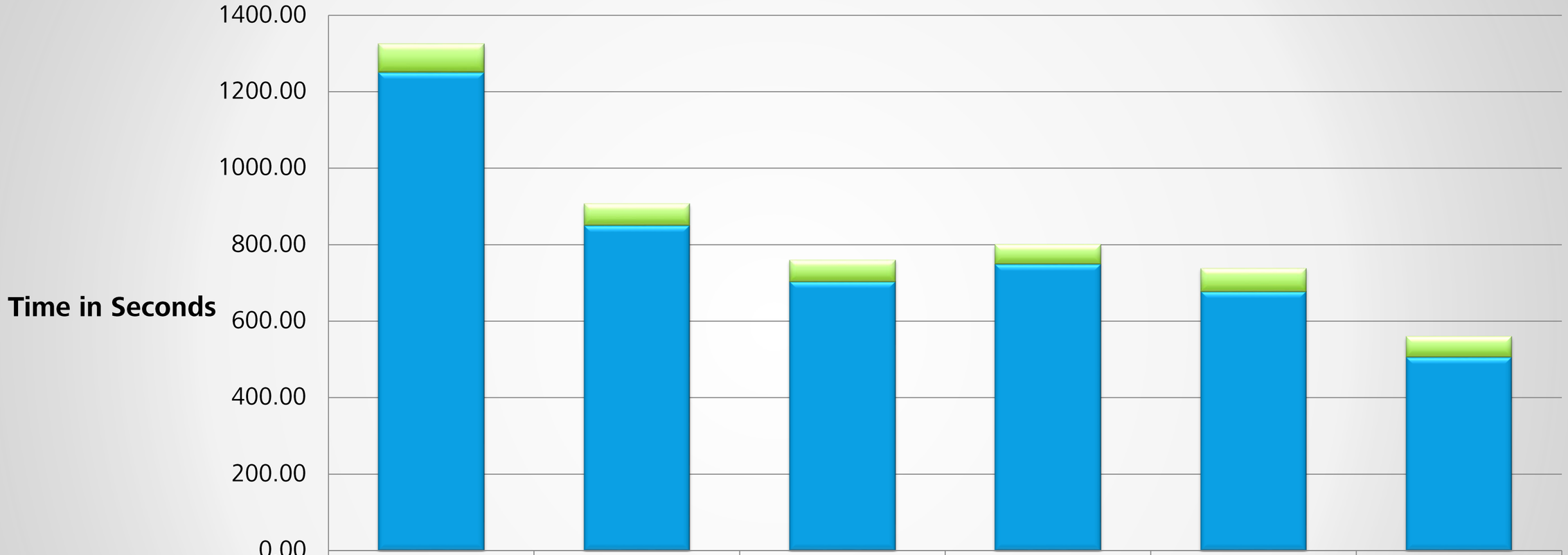


CAD Source Influence: Time to Mesh and Prepare Ideal

- Two primary focuses
  - Time to mesh
    - Pure meshing calculation time
    - From CAD to final 3D
  - Time to prepare ideal mesh
    - Manual fixing of mesh related issues
    - Reviewing mesh statistics
    - Importing model
- Focus on two approaches
  - Meshing to Dual Domain first
    - Then to 3D
  - Meshing directly to 3D

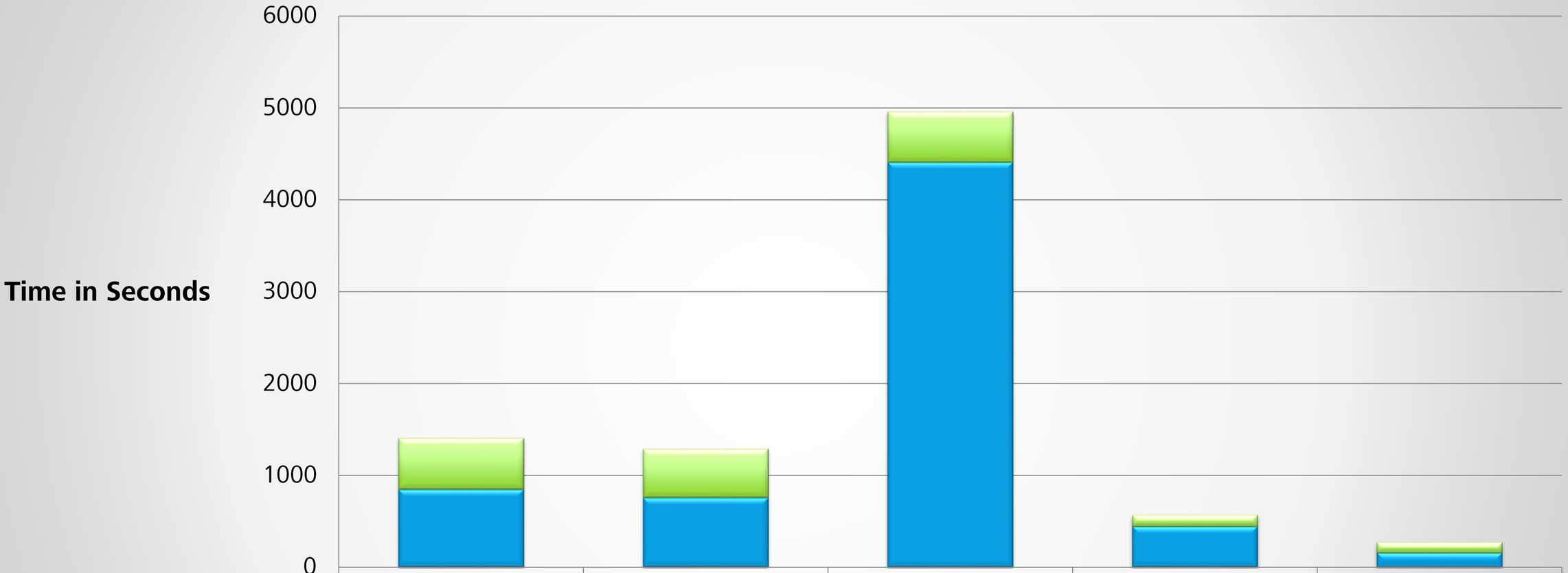


CAD Source Influence: Time to Mesh and Prepare



	DD Start (stl)	3D Start (stl)	DD Start (igs)	3D Start (igs)	DD Start (nat)	3D Start (nat)
Total Mesh Time	74.41	56.20	57.49	51.50	61.06	53.90
Total Ideal Prep Time	1250.28	850.34	702.90	749.22	677.00	505.64

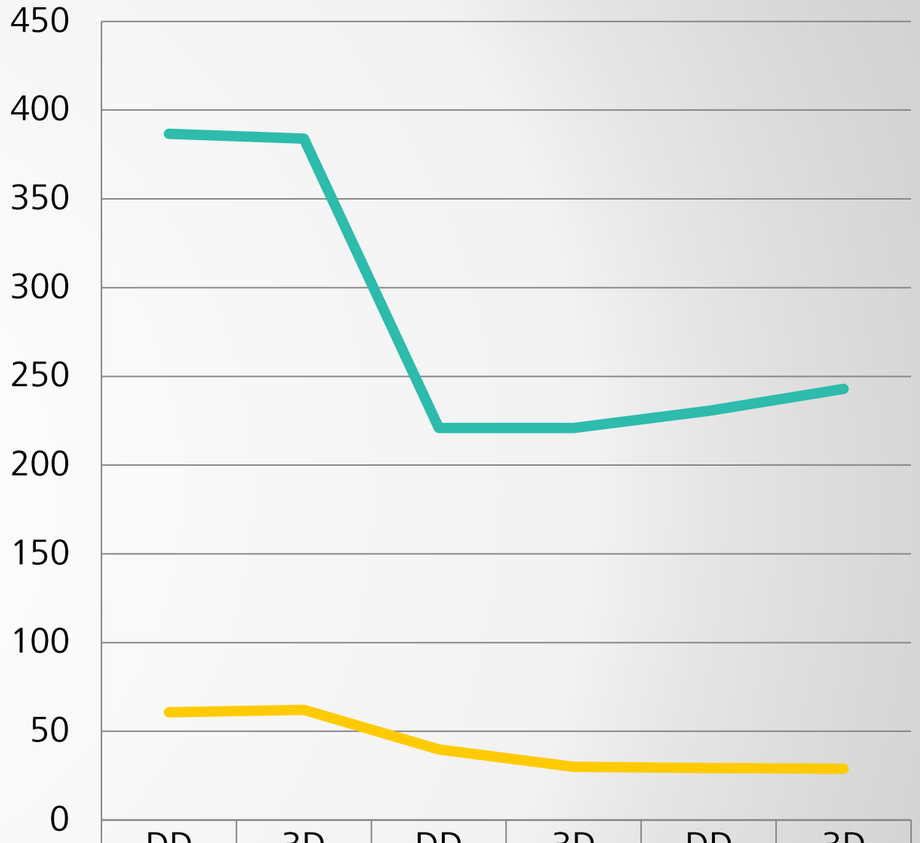
CAD Source Influence: Time to Mesh and Prepare



	DD Start (stl)	3D Start (stl)	DD Start (igs)	DD Start (nat)	3D Start (nat)
Total Mesh Time	558.80	532.22	547.12	126.33	113.98
Total Ideal Prep Time	846.18	754.86	4409.04	442.20	153.54

CAD Source Influence: Mesh Quality

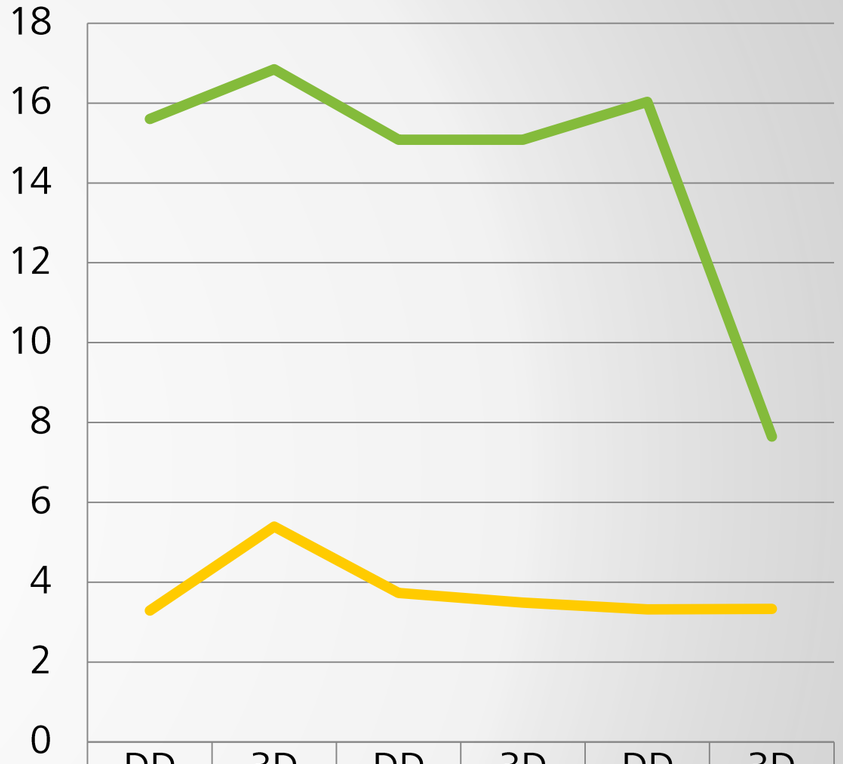
- Time is only one component
- How does this translate to the quality of the mesh
  - Is the time offset worth loss in quality where applicable?
- Original mesh stats
  - Max aspect ratio
- Ideal mesh stats
  - Max aspect ratio



	DD Start (stl)	3D Start (stl)	DD Start (igs)	3D Start (igs)	DD Start (nat)	3D Start (nat)
Ideal Max Aspect	60.75	62.05	39.80	30.04	29.32	28.93
Max Aspect	386.64	383.96	220.96	220.96	230.50	242.96

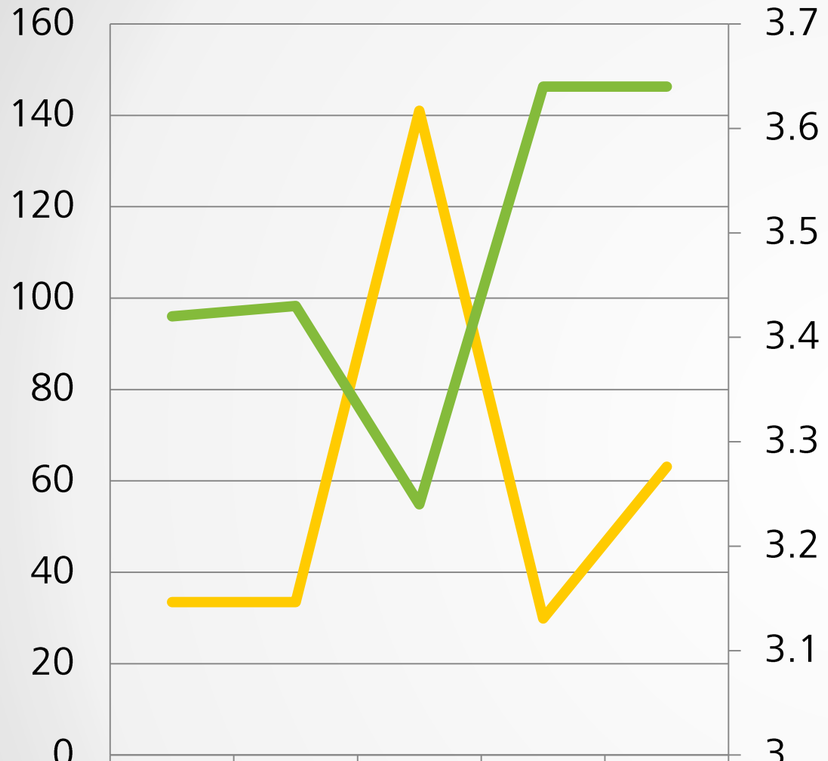
CAD Source Influence: Mesh Quality

- Average aspect ratio
  - More representative of overall quality
    - Possible to have single outlier driving max aspect ratio
  - Captures influence of all elements
- Results show different trend
  - Primary difference only exists between initial and ideal



	DD Start (stl)	3D Start (stl)	DD Start (igs)	3D Start (igs)	DD Start (nat)	3D Start (nat)
Ideal Avg Aspect	3.29	5.39	3.73	3.49	3.32	3.33
Avg Aspect	15.60	16.85	15.08	15.08	16.03	7.65

CAD Source Influence: Mesh Quality



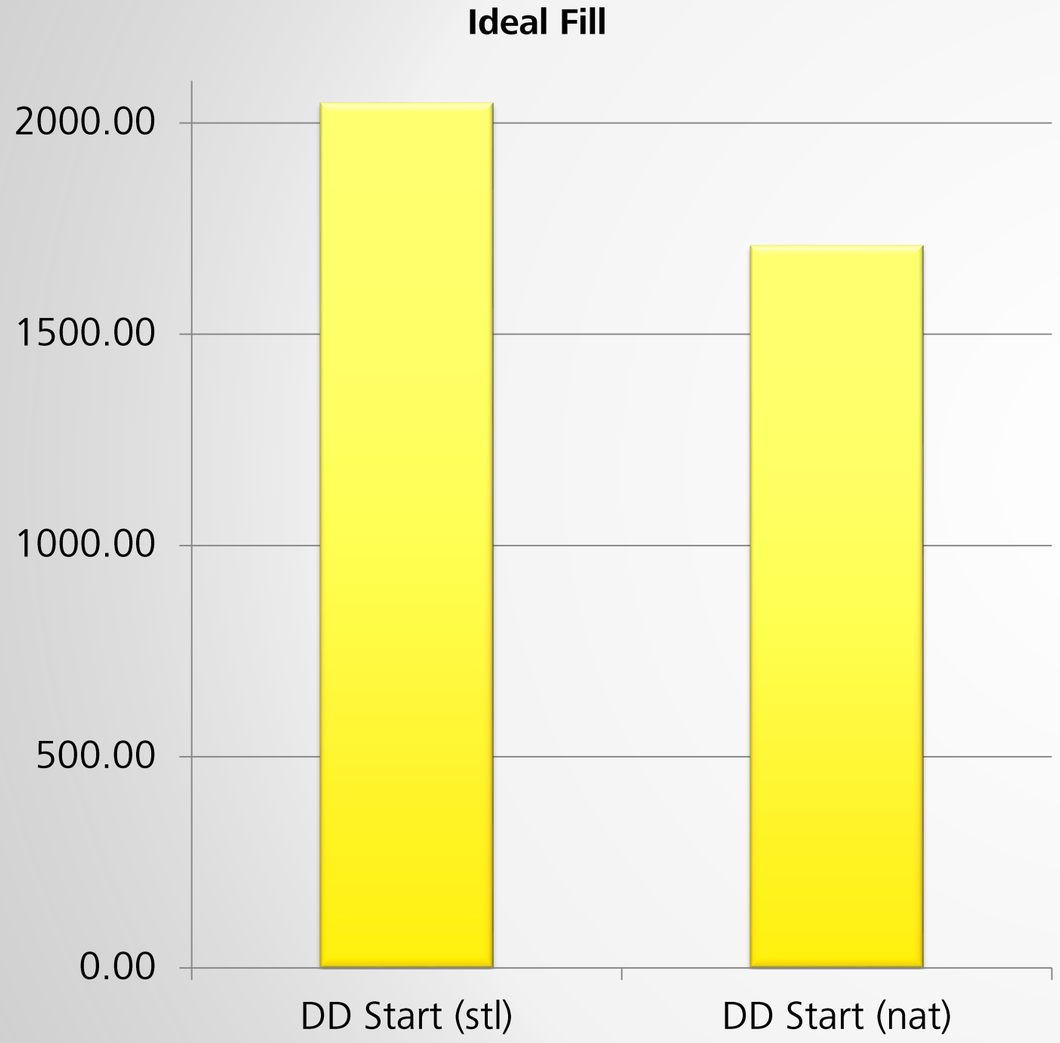
	DD Start (stl)	3D Start (stl)	DD Start (igs)	DD Start (nat)	3D Start (nat)
Ideal Max Aspect	33.48	33.48	141.01	29.89	63.09
Ideal Avg Aspect	3.42	3.43	3.24	3.64	3.64

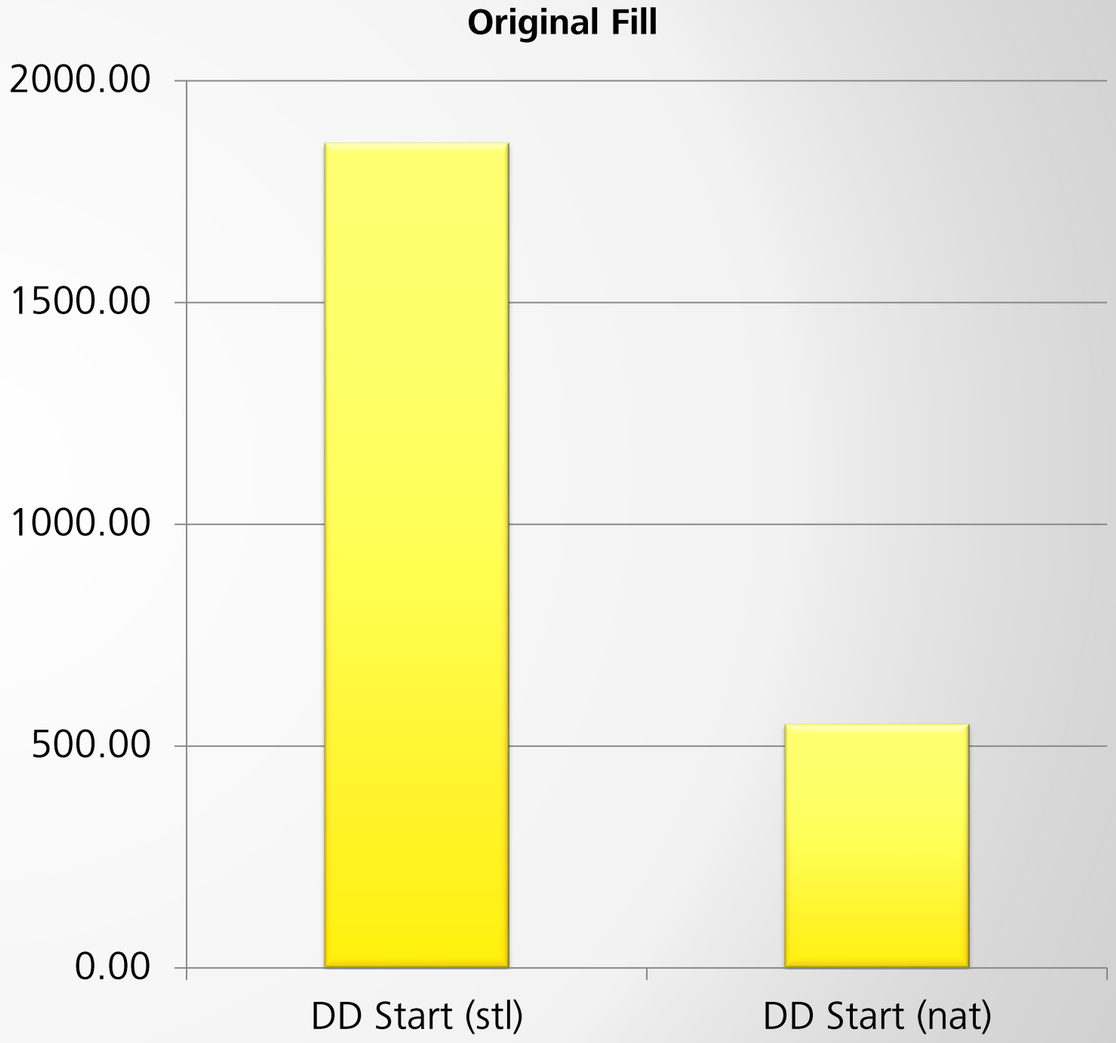
- More complex lampshade
- Comparison of ideal mesh only
- Max aspect spikes for IGS
  - Consistent otherwise
    - Dual Domain start for native best
- Average plotted on right Y-axis
  - Fairly consistent
  - 3.24-3.64 range

CAD Source Influence: Time to Analyze

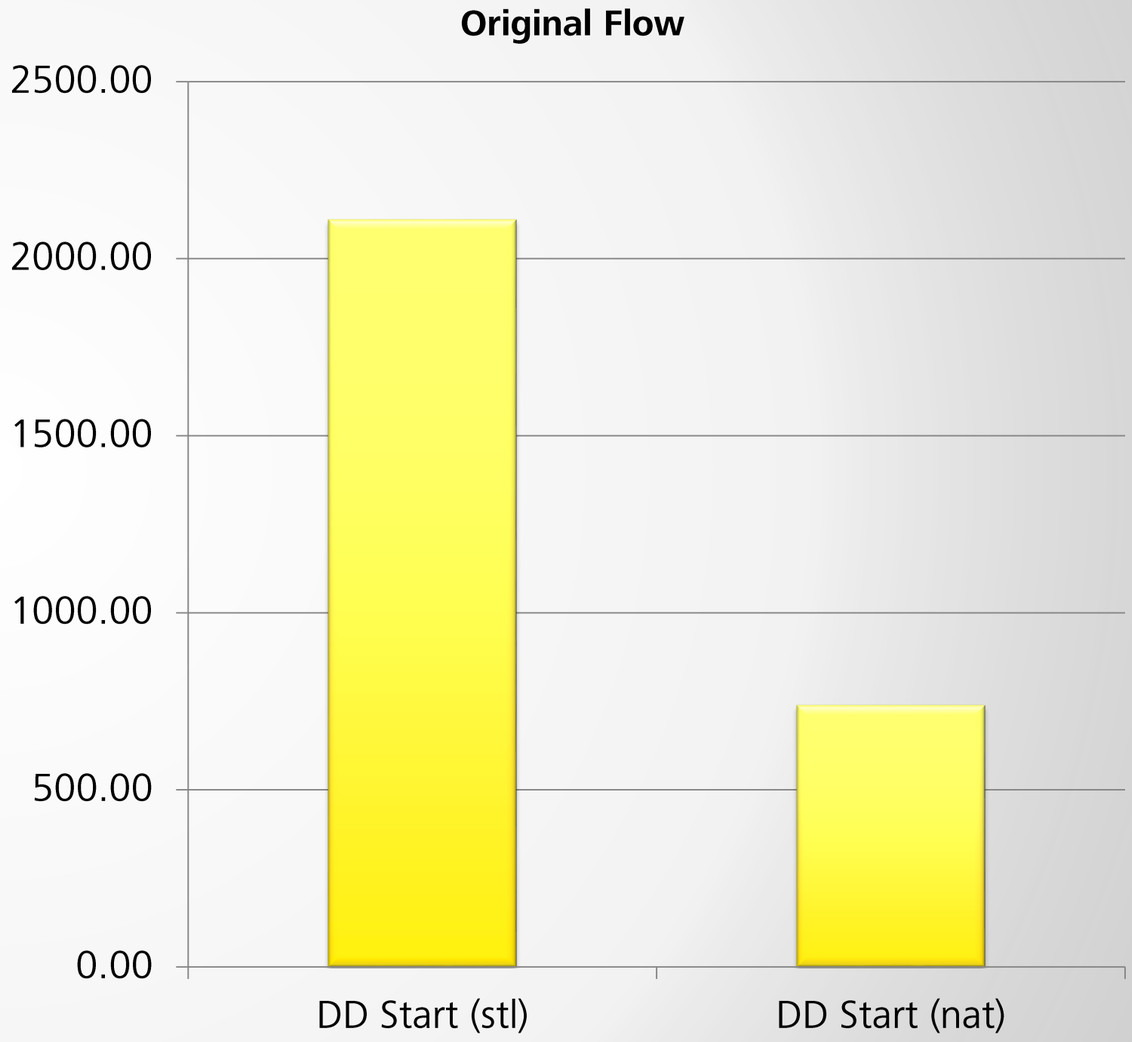
- How does mesh translate to analysis time
  - Relative to influence on overall quality
  - Fewer mesh related issues
    - Improved accuracy
    - Fewer failures due to mesh issues
- Compared DD to 3D CPU models
  - Better overall mesh quality
  - Excluded direct to 3D
  - Excluded IGS (similar to native for this part as determined earlier)

CAD Source Influence: Time to Analyze

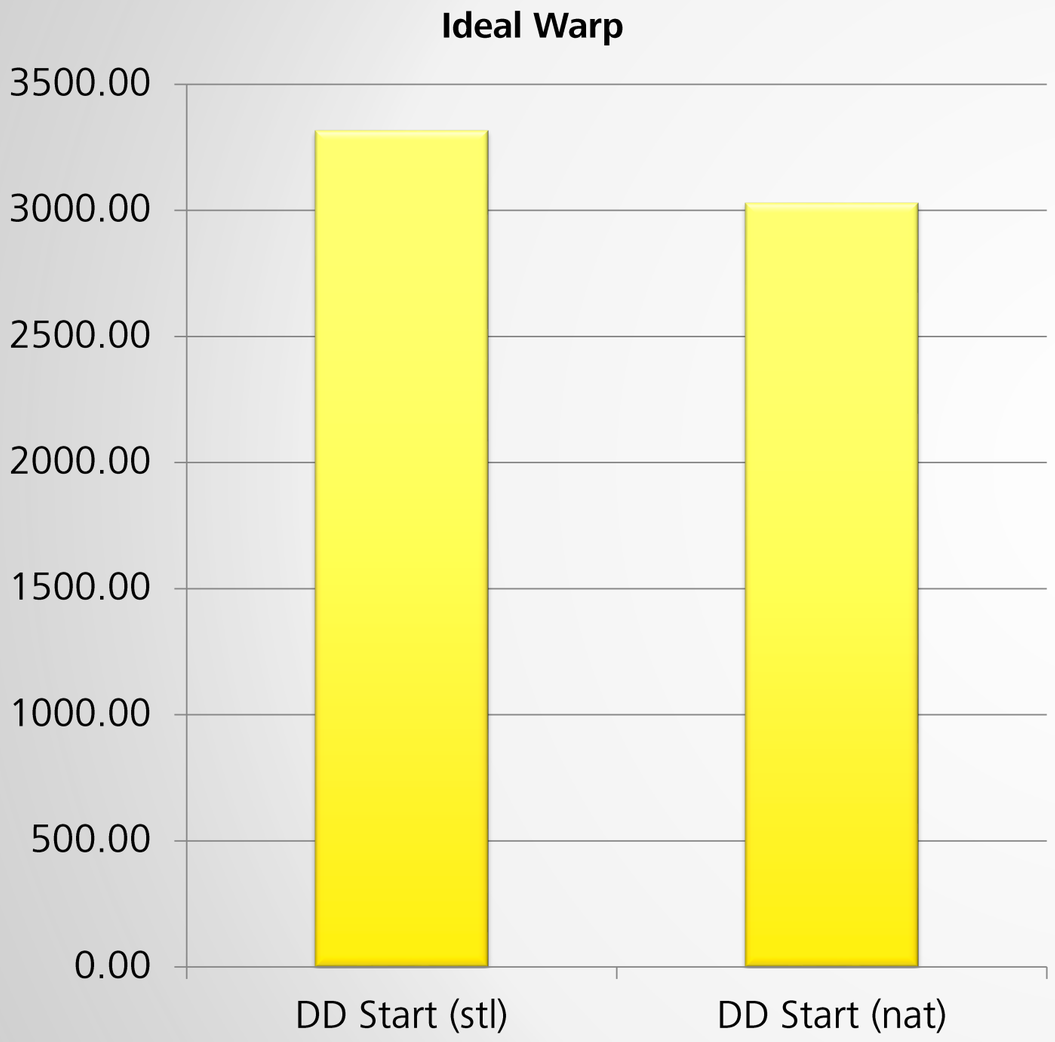


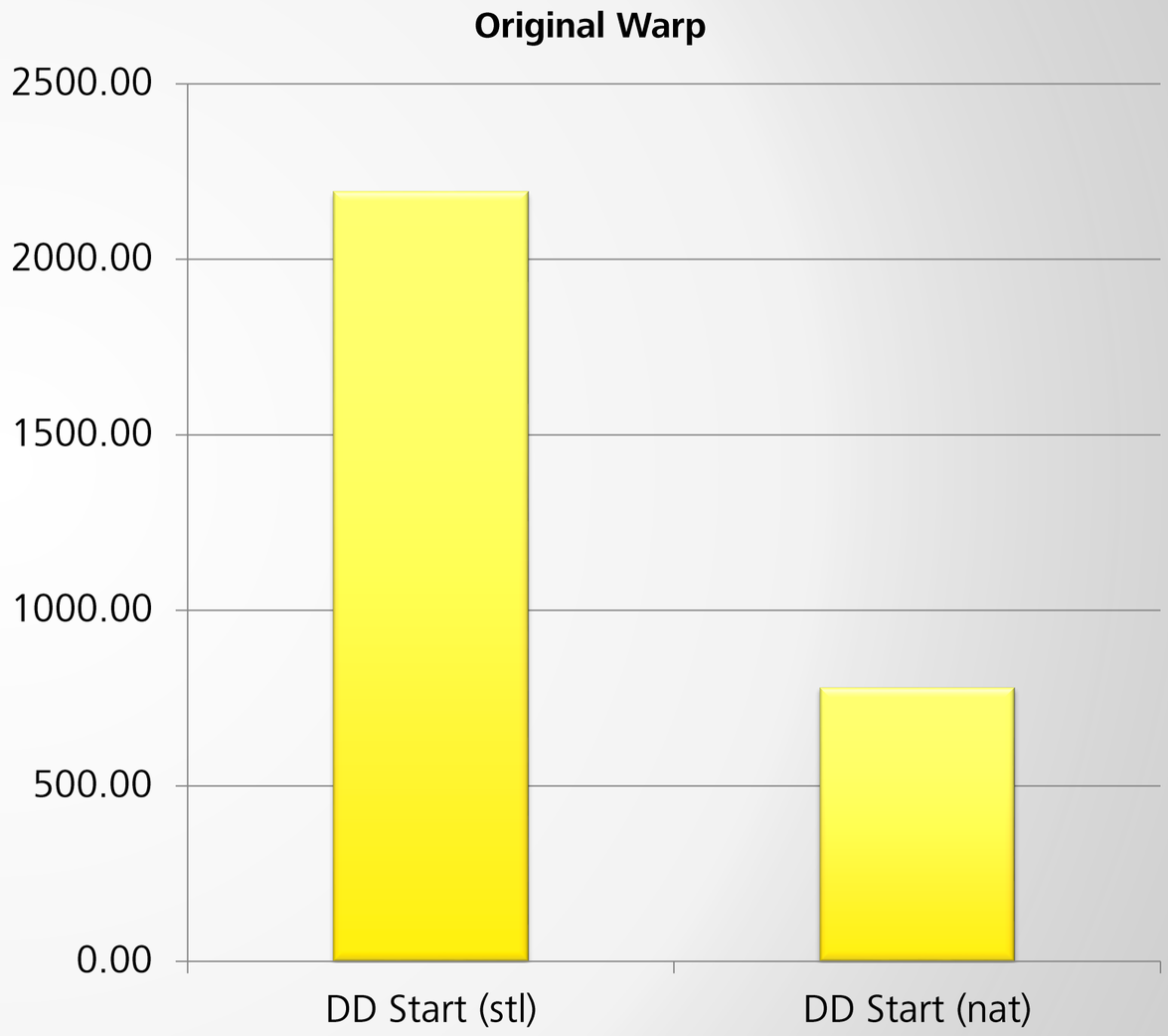


CAD Source Influence: Time to Analyze



CAD Source Influence: Time to Analyze



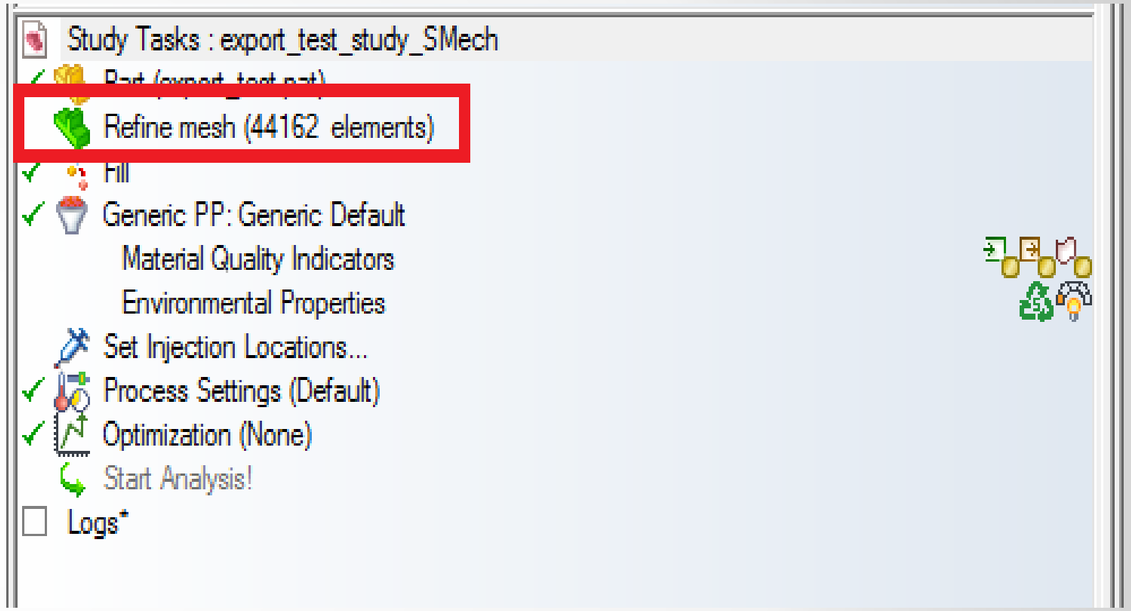


CAD Source: Non-Moldflow Mesh

- Moldflow requires a triangle or tetrahedral mesh
- Many external programs can generate such a mesh
  - Noted earlier in this section
- Often concerns arise regarding usability of Moldflow mesher
  - Not as many options and tools to generate a mesh
  - Visual appeal is another concern (Not as tight and trimmed as a structural mesh)
- Moldflow mesh is generated specifically with simulating plastic behavior
  - External mesh often have differing needs and requirements

CAD Source: Non-Moldflow Mesh

- Moldflow flags external 3D tetrahedral meshes
  - Signifying compatibility
  - Only *.sdy and *.udm files bypass this flag
- Requires mesh refinement
  - Modifies internal mesh to become Moldflow valid
- Ensures proper representation for Moldflow solver behavior



Summary

- CAD model source is extremely important
  - Directly influences
    - Mesh quality
    - Time to mesh and setup
    - Time to analyze
- Tools are available to assist this process
  - Autodesk tools and external tools
- Many external tools still require a remesh of 3D tets
  - To ensure proper Moldflow recognition required for accurate simulation

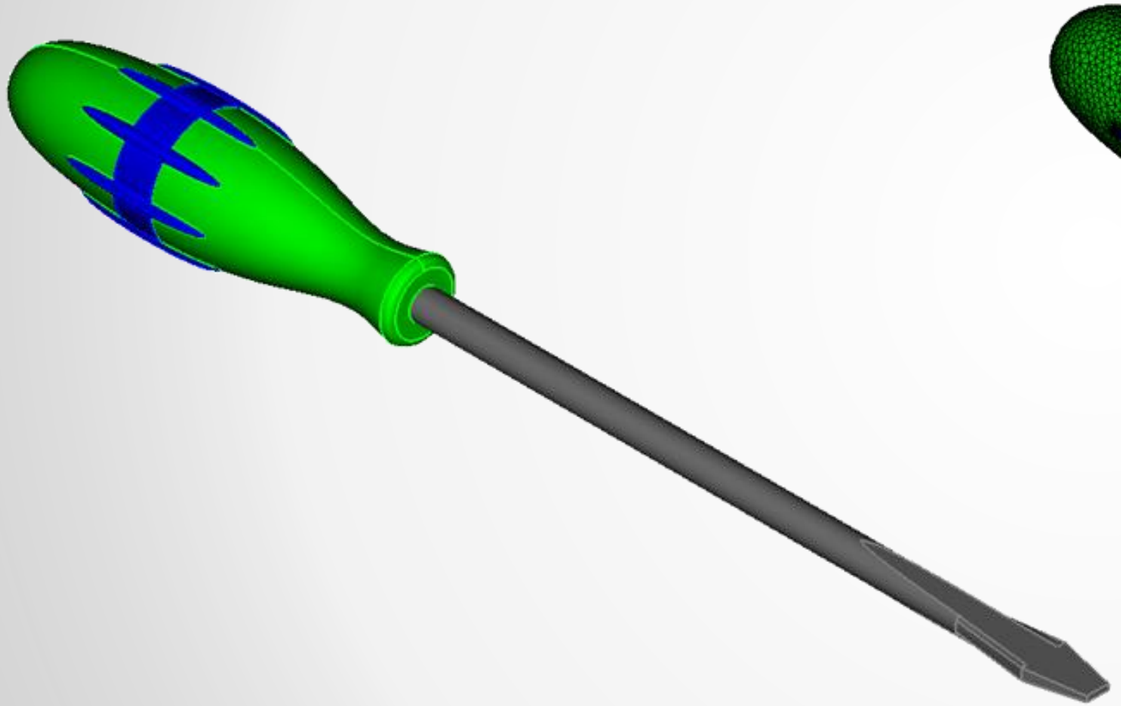
Misconceptions Purged: Model Quality and Tools

- Dual Domain is required first before meshing to 3D
  - Not required but recommended and highly beneficial
  - Primary advantage is easier access to addressing troubleshooting
  - With native CAD less beneficial as fewer model related issues exist
- Original CAD geometry source doesn't influence prep time
  - Reduces time to mesh
  - Reduced time to fix/improve mesh
- Original CAD geometry source doesn't influence analysis time
  - Models often have improved quality and fewer elements
    - Run faster
  - Fewer mesh related warnings and errors
- Structural meshes are ideal for use in Moldflow
  - Often remeshed due to flagging as unacceptable
  - Introduce potential for accuracy issues if bypassed via *.udm format

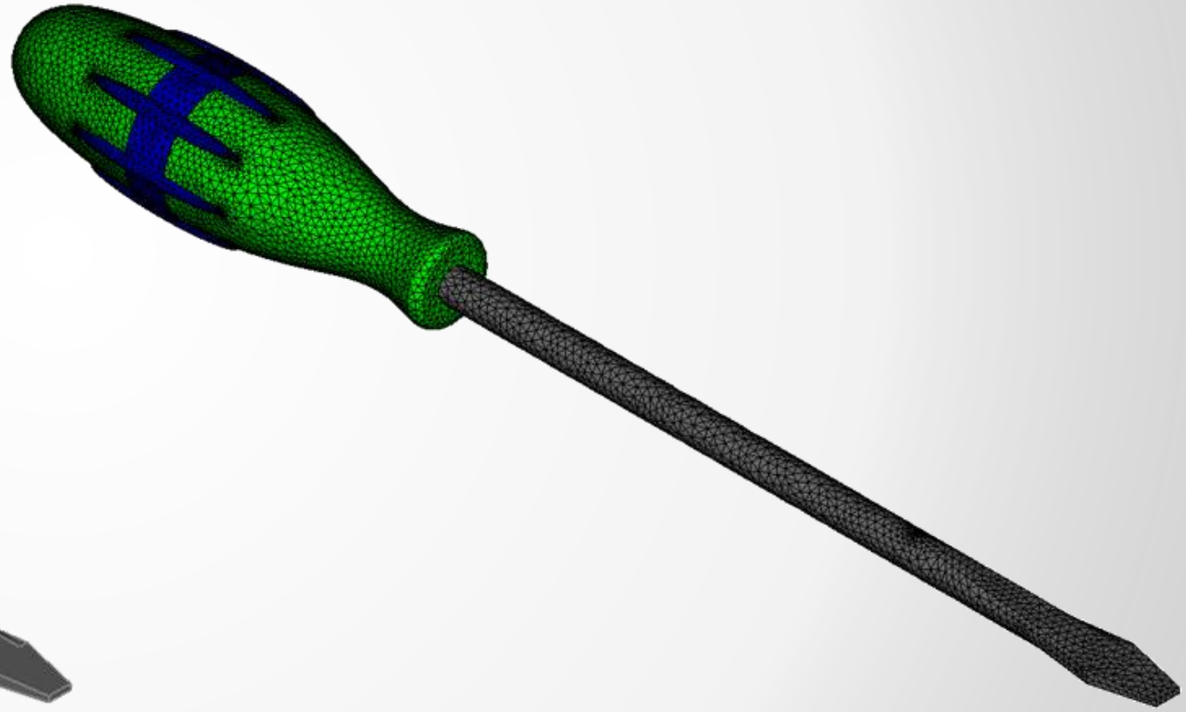
Mesh Type Determination

What is mesh?

- Mesh defines the model for the analysis



CAD Model

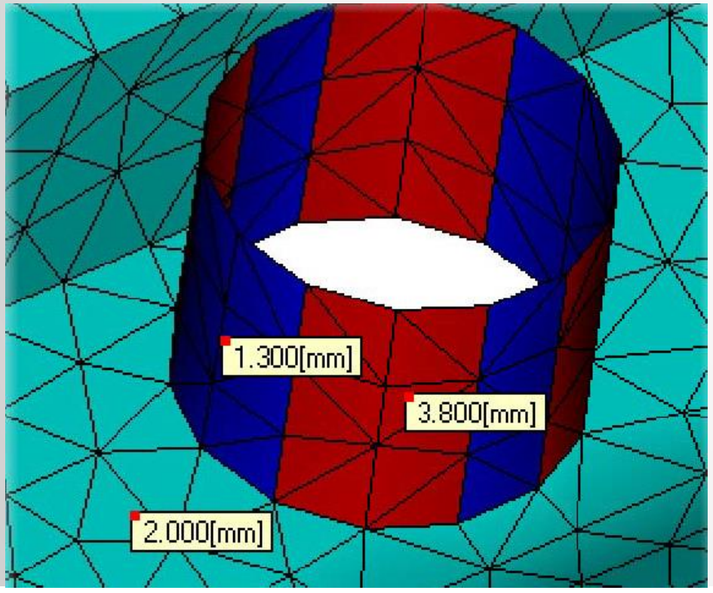


Meshed Model

Mesh Type Differences

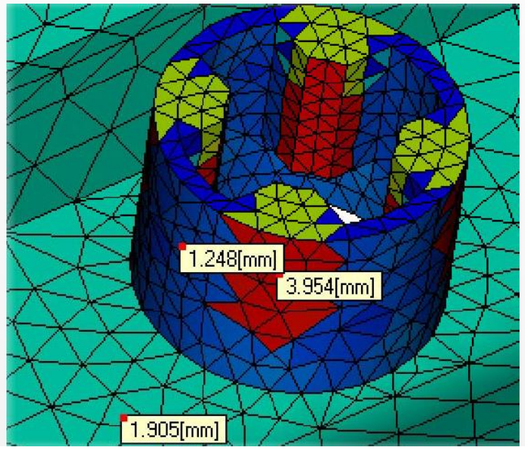
Midplane

- 2D representation
  - Centerline of geometry
- Assign thickness



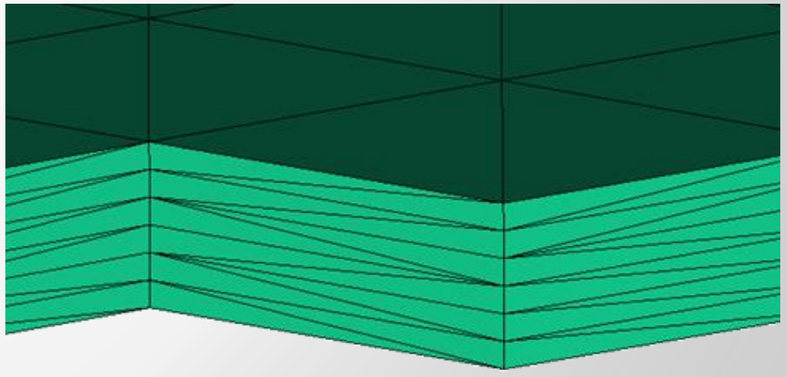
Dual Domain

- Shell-like geometry
  - Default 12 laminates
- Thickness assigned automatically
  - Can assign manually
- Thin wall applications



3D

- No thickness assigned
  - True volume-filling mesh
- Assign layers through thickness
- Thick, chunky geometries



Ideal Mesh Uses

Midplane

- Thin geometries
  - Center-line
- Global edge length
  - Several times nominal wall thickness
  - Ensure at least 3 elements to define features
- Aspect Ratio
  - 20:1

Dual Domain

- Thin wall applications
  - 4:1
- Global edge length
  - 2 times nominal wall thickness maximum
  - Ensure at least 2 elements to define thickness
  - Ensure at least 3 elements to define features
- Aspect Ratio
  - 20:1

3D

- Thick, complex geometries
- Assign layers through thickness
  - 6 layers minimum
  - 8 layers fiber filled
  - 10 layers gas-injection
  - Increased layers for temperature/shear sensitive
- Global Edge length
  - 2 times nominal wall thickness maximum
  - Ensure 2 at least elements to define thickness
  - Ensure 3 at least elements to define features
- Aspect ratio
  - 100:1
  - 30:1 Dual Domain ➔ 3D

Concerns of Mesh Types

Midplane

- Predominately curved geometry
- Element orientation
  - Consistency can be difficult to achieve

Dual Domain

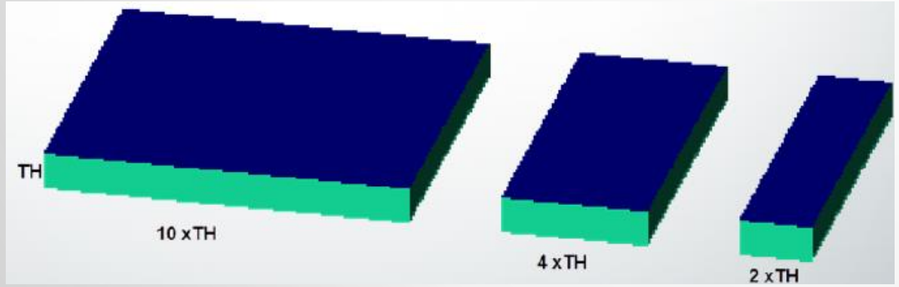
- Lettering/logos
- Rounded features
  - Mesh match
- Thick, chunky parts
  - Mesh match
  - Heat transfer

3D

- Surface refinement for thin walled parts
  - Ensuring appropriate
- Watertight surface mesh

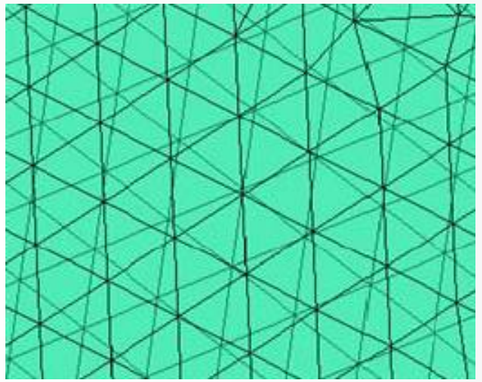
Concerns with Thick Chunky Parts

- Heat transfer
  - Less than 4:1 width:thickness ration
    - Greater than10:1 is preferred
  - Heat transfer is only done on blue faces
    - 2:1 ratio – thickness is 33% of perimeter
    - 4:1 ratio – thickness is 20% of perimeter
    - 10:1 ratio – thickness is 9% of

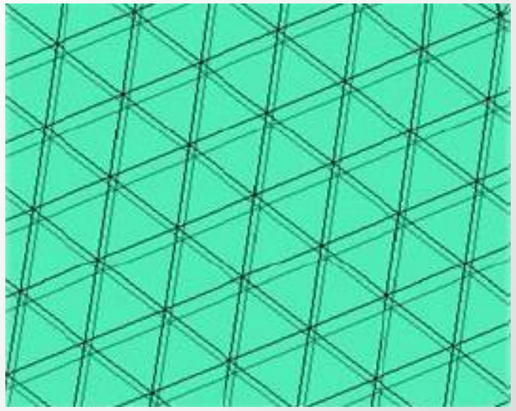


- Mesh match

Unsuitable



Suitable

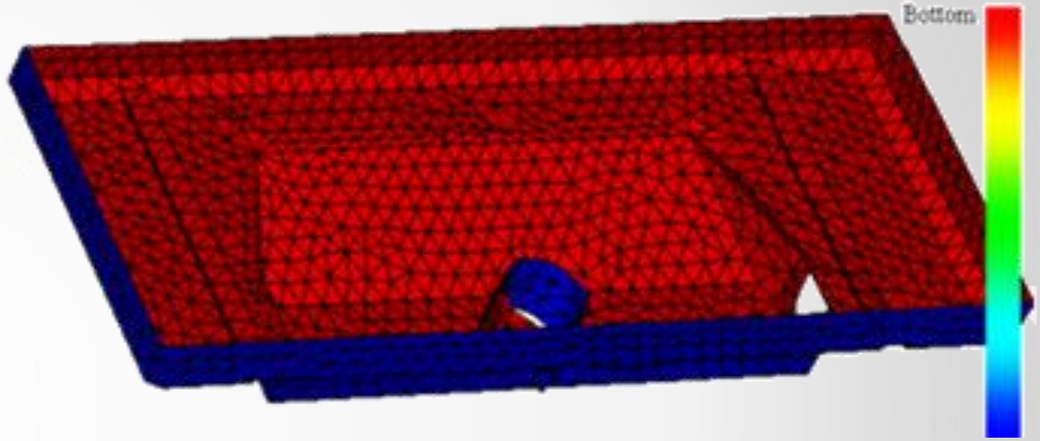


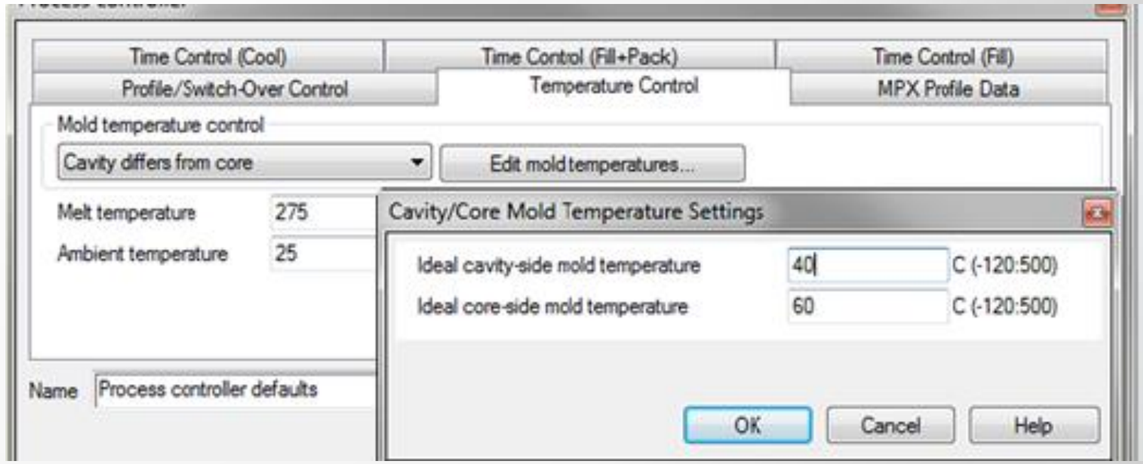
Concerns with Thin-Walled Parts

- Proper thickness representation in 3D
  - May require increase surface refinement
  - Computationally inefficient compared to Midplane and Dual Domain
- Large thin-walled parts
  - May not be usable in 3D due to overall element count

Concerns with Orientation

- Orientation
  - Convention:
    - Top = positive = cavity side
    - Bottom = negative = core side
  - Midplane/Dual Domain
    - Must be correctly orientated for cooling, warpage, and stress analysis
    - Midplane must be correctly orientated if top/bottom is different temperature

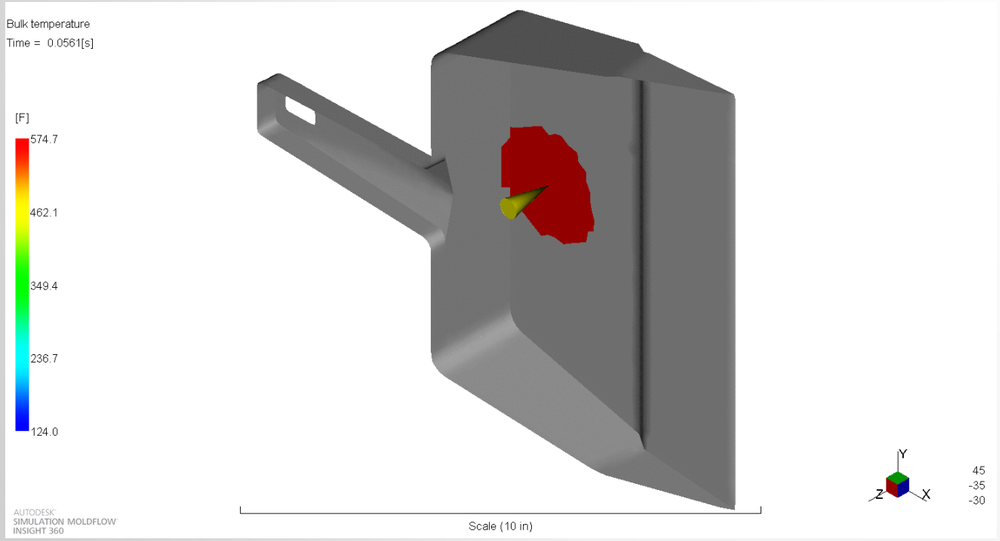




Result Differences – Fill and Pack Analysis

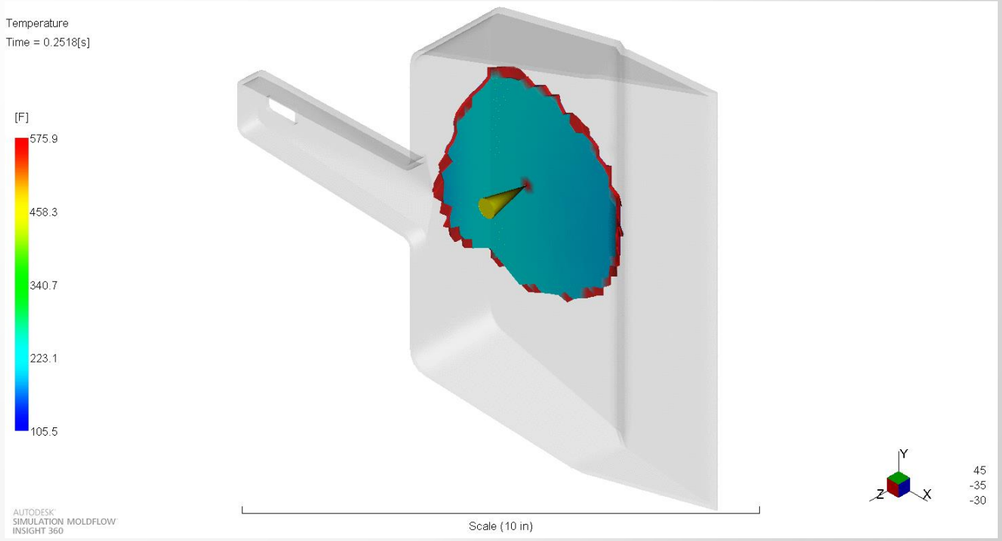
Midplane & Dual Domain

- Bulk Temperature
  - Indicates the average temperature across the thickness
  - Intermediate result
    - Animation is through time & scale is through entire range of results



3D

- Temperature
  - Plastic temperature over a specified time



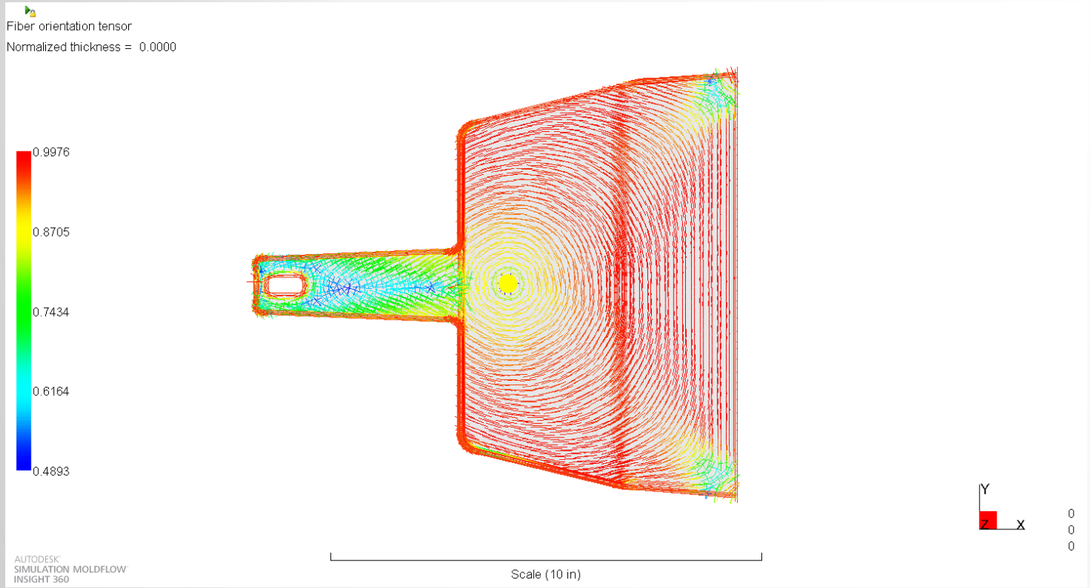
Result Differences – Fiber Analysis

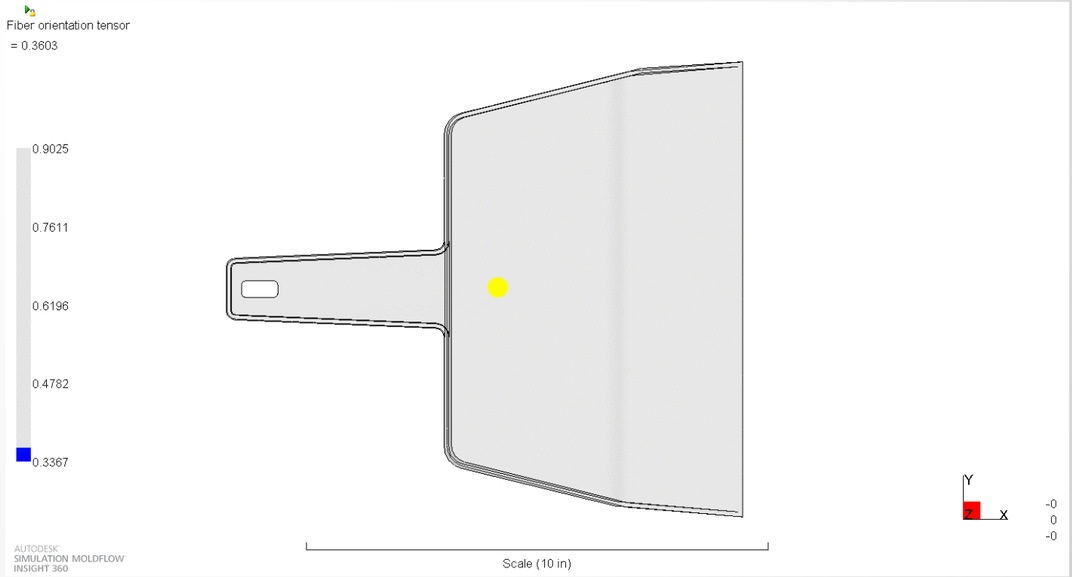
Midplane & Dual Domain

- Fiber Orientation Tensor
  - Calculated at each time-step throughout the Fiber orientation analysis

3D

- Fiber orientation tensor
  - Nodal and elemental result





Result Differences - Example

Midplane

- Temperature, mold, (top)
- Temperature, mold (bottom)
- Temperature, part (top)
- Temperature, part (bottom)
- Temperature profile, part
- Frozen layer percentage, part
- Average temperature, part
- Temperature difference, part
- Flux, part (top)
- Flux, part (bottom)

Dual Domain

- Temperature, mold
- Temperature, part
- Temperature, profile, part
- Frozen layer percentage, part (top)
- Average temperature, part
- Temperature, max, part

3D

- Temperature, mold
- Temperature, part
- Percentage frozen layer
- Percentage molten layer

Results and Analysis Availability

Midplane & Dual Domain

- In-cavity residual stress in first principal
  - Shows stresses before ejections in orientation direction
- In-cavity residual stress in second principal
  - Stresses before ejection, perpendicular to first principal

3D

- No residual stress

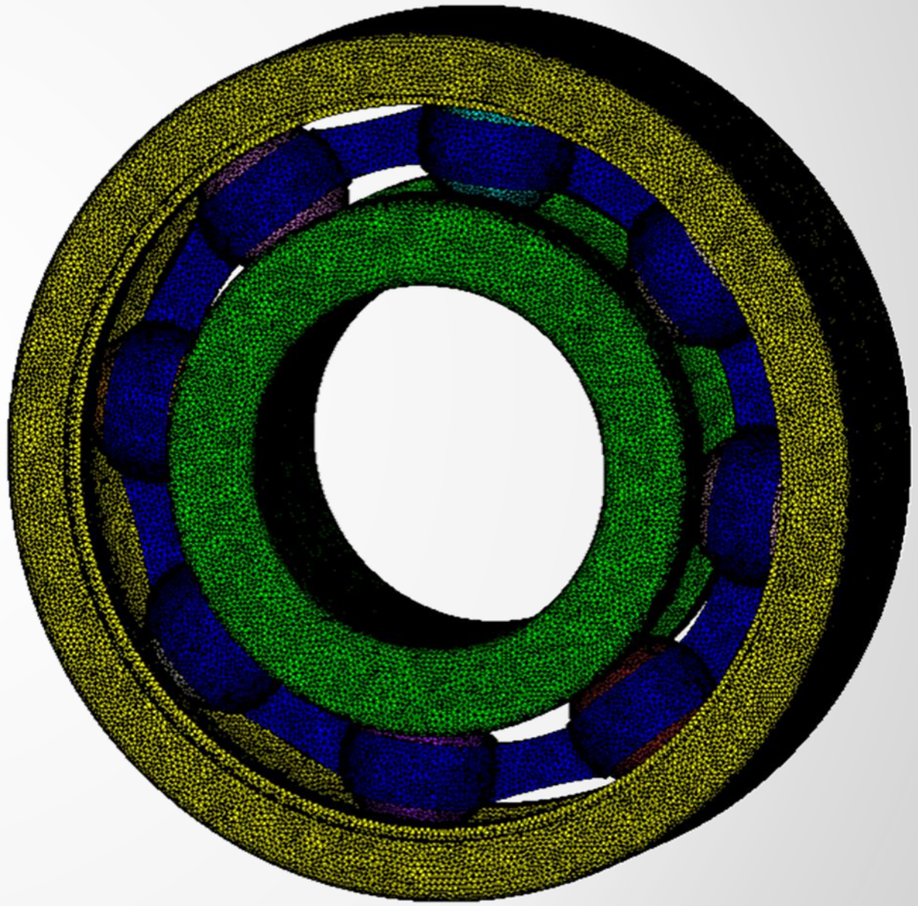
Misconceptions Purged: Mesh Type Determination

- Any mesh type is ideal for a given geometry
  - Each mesh type is often suitable for most geometry, but far from ideal
    - Midplane/Dual Domain are ideal for thin-walled parts
      - Ease of representation
      - Analysis computational efficiency
    - 3D is ideal for thicker, more complex part geometry
      - More accurate thermal and flow behavior
- Mesh type does not effect results
  - End results influenced by mesh type used
    - Display
    - Availability

Mesh Refinement

The Importance of Mesh Refinement

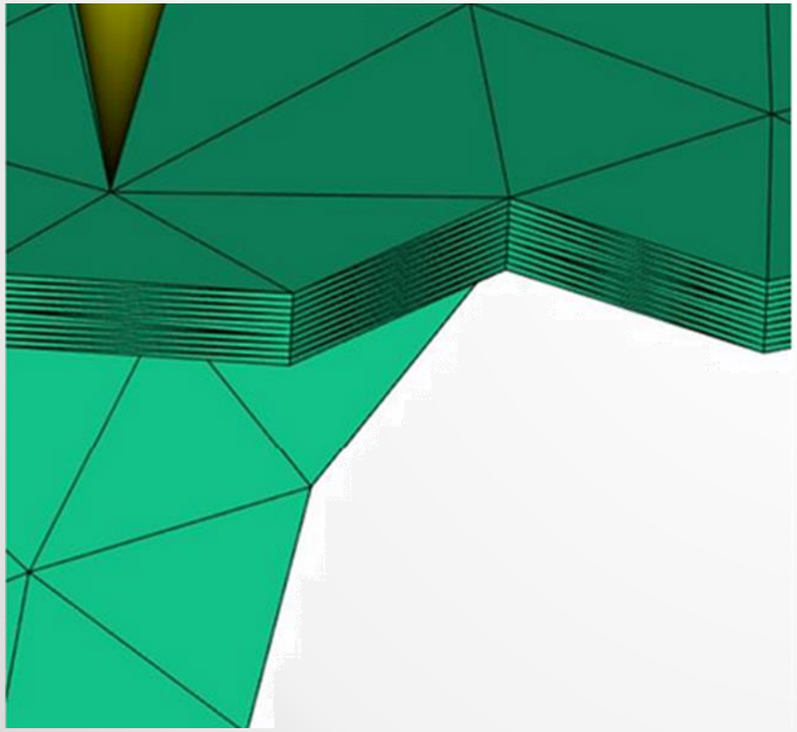
- Flow front predictions
- Fill imbalances
- Pressure
- Results
  - Airtraps
  - Hesitation
  - Racetacking
  - Weldline



Proper Mesh Refinement: Global Edge Length

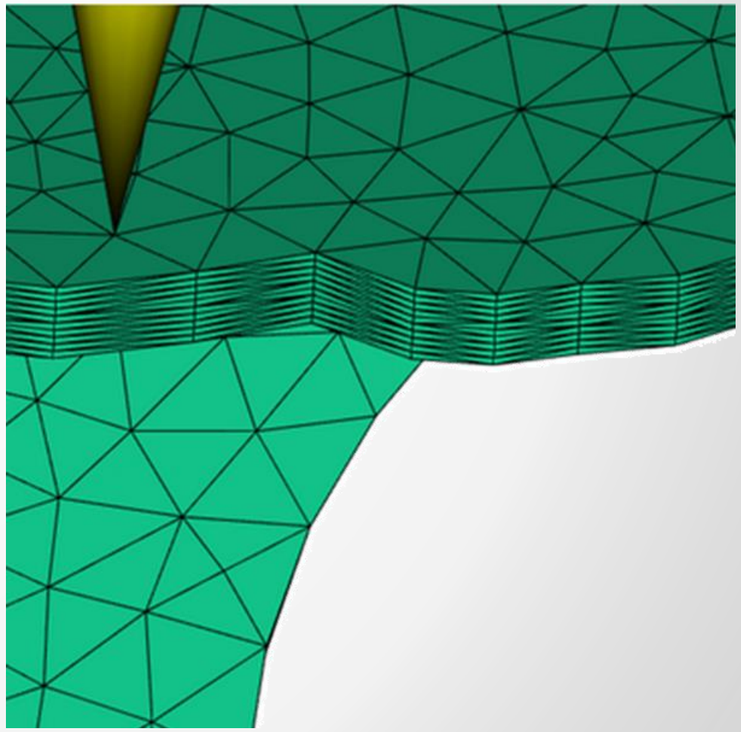
Functional

- Coarse mesh
- Increased layers



Preferred

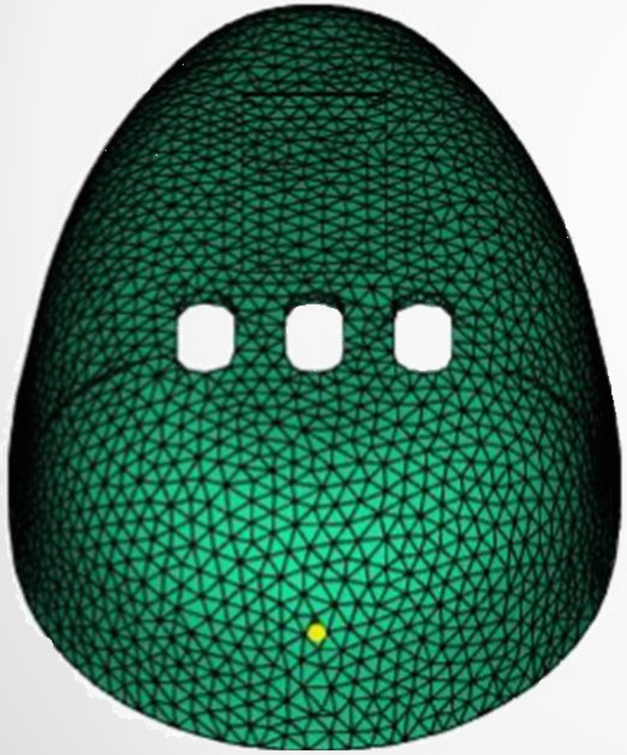
- Refined mesh
- Increased layers



Proper Mesh Refinement: Gate Refinement

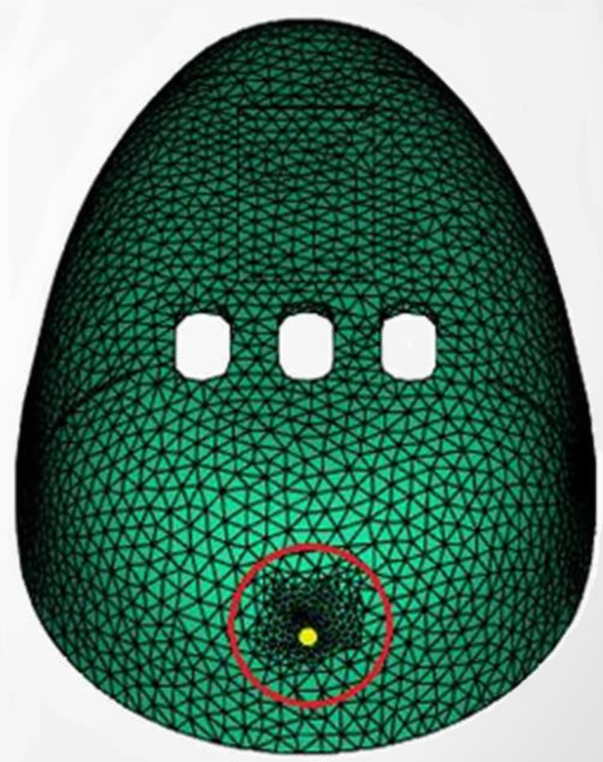
Functional

- Direct injection cone
- No gate refinement



Preferred

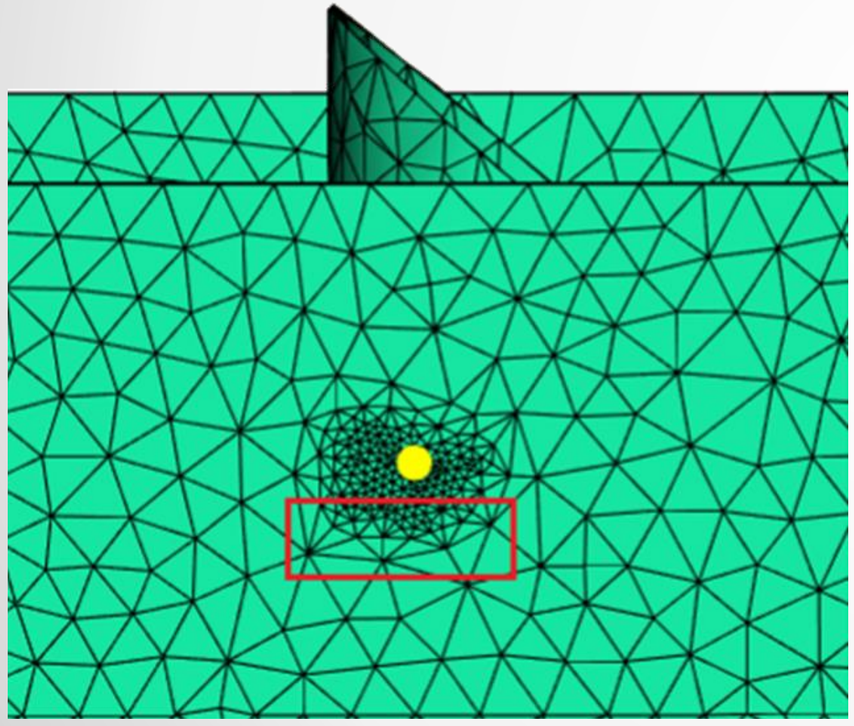
- Direct injection location
- Gate refinement
- Avoids large elements



Proper Mesh Refinement: Mesh Size Transition

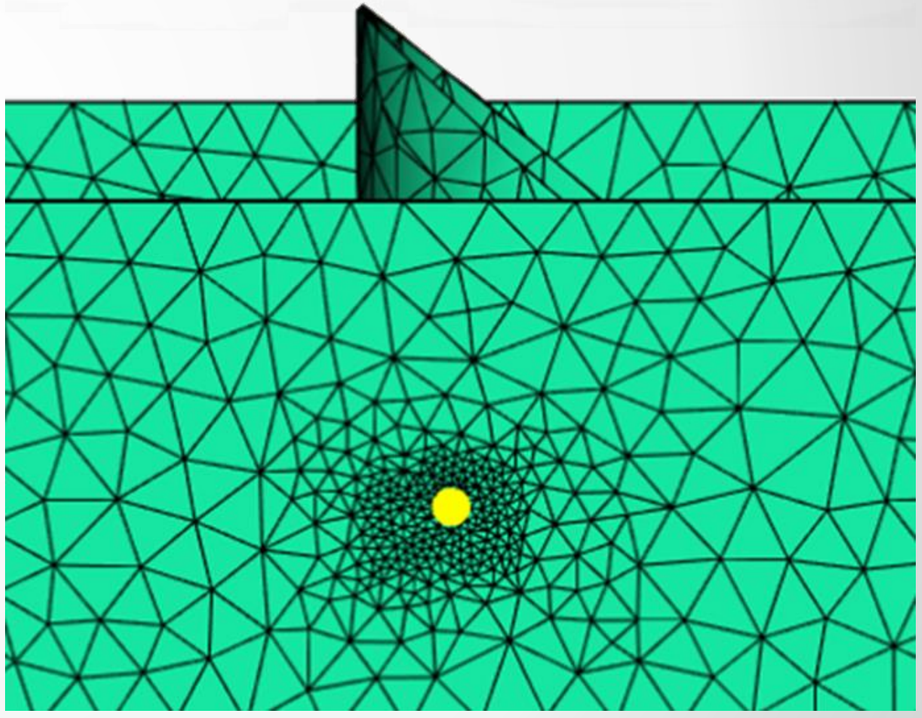
Functional

- Direct injection location
- Gate refinement
- Large elements by small elements

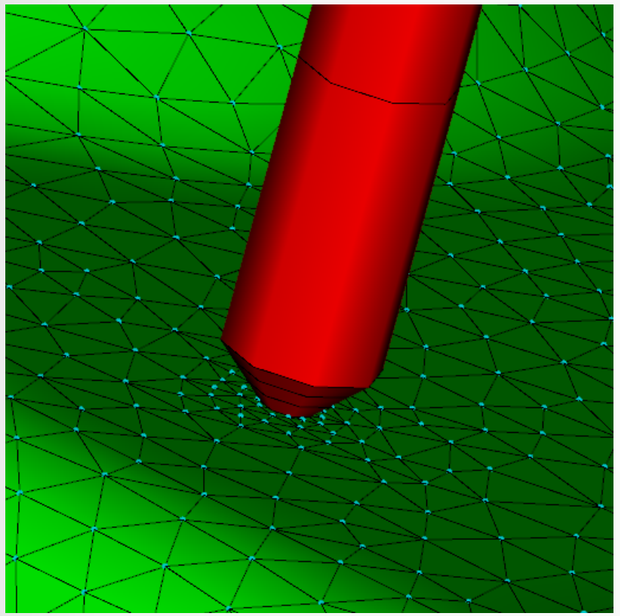


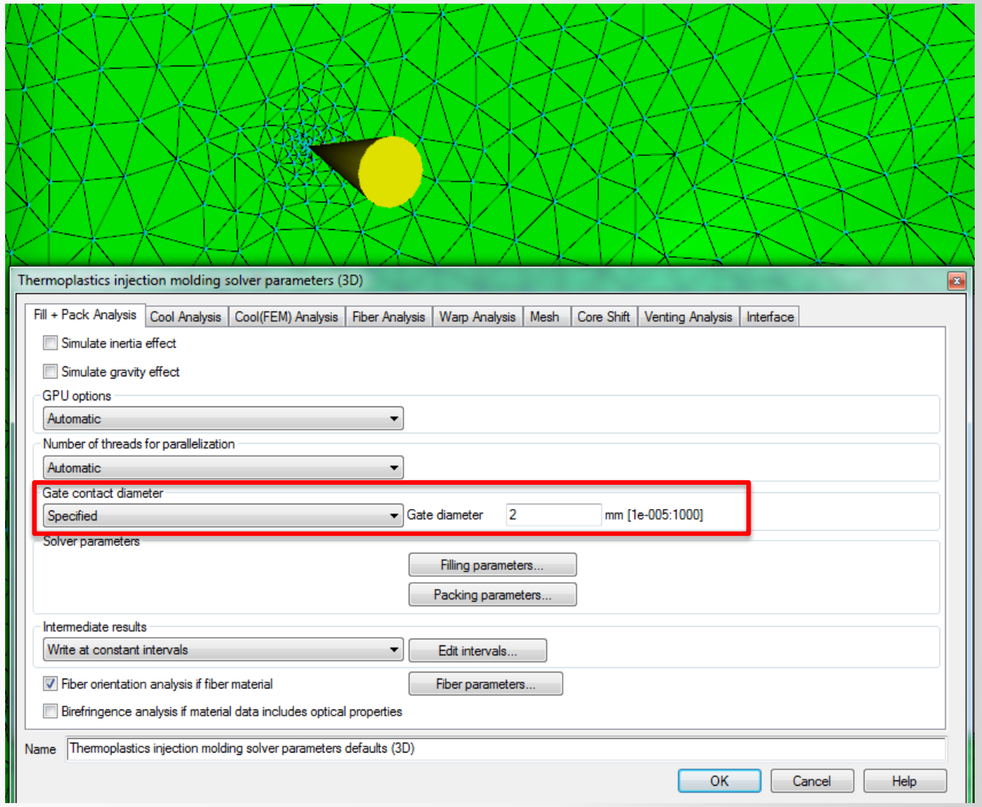
Preferred

- Direct injection location
- Gate refinement
- Mesh transition



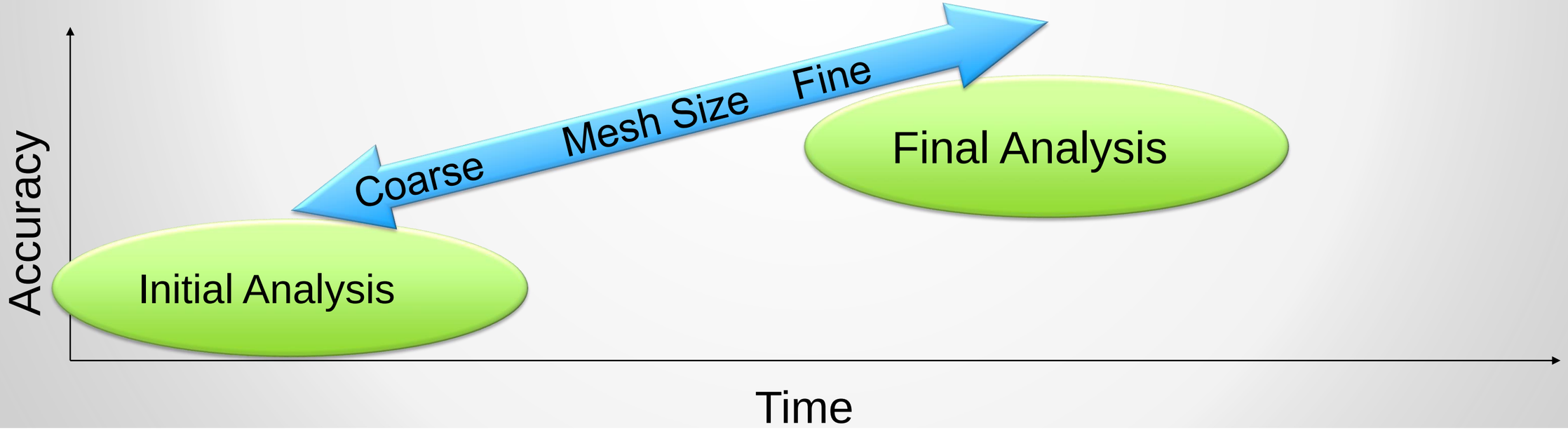
Proper Mesh Refinement: Contact Gate Diameter



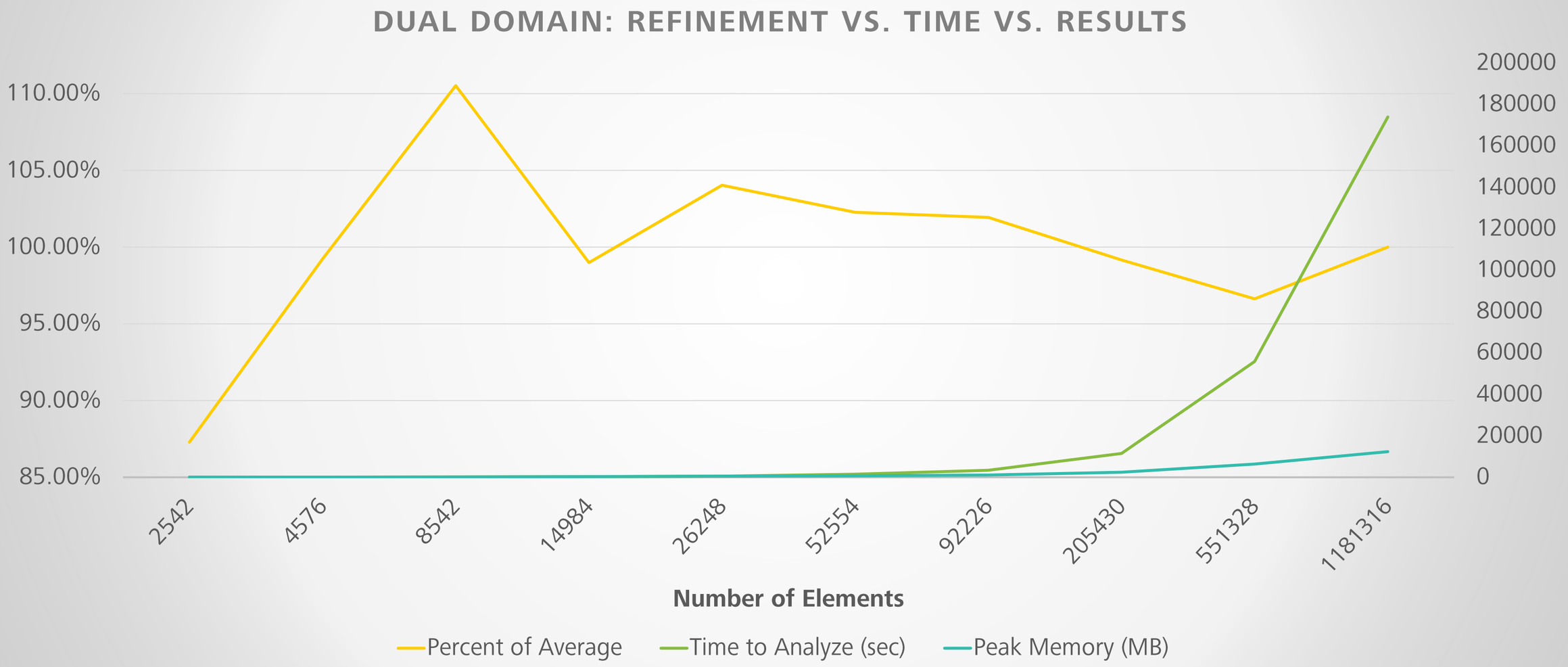


Impact on Time

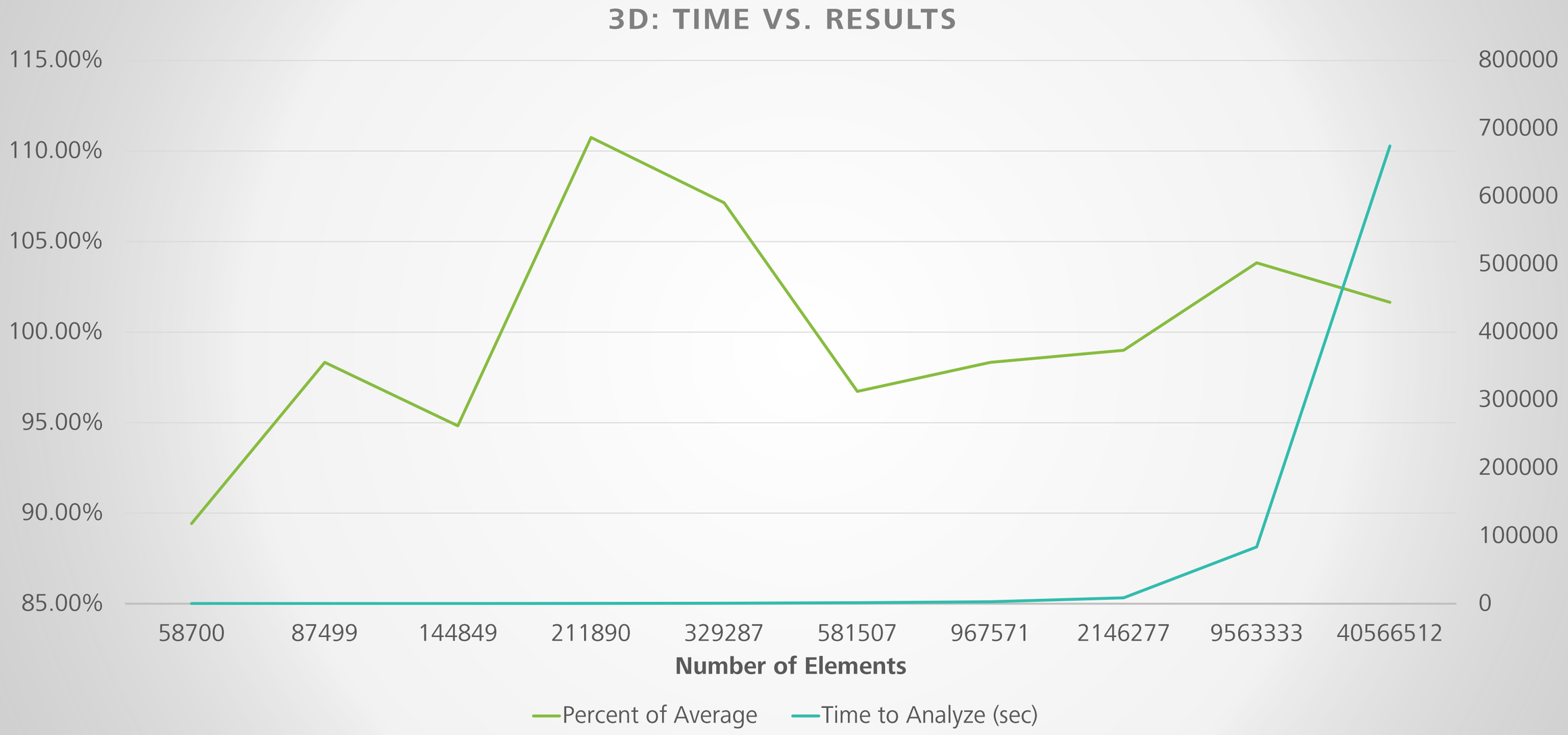
- Mesh defines where the results are computed
- Adjustments to the mesh size depends on goals for the analysis:
  - Relative comparison among designs: Can use a coarser mesh?
  - Match reality data: Typically requires finer mesh



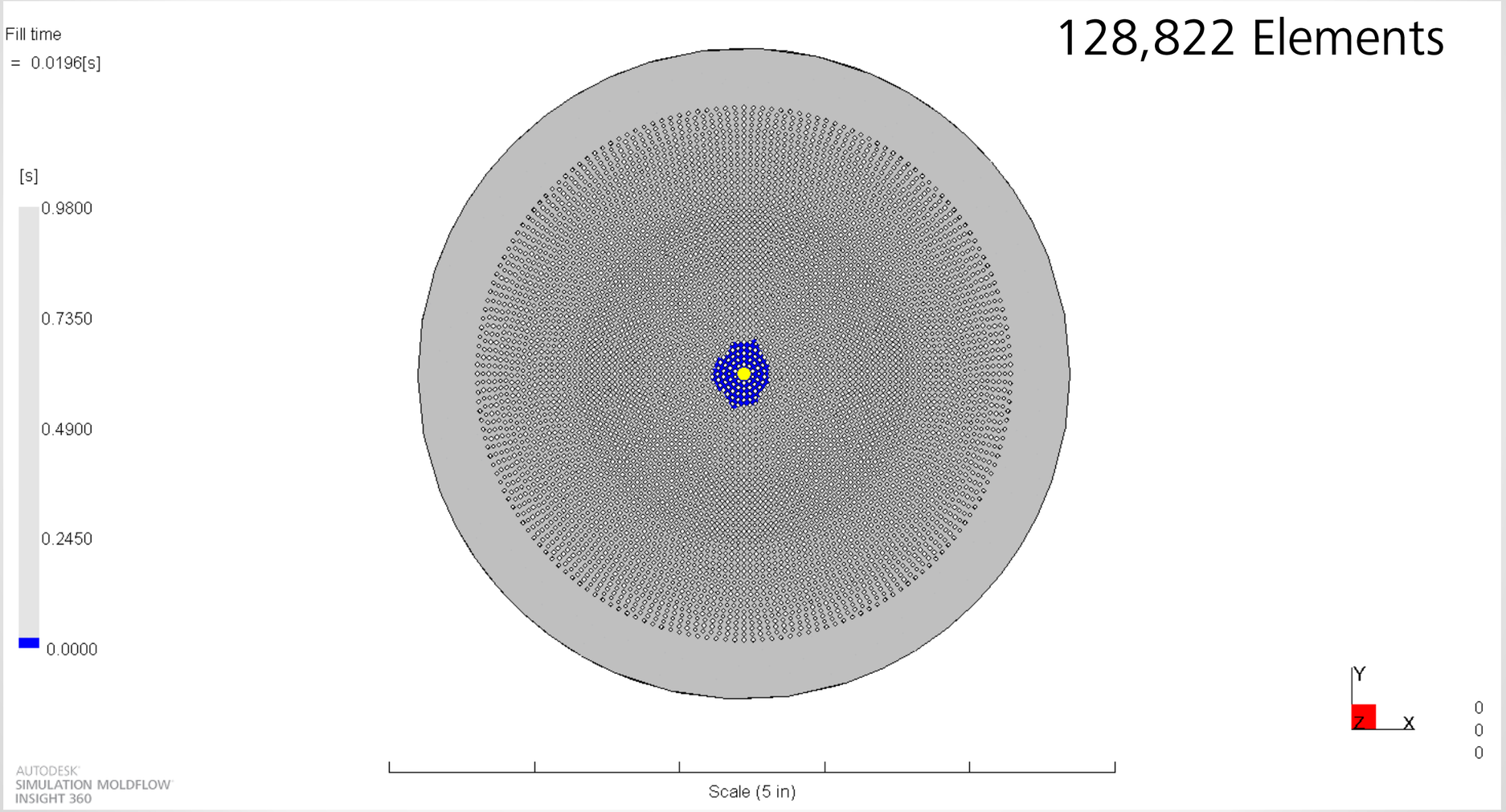
Impact on Time



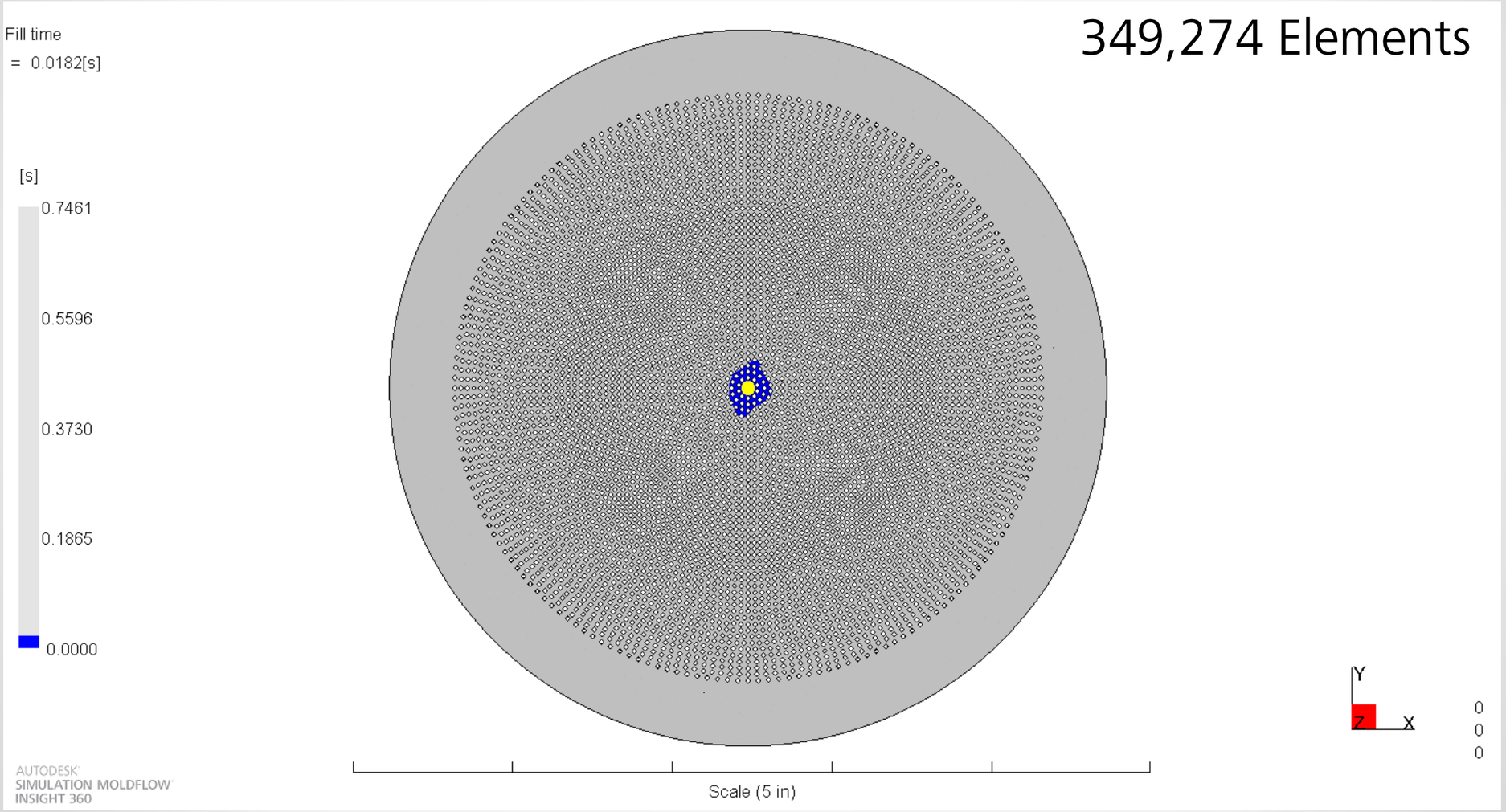
Impact on time



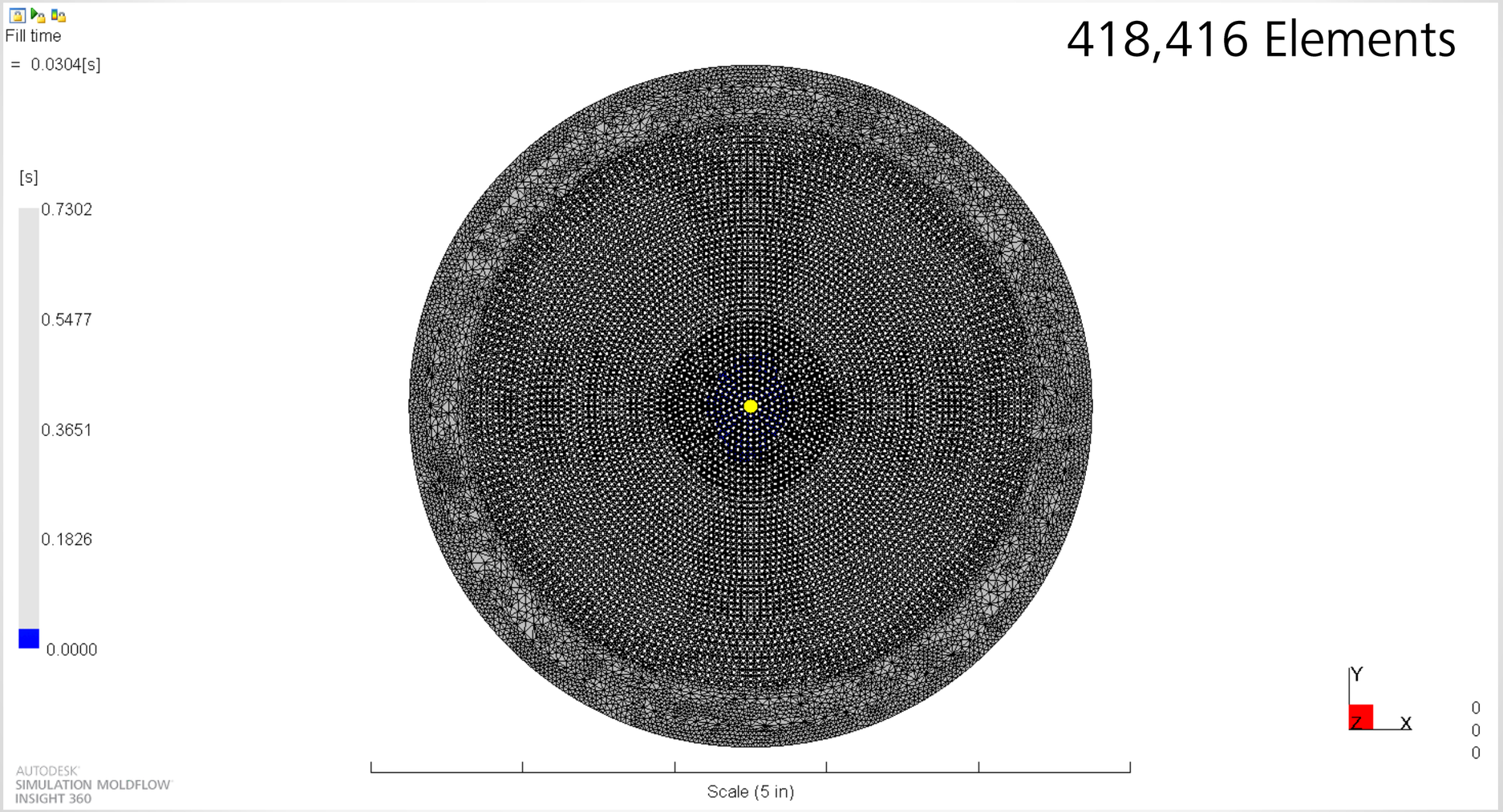
Impact on Accuracy: Coarse Mesh



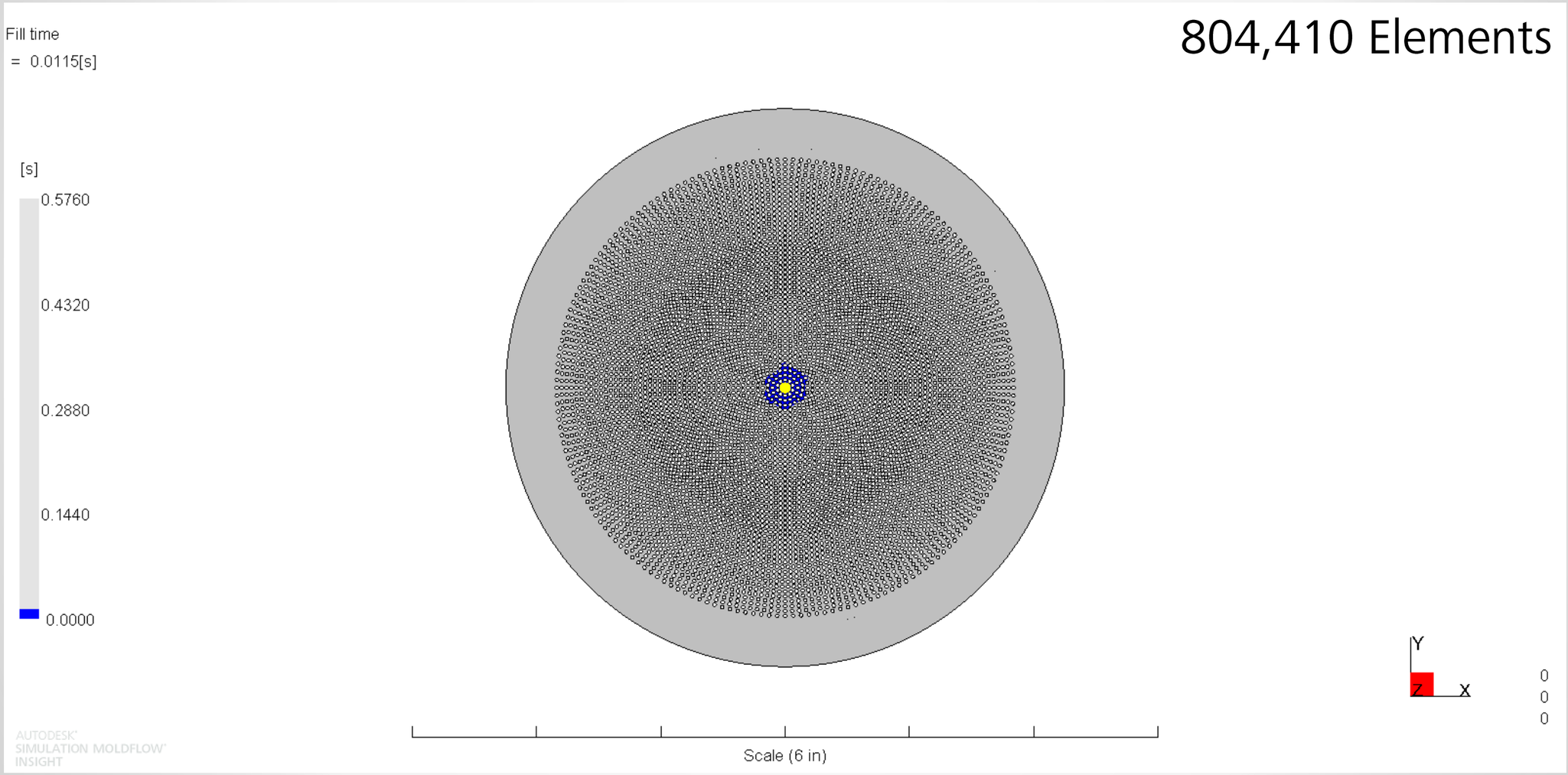
Impact of accuracy: Refined



Impact on Accuracy: Refined Gate Region



Impact on accuracy: Refined mesh



Misconceptions Purged: Refinement

- Increasing the refinement always improves accuracy
  - Geometry relative
  - Localized refinement to focus on areas of interest
    - Including around the gate
  - Could be computationally inefficient
- 3D is not used for thin-walled parts
  - May require increased surface mesh refinement
  - Accuracy not impacted

Feature Definition

Why is Feature Definition Important?

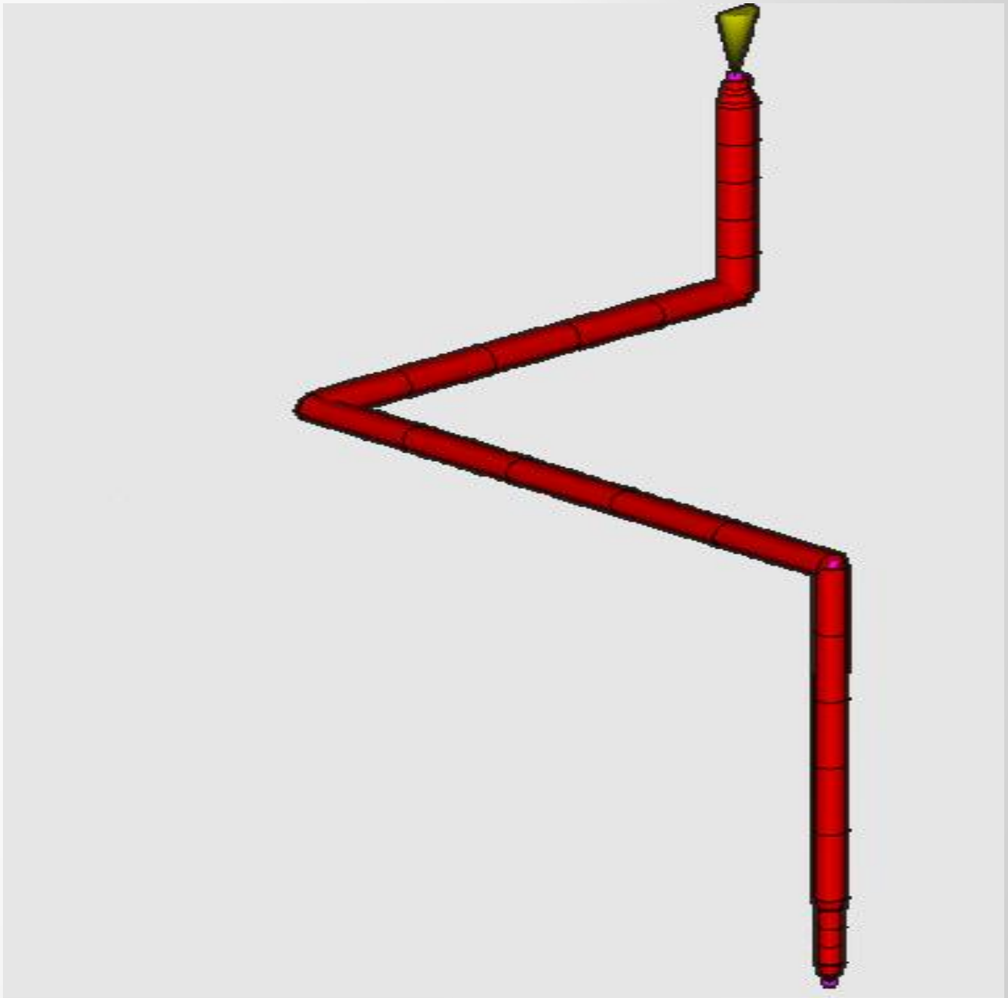
- Capture as many relevant components as possible
  - Mold components
  - Feed system
  - Cooling layout
- Accurately calculate influence of vital components
  - Real impacts on accuracy
  - Range depending on component inclusion or poor representation

Feature Definition: Overview

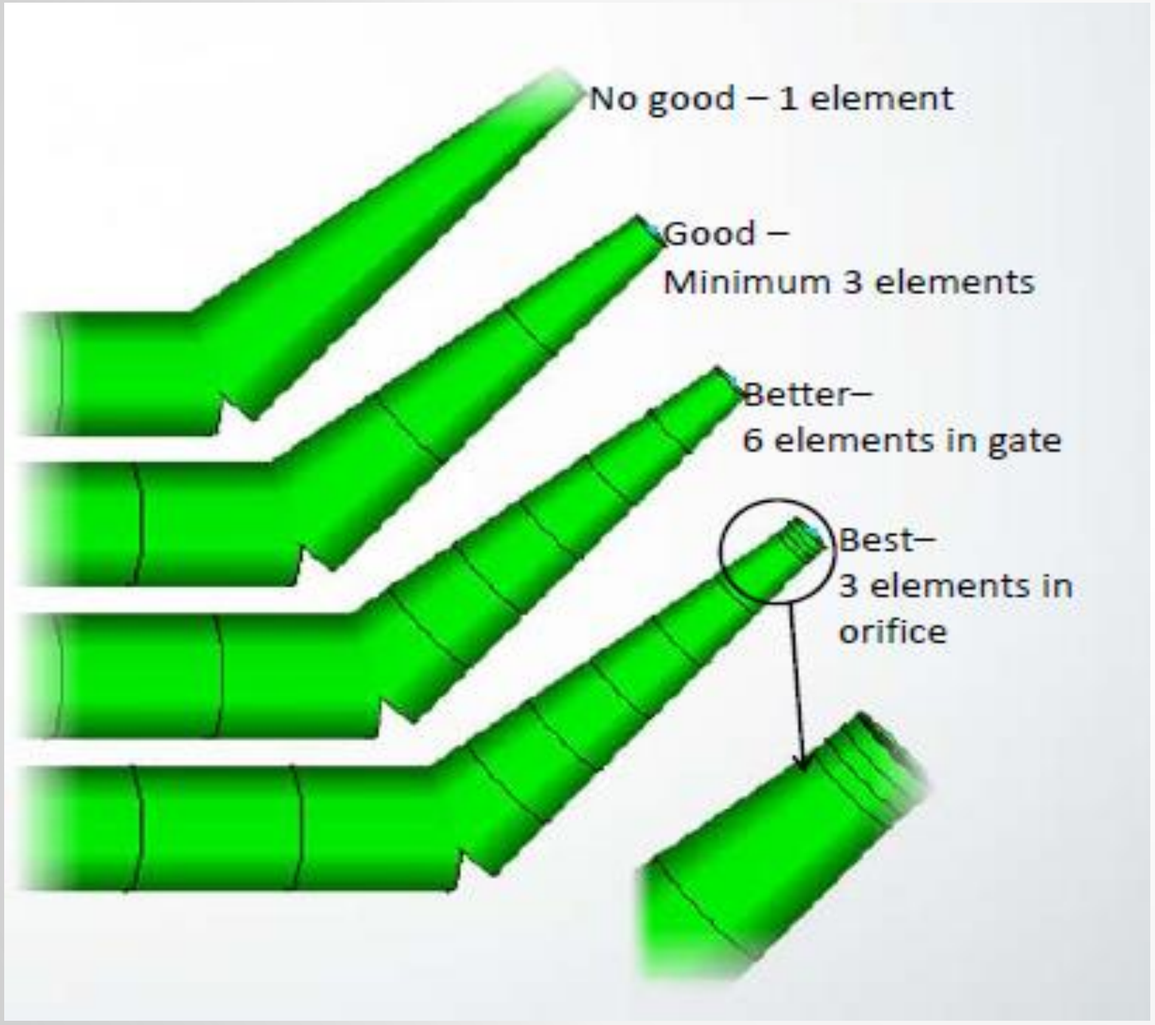
- Often most difficult/complex to handle
  - Require unique definition
  - Extra attention to ensure proper geometric representation
- Typically vital to design and overall behavior of part
  - Designed to drive some sort of result
  - Mis-representing will skew expected influence
- Different tools and options available
  - Variety of benefits and disadvantages
    - Mesh type
    - Process
    - Refinement and manual work

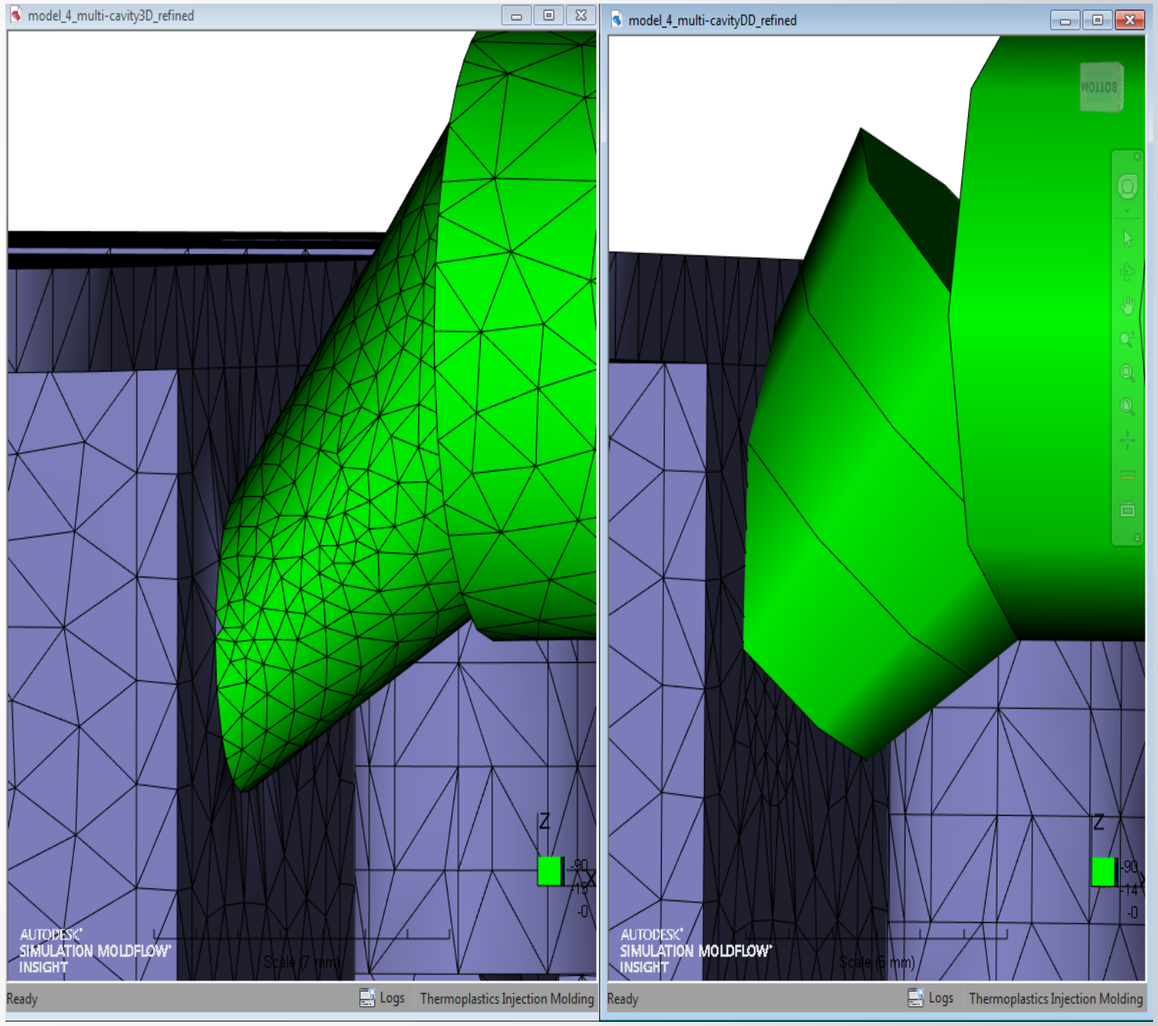
Feature Definition: Beam Element Feed System

- Beam elements
  - Midplane and Dual Domain always
  - In 3D with simple feed systems
    - Direct sprue
    - Very few intersections/transitions
- Default refinement higher than tetrahedral representation
  - 24 laminates
- 3D tetrahedral elements
  - Fully configured feed systems
    - Especially when expecting shear induced imbalances
  - If expecting significant shear
    - Higher layer refinement should be focused



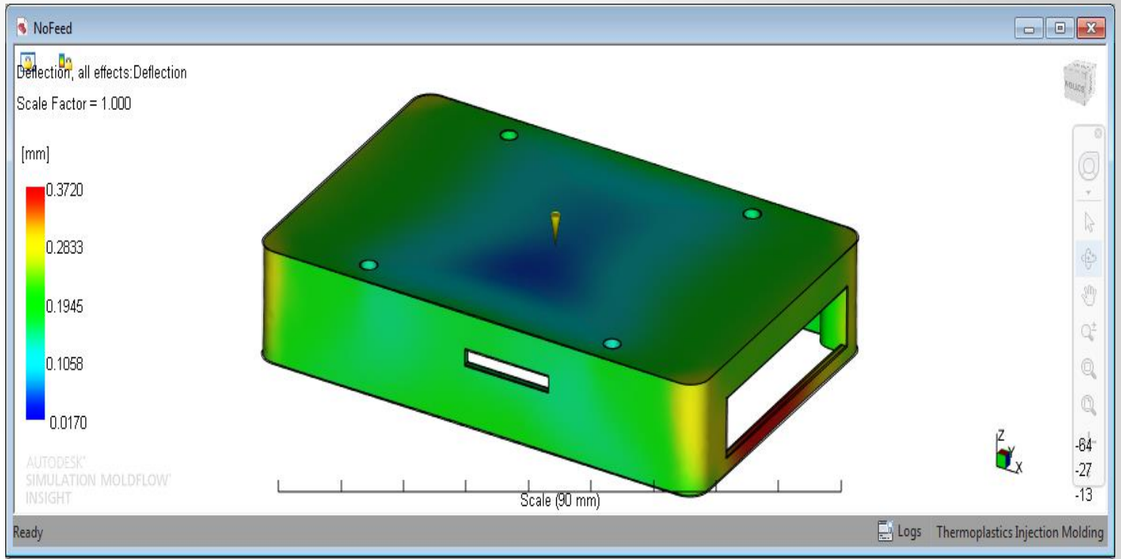
Feature Definition: Gates

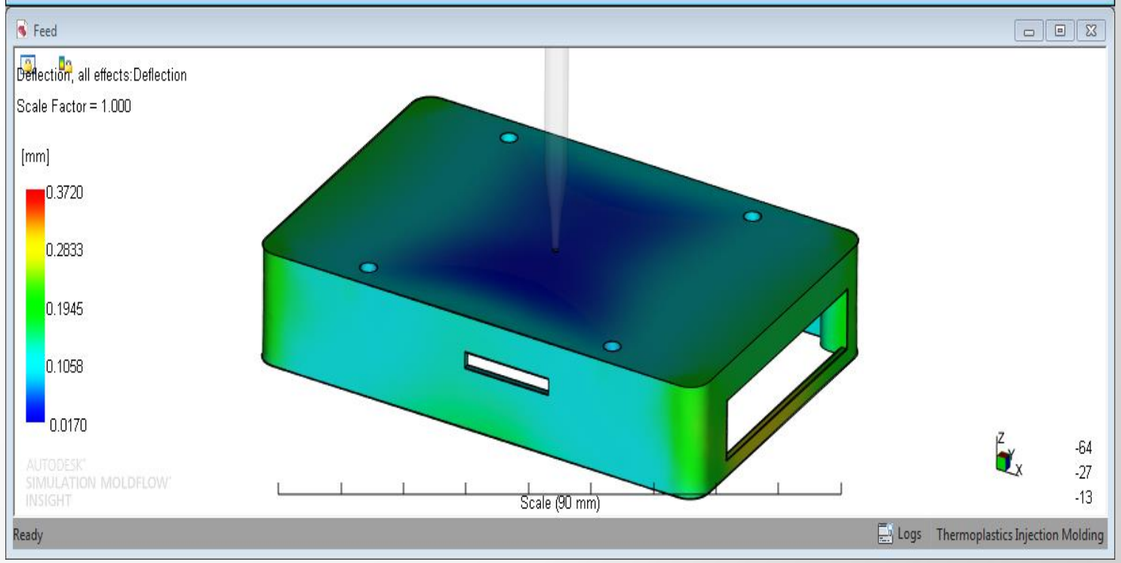




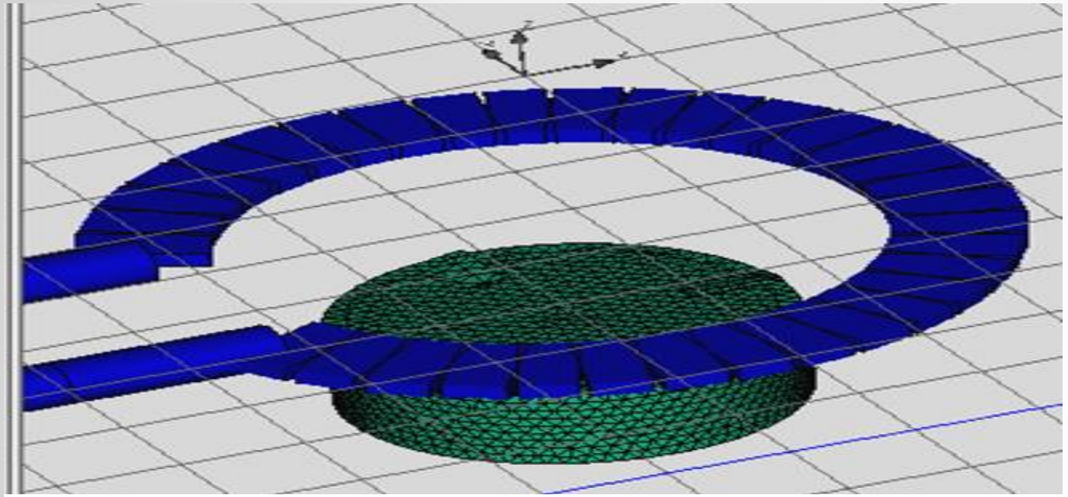
Feature Definition: Results Influence

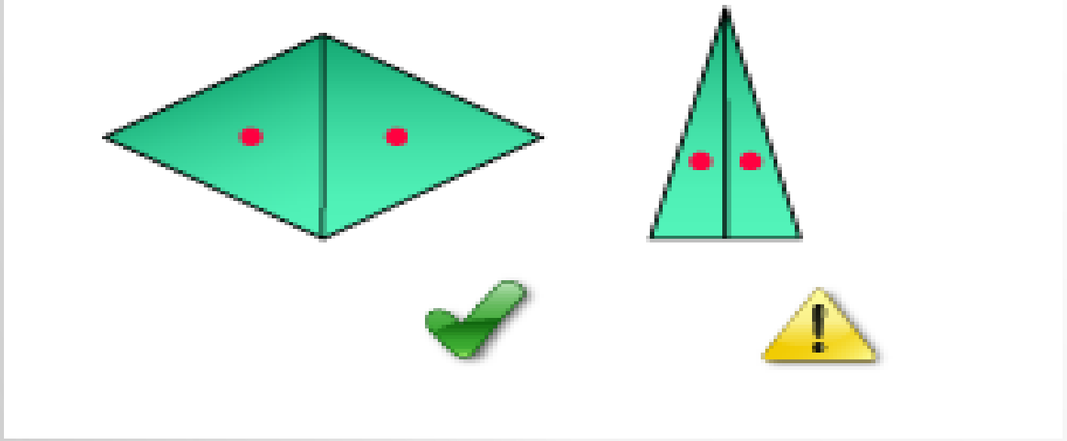
- Influence clear
  - Between none/beam/3D
- Significance relative
  - Specified gate diameter
  - Complexity of feed system
  - Material
  - Extent of analysis
    - Just fill or thru Warp
- Influences shear, pressure, compressibility, etc.





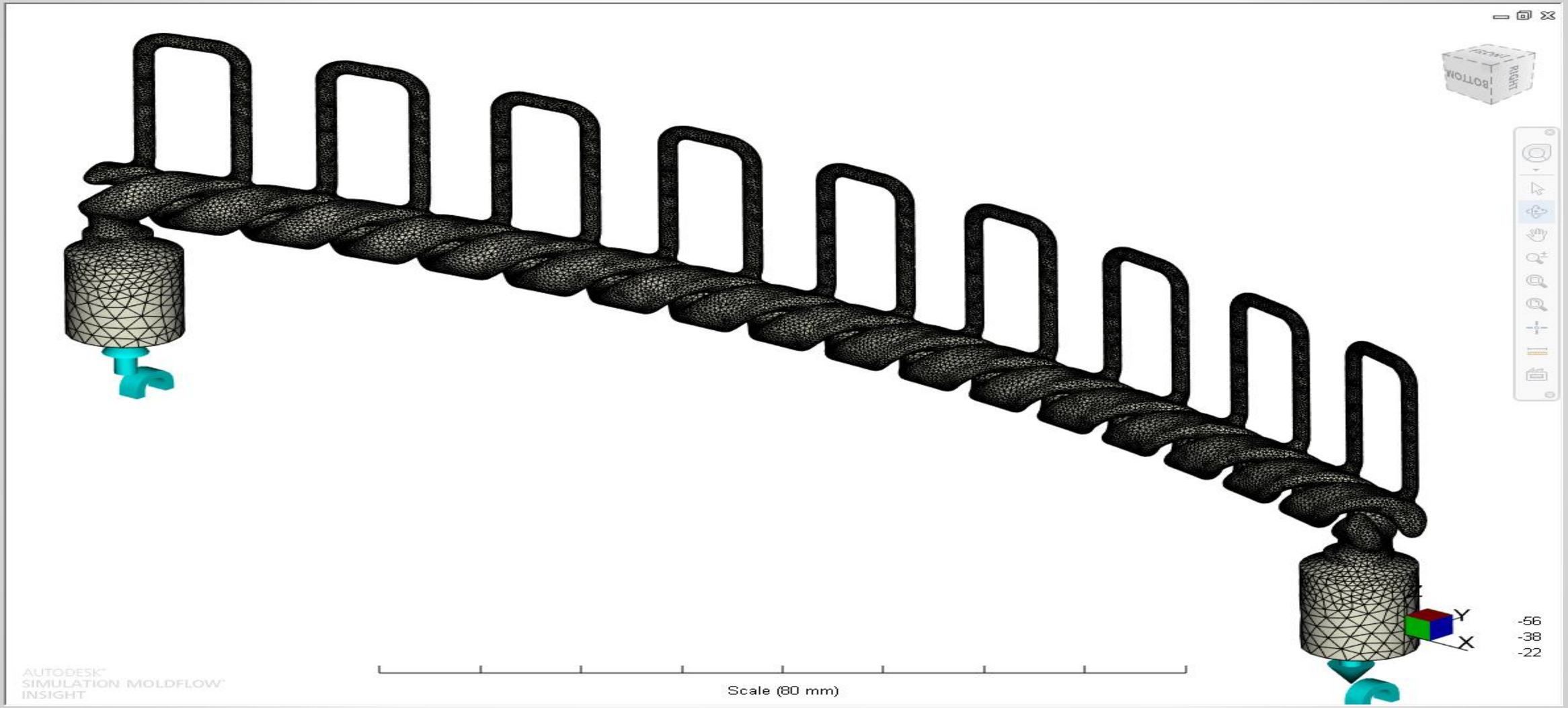
Feature Definition: Beam Element Cooling





- Most straight forward at this time
- Mesh refinement important
  - Ensure 2.5:1 beam length to diameter aspect ratio
    - For convergence in BEM cooling
  - Part element closeness
- One directional calculations
- Aspect ratio less important for FEM
  - Lower convergence sensitivity

Feature Definition: 3D Channel Representation (FEM)

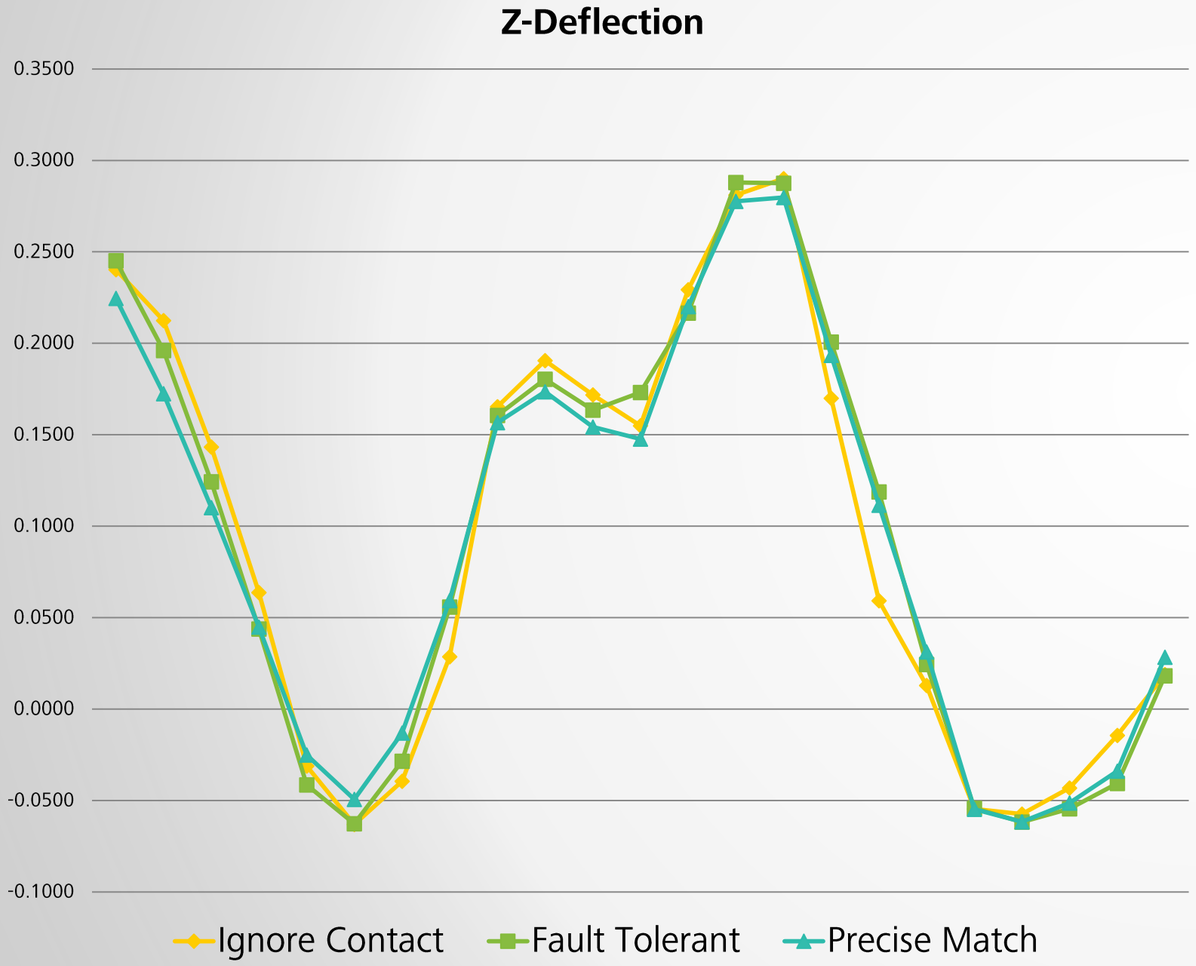


Feature Definition: Inserts

How we treat inserts?					
		Software package:			Comments
		Midplane	**DualDomain**	**3D**	
FLOW	*Part*	Yes	Yes	Yes	Mesh type can be mixed between Part & Insert.
					However, mesh type can not be mixed from part-to-part or within part itself
	Part insert	Yes	Yes	Yes	
	Mold insert	No	No	Yes	Mold inserts do not affect flow directly, only through a prior cool analysis
	In-Mold Lable	No	No	YES	Coupled3D can deal with in mold labels
					Midplane/Fusion : In-Mold Labels do not affect Flow directly,
					only through a prior cool analysis
COOL	*Part*	Yes	Yes	Yes	
	Part insert	Yes	No	Yes	
	Mold insert	Yes	Yes	Yes	
	In-Mold Lable	Yes	Yes	Yes	
WARP	*Part*	Yes	Yes	Yes	
	Part insert	No	No	Yes	A part insert does not constrain or deflect with the part in Midplane or DD
	Mold insert	No	No	No	A mold insert does not affect warp directly, only through Cool
	In-Mold Lable	No	No	No	In-mold Labels do not affect warp directly, only through a prior cool analysis

- Imported separately or as part of assembly
- Different inserts are handled differently
  - Mesh type
  - Insert type
- Impact will influence decision of mesh type
- Surface mesh refinement
  - Does not need to match
- Internal mesh (3D)
  - Can be lower to reduce element count

Feature Definition: Assembly Mesh



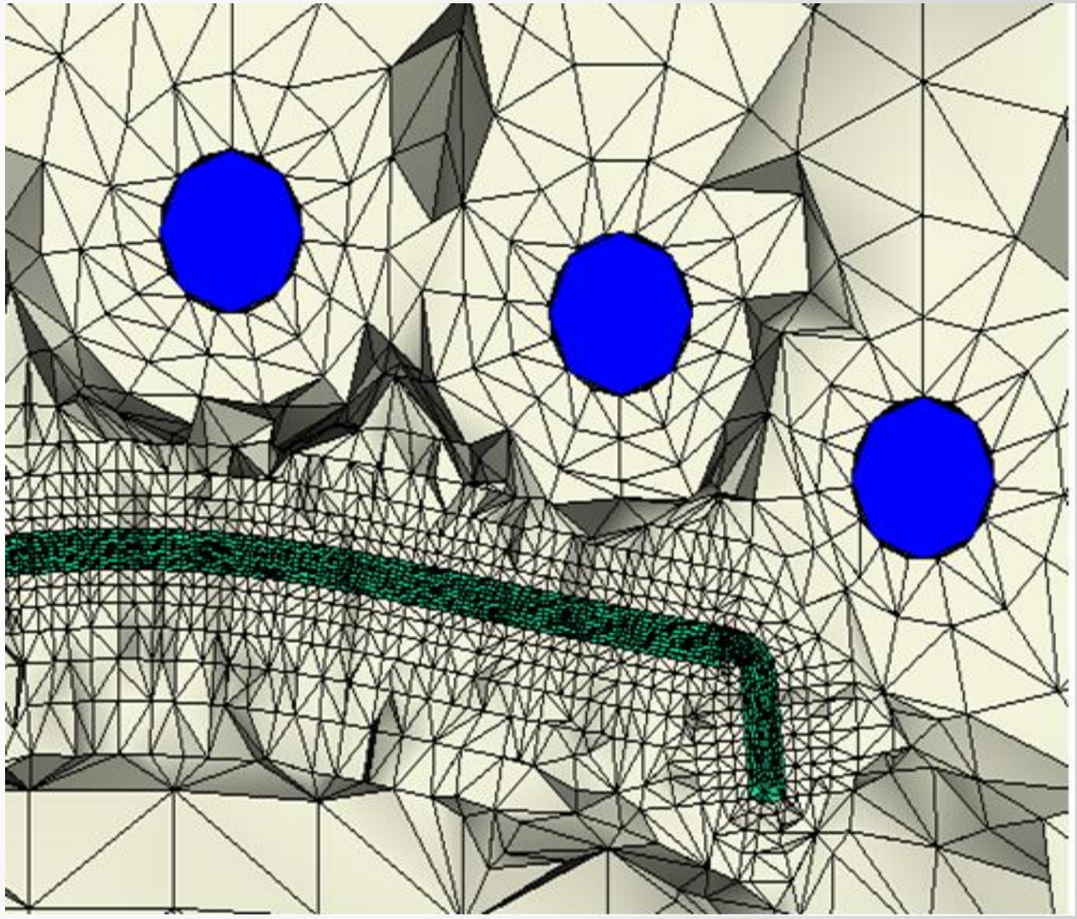
- Not necessary
- Negligible results impact
  - Severe mesh issues exception
- Restrict meshing success
  - Tighter tolerance options require very specific criteria
  - Time to mesh increased
  - Outright failures

Feature Definition: Mold Boundary

- Boundary mold representation
  - Surfaces
  - Triangles
    - Determines a volume of the mold
    - Necessary in thermal calculations and convergence
- Made via mold boundary generator
  - Specify dimensions
- Ensure holes are cut to avoid intersections
  - Can cause convergence issues

Feature Definition: 3D Mold

- Two methods
  - Created geometry within Moldflow
    - Mold building tool
  - CAD representation imported
    - Meshed via 3D mold mesher
- Internal components
  - Recognized by mesher
  - Internal and external surface mesh control



Summary

- Important for improving accuracy
  - Variables that influence temperature, pressure, and constraining calculations
    - Excluding completely or misrepresenting can decrease accuracy
- Direct approach to most
  - Increase refinement for geometric design features
    - Localized refinement tool

Misconceptions Purged: Feature Definition

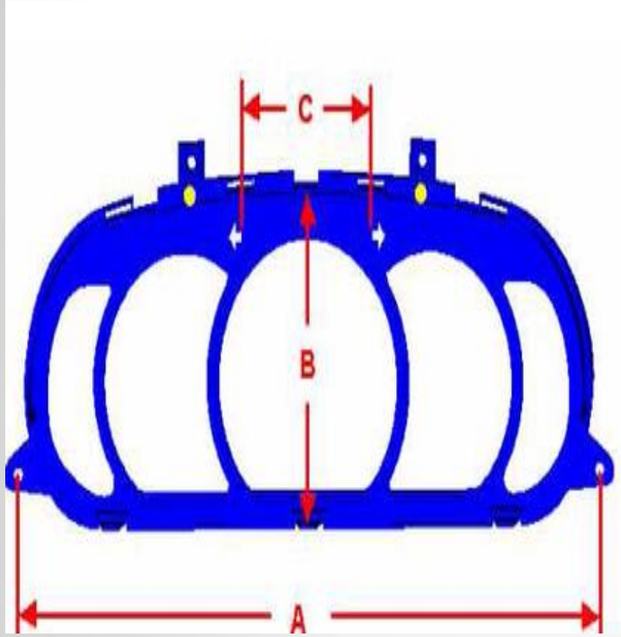
- Unique features require the same refinement as the part
  - Both lower(inserts) and higher(gate) mesh refinement depending on feature
- Beam element feed systems provide less accuracy
  - 24 laminates actually increase accuracy
  - Better than no feed system
  - There are limitations due to 1D flow capturing shear
- Interfacing components need to replicate contact surface mesh
  - This is a legacy requirement that is no longer valid
  - Nodes from each surface need to exist on same plane, not in same space

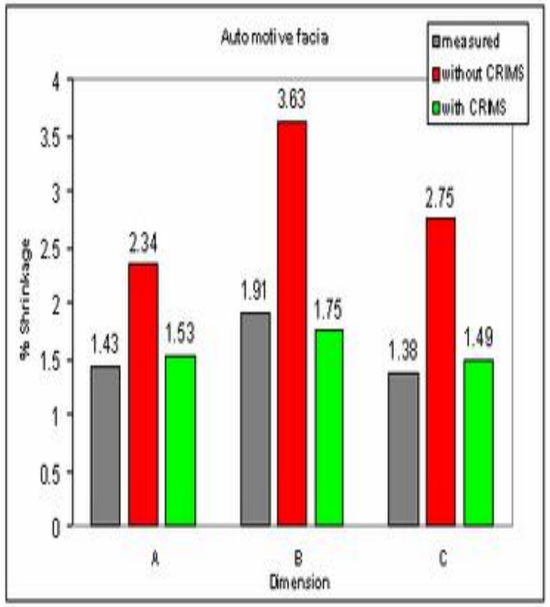
Material Impact

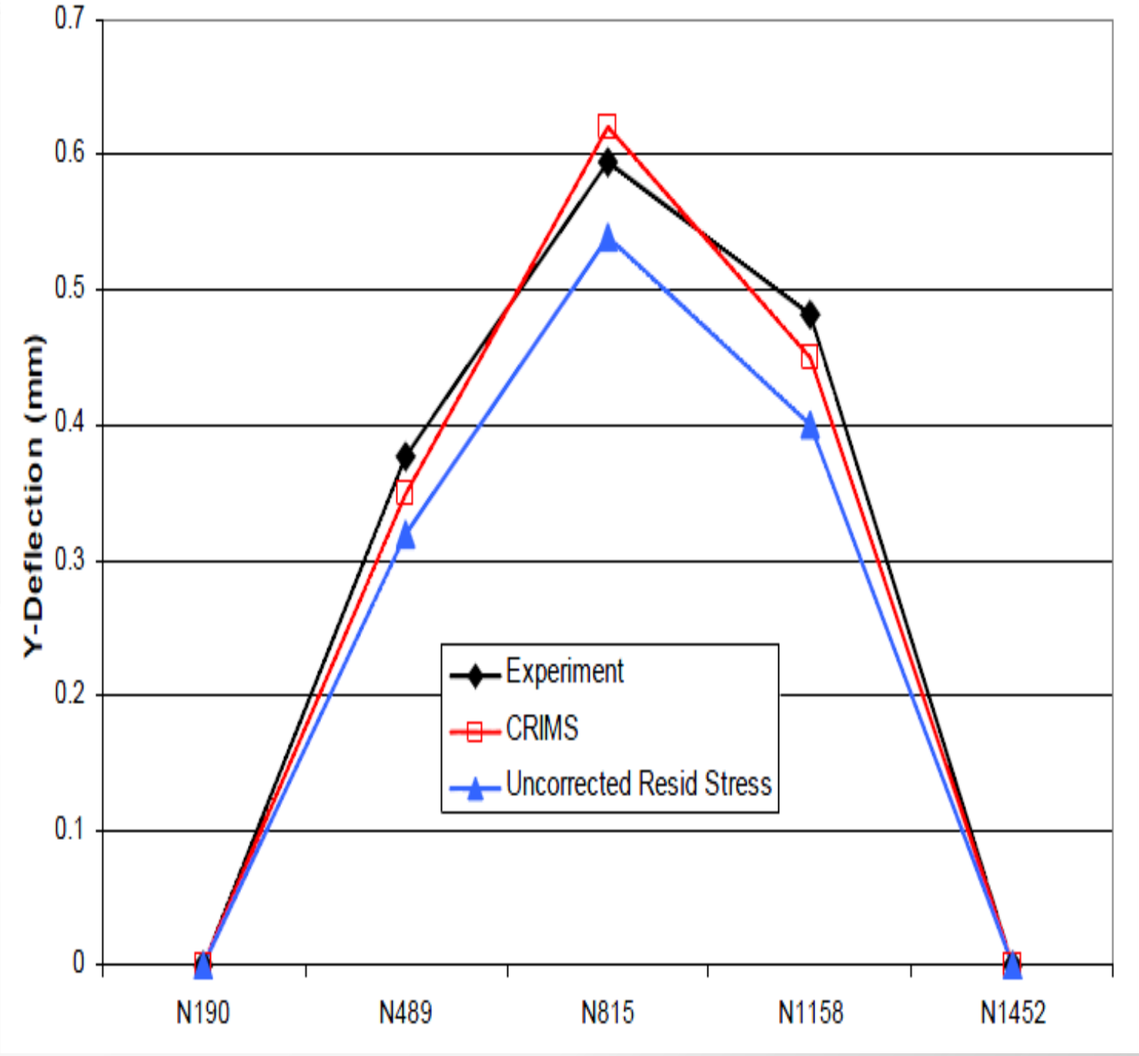
Do Different Mesh Types Use Material Differently?

- Mesh type can impact how material data is handled
  - Calculations necessary can differ
    - Different means of representing geometry
    - Material data necessary for such calculations
- Mesh quality
  - Mesh determination driven by need
    - Model data available, part geometry, etc.
  - Desired mesh type may not be feasible for quality representation
    - Material data needs may change

Material Influences: CRIMS

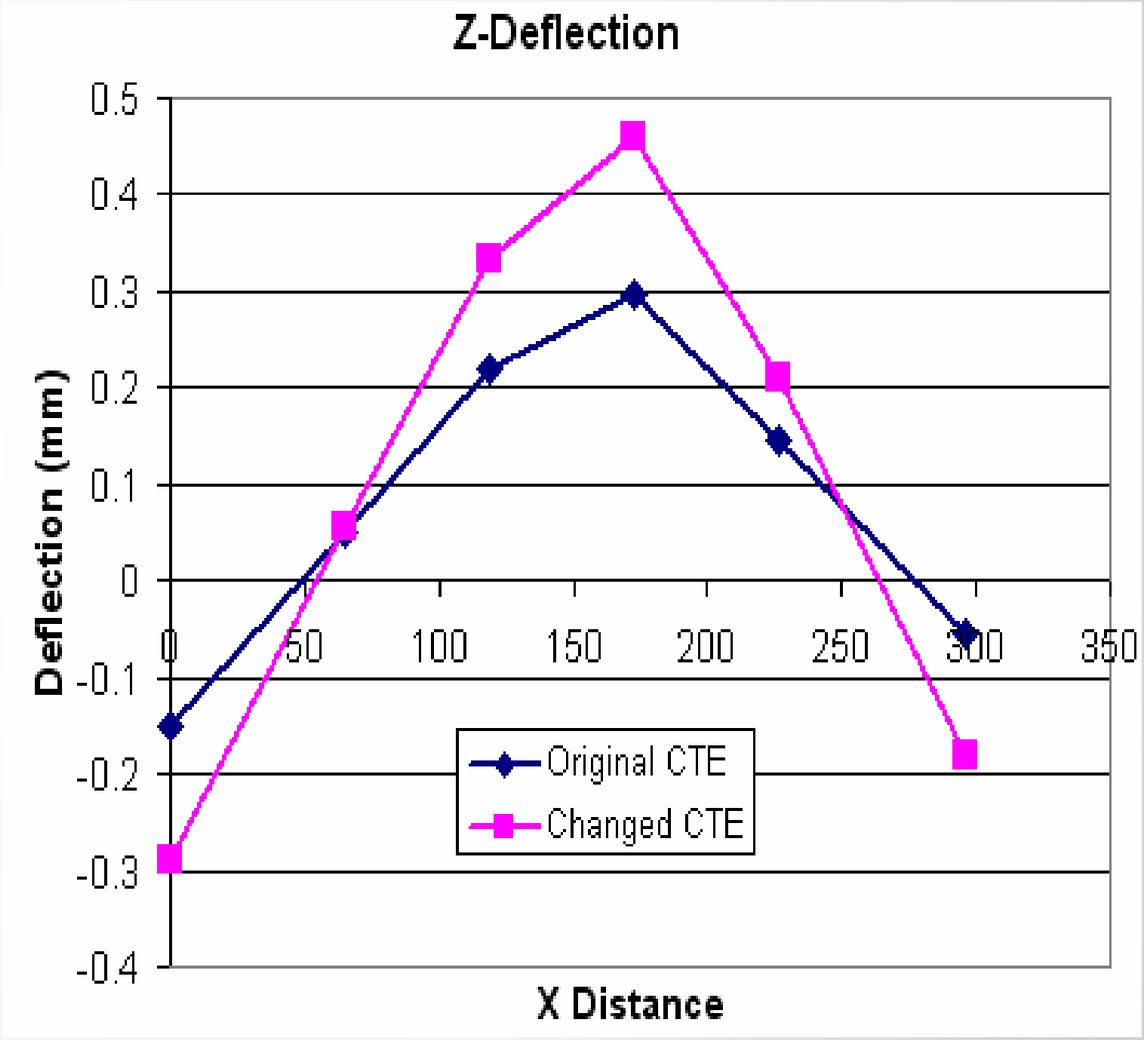






Material Influences: Coefficient of Thermal Expansion

- Used in 3D warpage
  - Along with volumetric shrinkage
  - Instead of CRIMS
- Many materials have supplemental CTE
  - Average increase of CTE is 38%
  - Increases deflection by up to 50%



Additional Material and Mesh Related Notes

- Unique analyses types only available based on specific material data
  - Crystallization is material data and mesh dependent
    - Currently only available for Dual Domain and Midplane
  - Birefringence is material data and mesh dependent
    - Currently only available for 3D
- Juncture loss and pressure calculation
  - Only used in beam feed system configuration
  - Improves pressure calculations

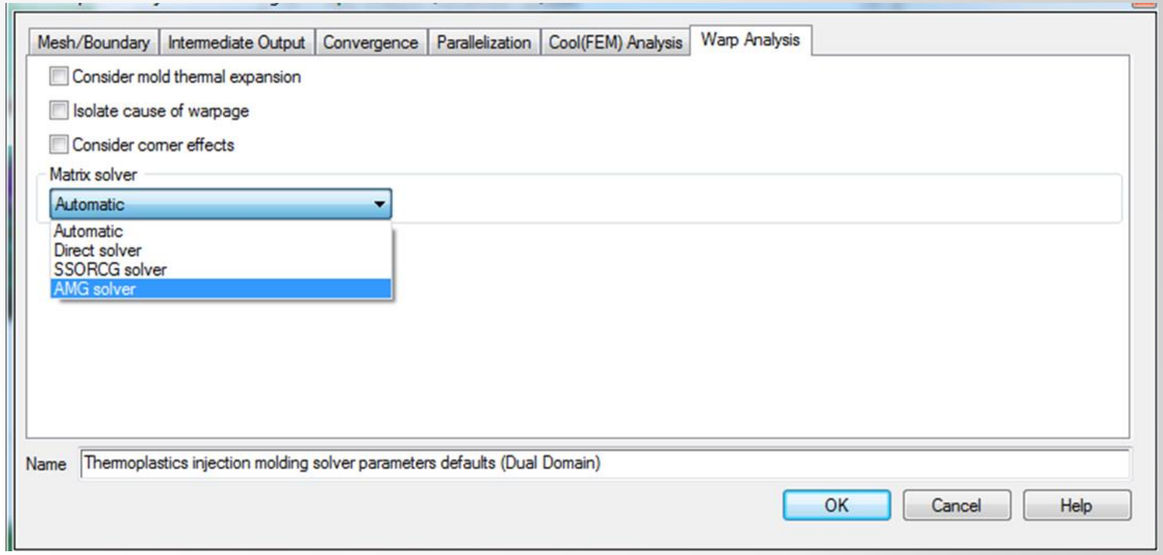
Misconceptions Purged: Material Influence

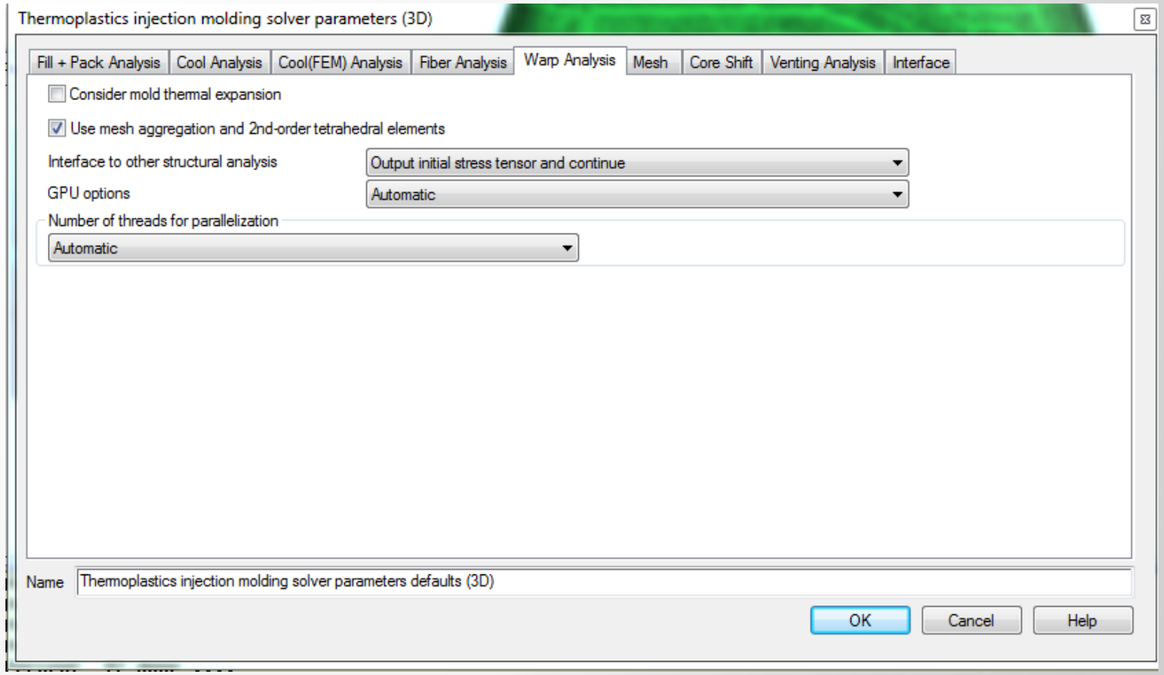
- All mesh types utilize the same material data
  - Mesh type provides different representation of geometry
    - Different solver behavior depending on that representation
  - Poor quality mesh can dampen or amplify material influence
- CRIMS improves warp accuracy on all models
  - Only if the model in question is a Midplane or DD model
  - 3D uses vol. shrinkage and CTE
- Juncture loss will improve pressure calculation
  - Only if beam feed systems are used

Solver Impact

Different Solvers

- Algebraic Multi-Grid; a type of iterative matrix solver used in analysis calculations, which uses progressively coarser grids for computations.
- Newest solver technology
- Can improve performance by reducing analysis time for large models

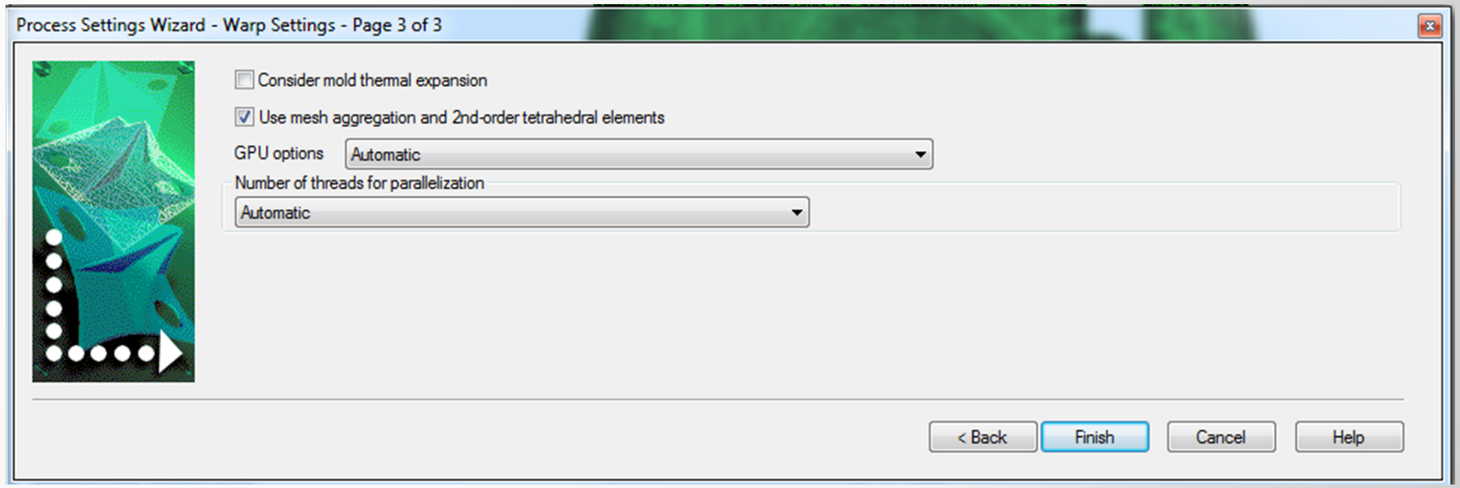




Mesh Aggregation -3D Warpage

- Process used that squeezes the layers down to two larger layers versus the number of layers that are originally specified when initially meshing a part

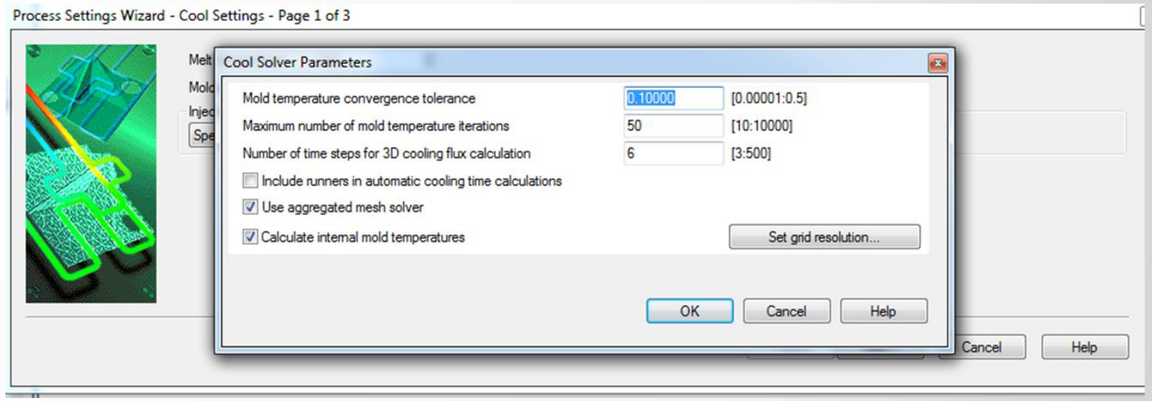
- Uses 2nd-order, 10-node tetrahedral elements



- Improves analysis time

Mesh Aggregation - Cooling

- Midplane, Dual Domain, and 3D
- Works by aggregating similar elements with their immediate neighbors to form larger master elements, reducing the overall number of the elements of the model internal to the solver, and therefore, analysis time.
- Recommended to be run with all cooling analysis



Misconceptions Purged: Solver Impact

- Mesh aggregation reduces results accuracy and should be disabled to improve accuracy
  - Turning it off is often negligible with respect to results
  - Mesh Aggregation allows for improved analysis time
    - Often vital to ensure completion on large model due to hardware restrictions
- Solver behavior is the same for all mesh types
  - To account for different means of representation solver behavior is dynamic
  - Mesh and setup will dictate how Moldflow handles data

Session Feedback

- Via the Survey Stations, email or mobile device
- AU 2015 passes given out each day!
- Best to do it right after the session
- Instructors see results in real-time

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