Research Directions in Moldflow Insight

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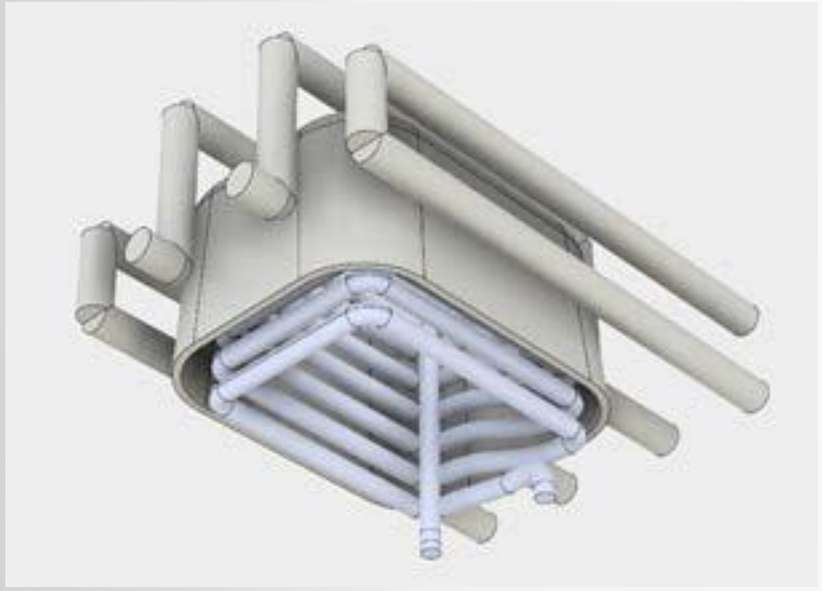
Senior Research Leader, Moldflow Development

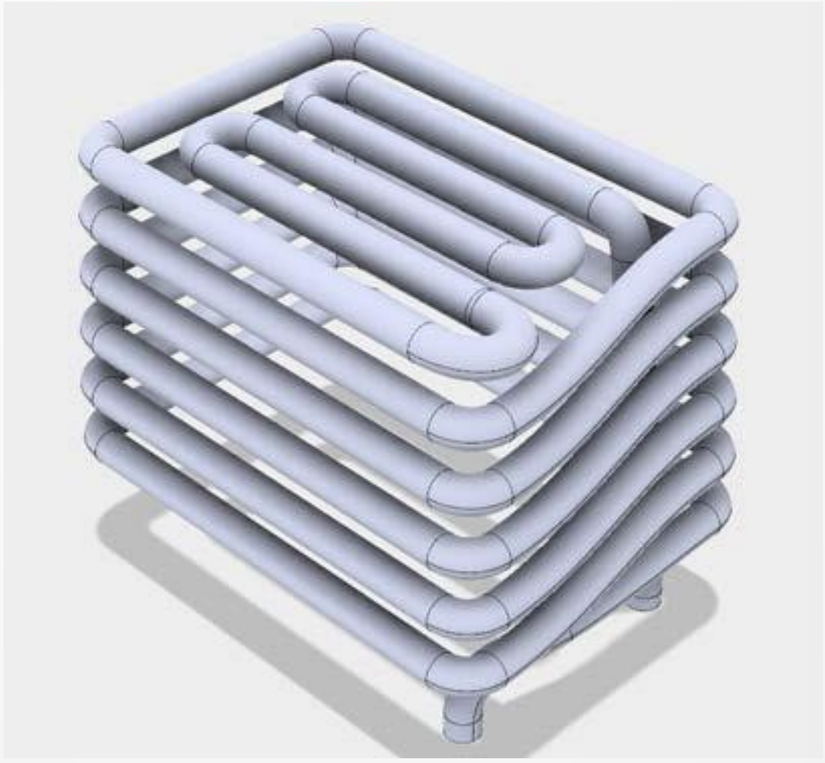
Class Outline

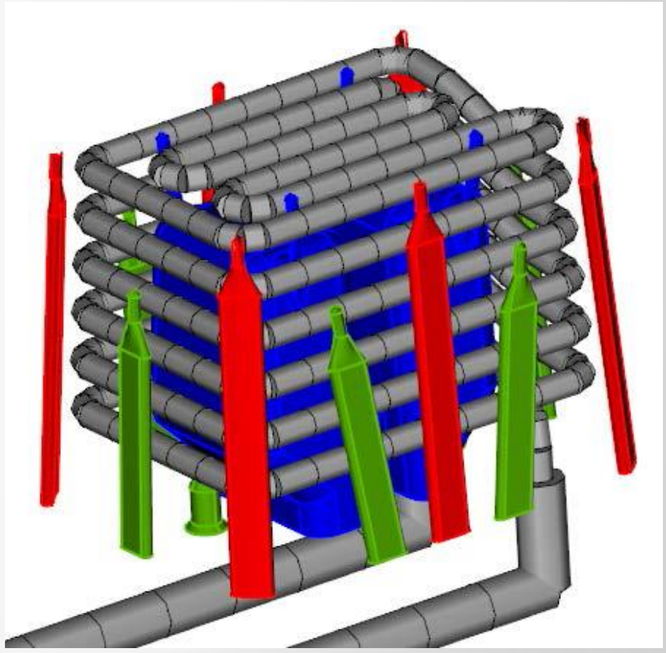
- Validation
- Scandium 2016
- Moldflow 2017 Beta
- Research Projects & Collaborations

Validation: Transient Cool (FEM)

- Highly Instrumented Box Tool with Conformal Channels

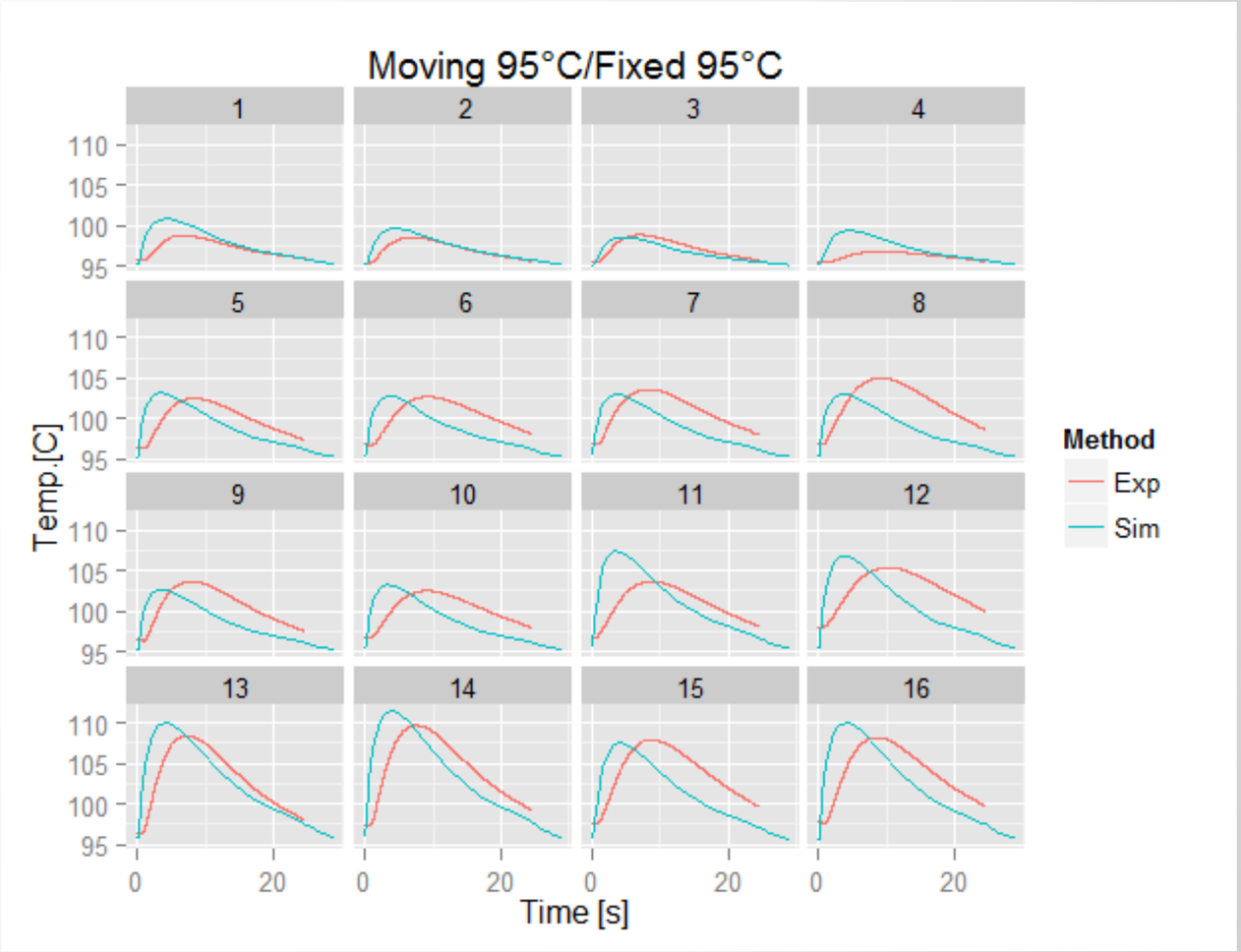






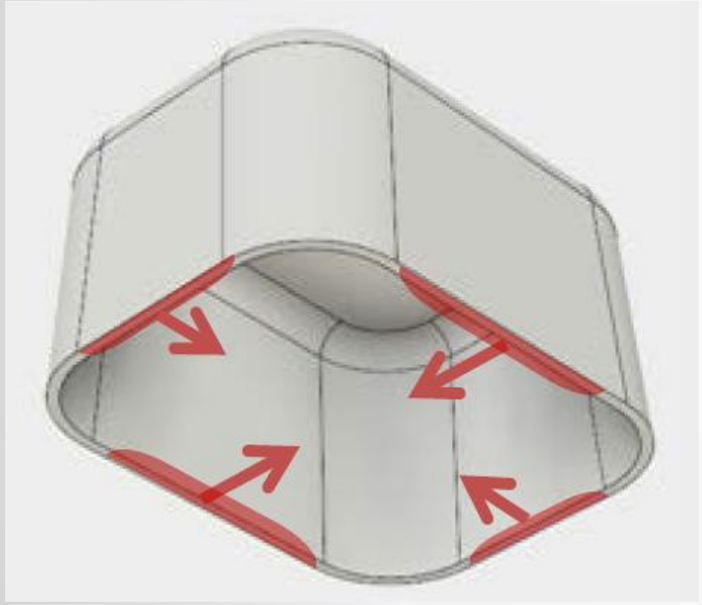
Validation: Transient Cool (FEM)

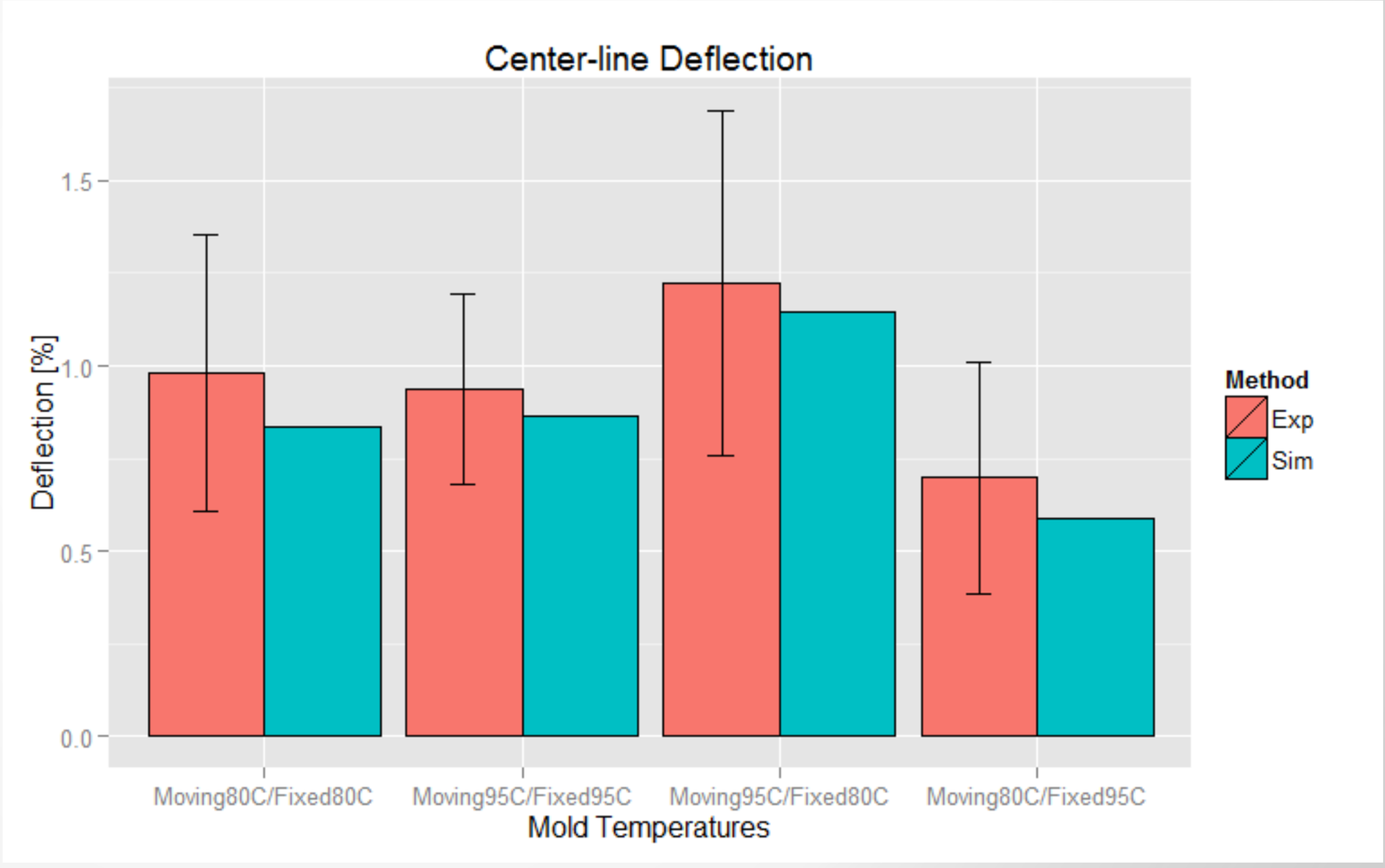
- PA 6 material molded
  - 30wt% Glass Fiber
- Cool (FEM) using Conduction solver
- Agreement on temperature rise and timing



Validation: Warp (3D)

- Deflection along long edge
- PA6 30wt%GF





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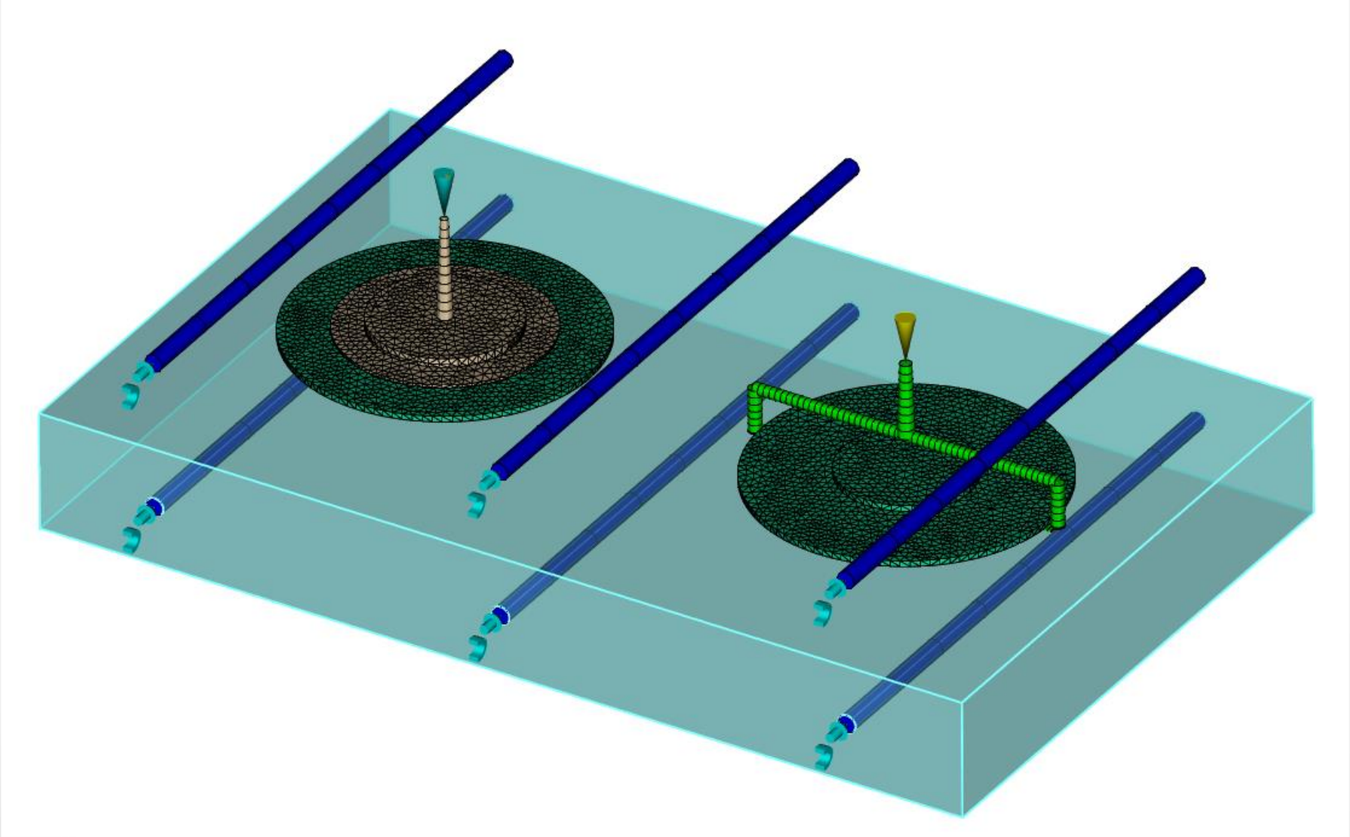
Disclaimer

We may make statements regarding planned or future development efforts for our existing or new products and services. These statements are not intended to be a promise or guarantee of future delivery of products, services or features but merely reflect our current plans, which may change. Purchasing decisions should not be made based upon reliance on these statements.

The Company assumes no obligation to update these forward-looking statements to reflect events that occur or circumstances that exist or change after the date on which they were made.

Mold Cooling Analysis for 2K-Overmolding

- Consider all cavities and mold movement



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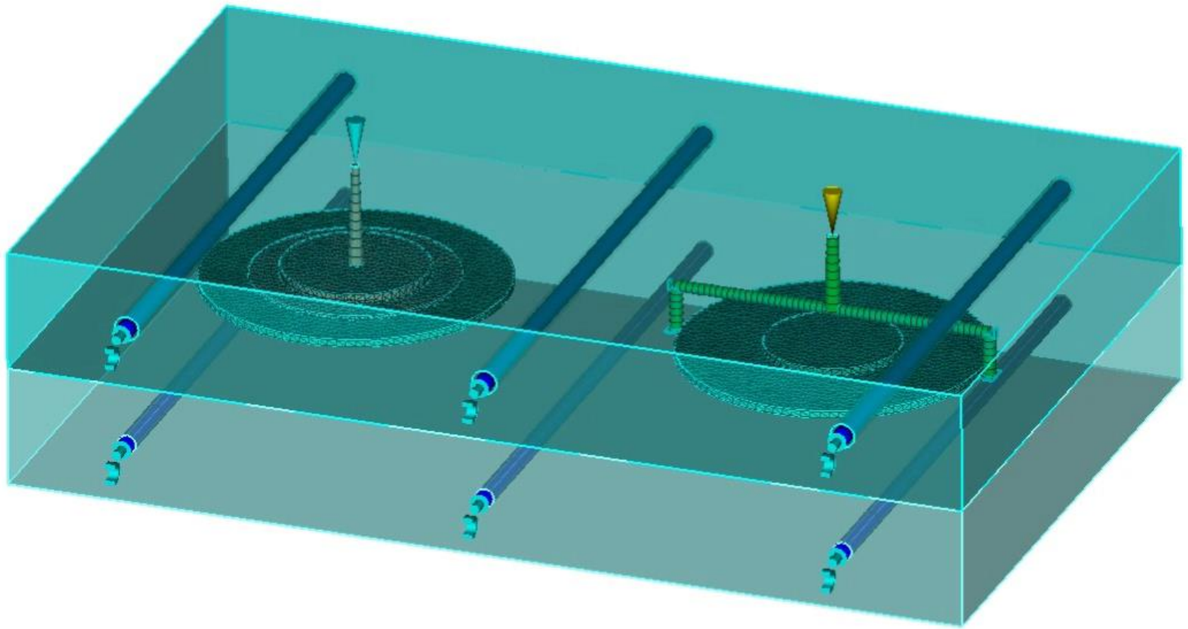
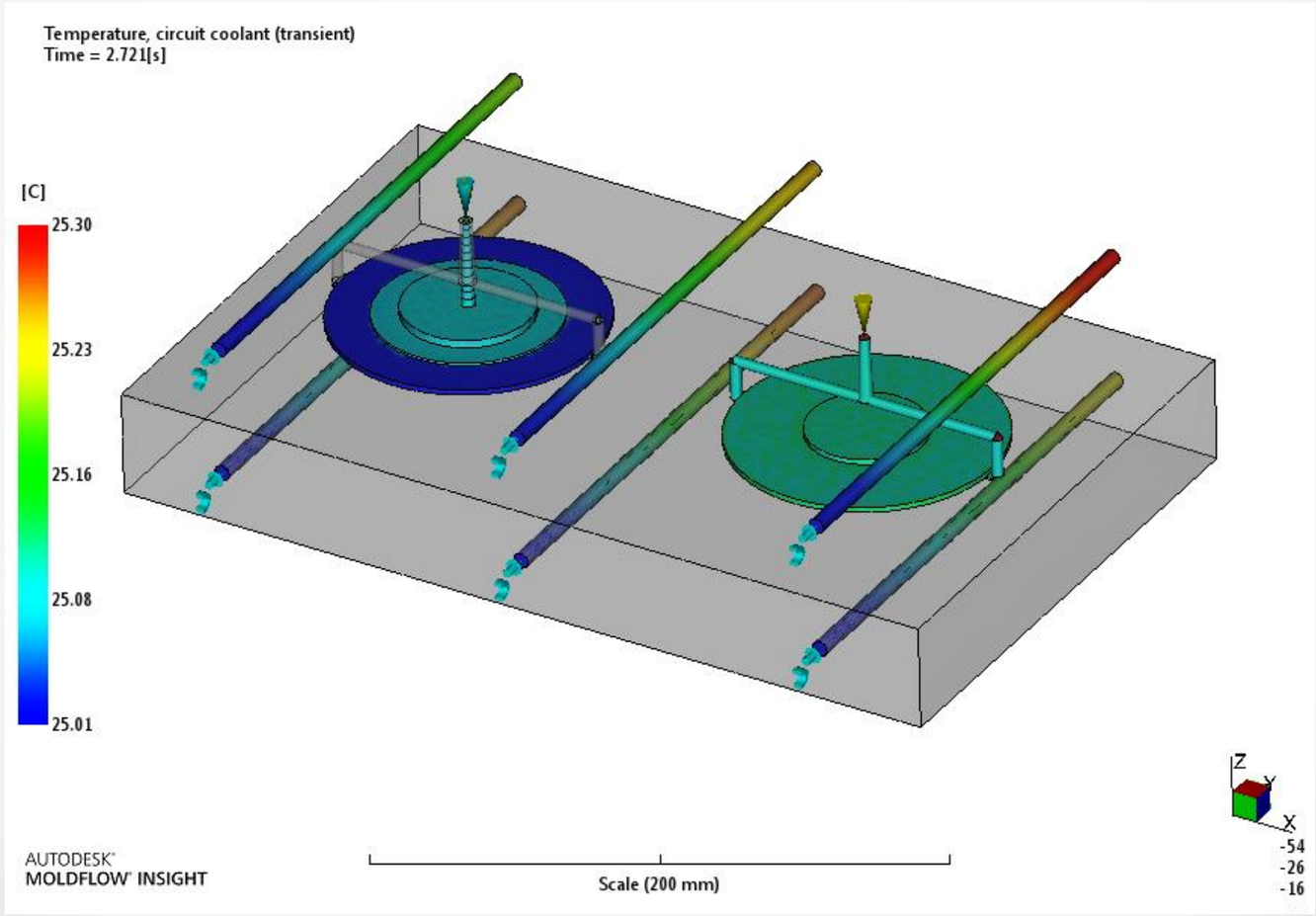


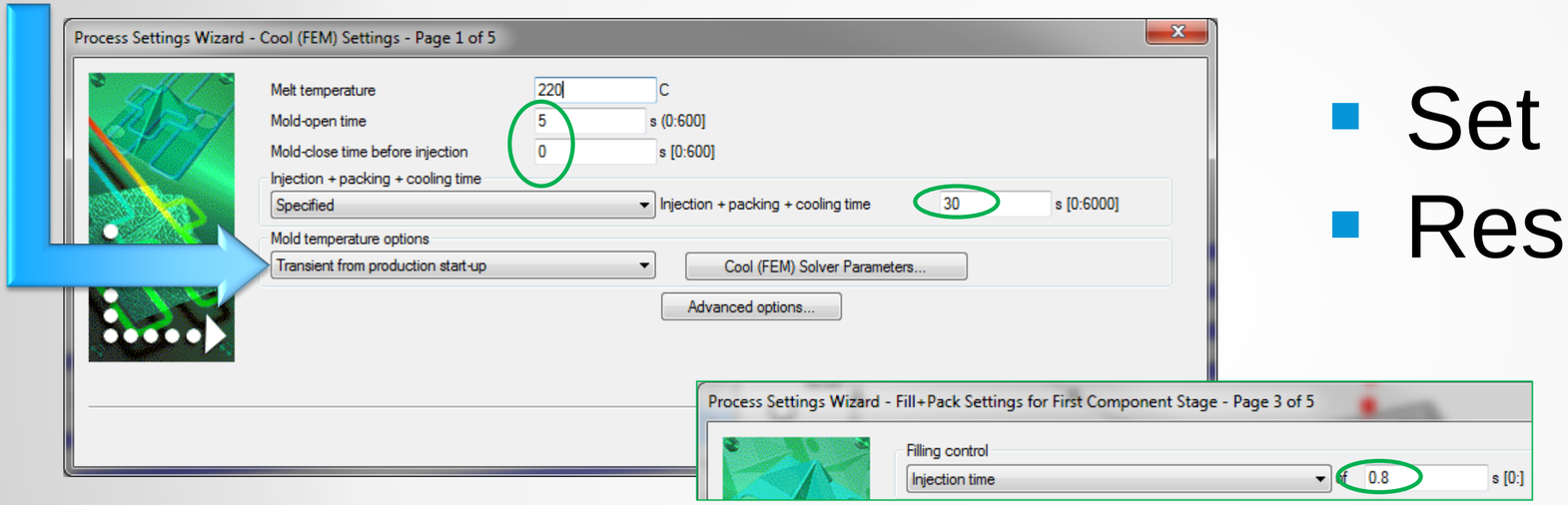
Mold Cooling Analysis for 2K-Overmolding

- Cool (FEM), Transient results across multiple cycles

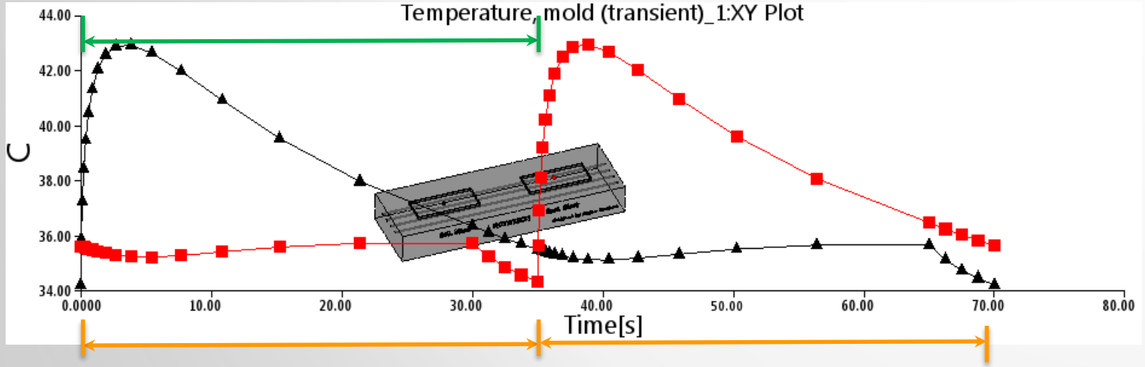


Mold Cooling Analysis for 2K-Overmolding

- Select “Transient from production start-up”

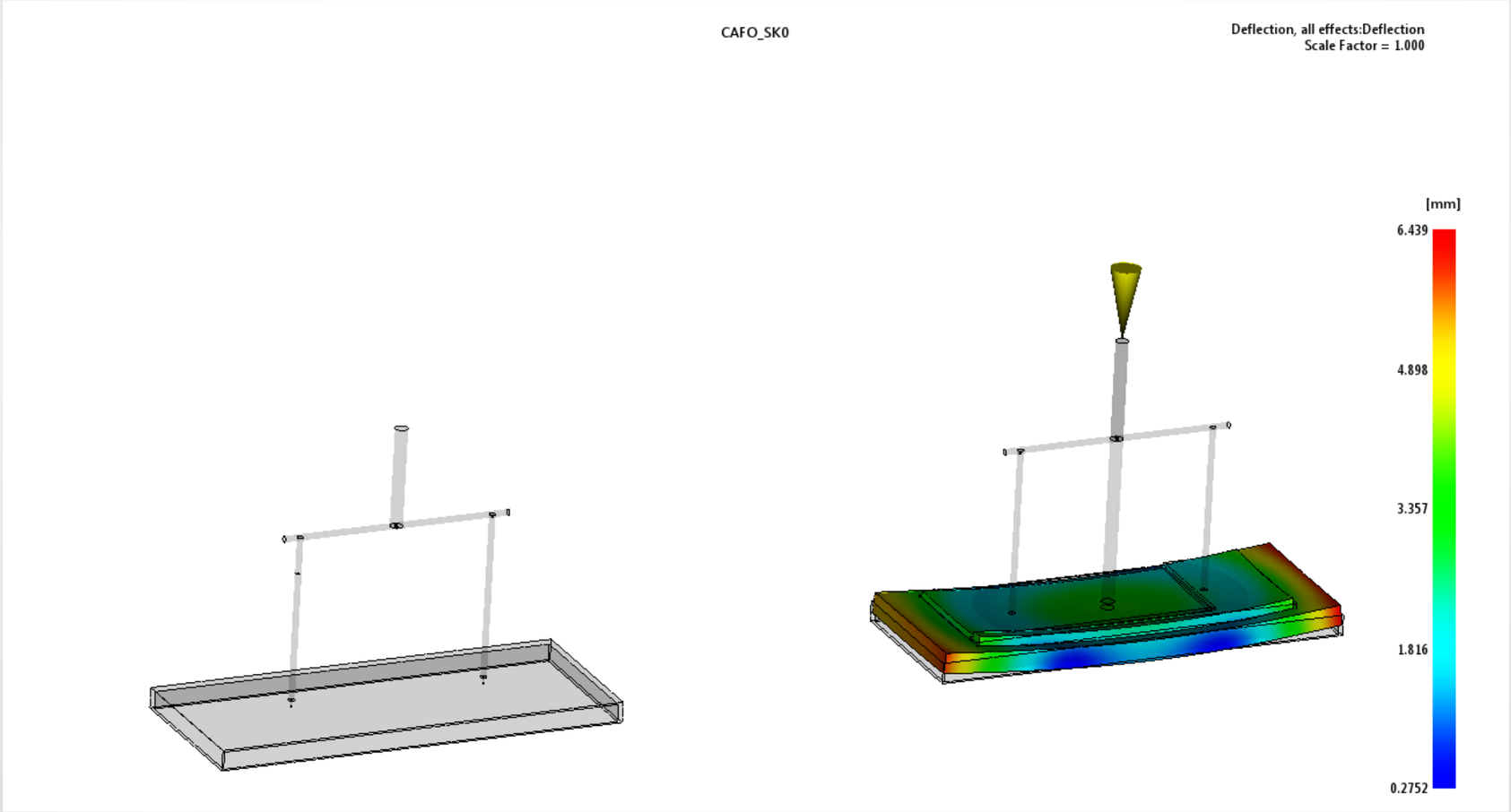


- Set up one cycle
- Results span two cycles



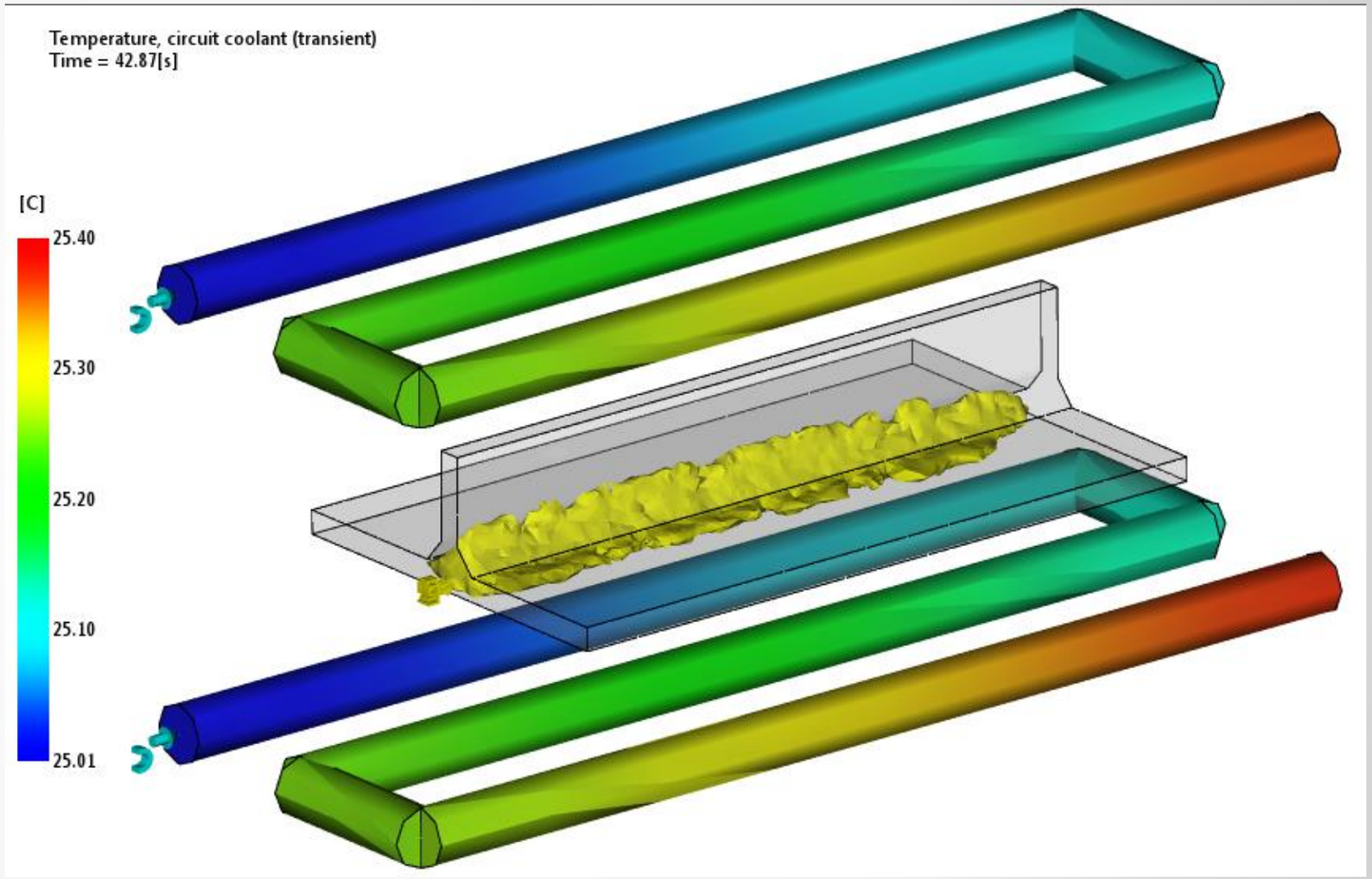
Mold Cooling Analysis for 2K-Overmolding

- Warpage analysis on final component only



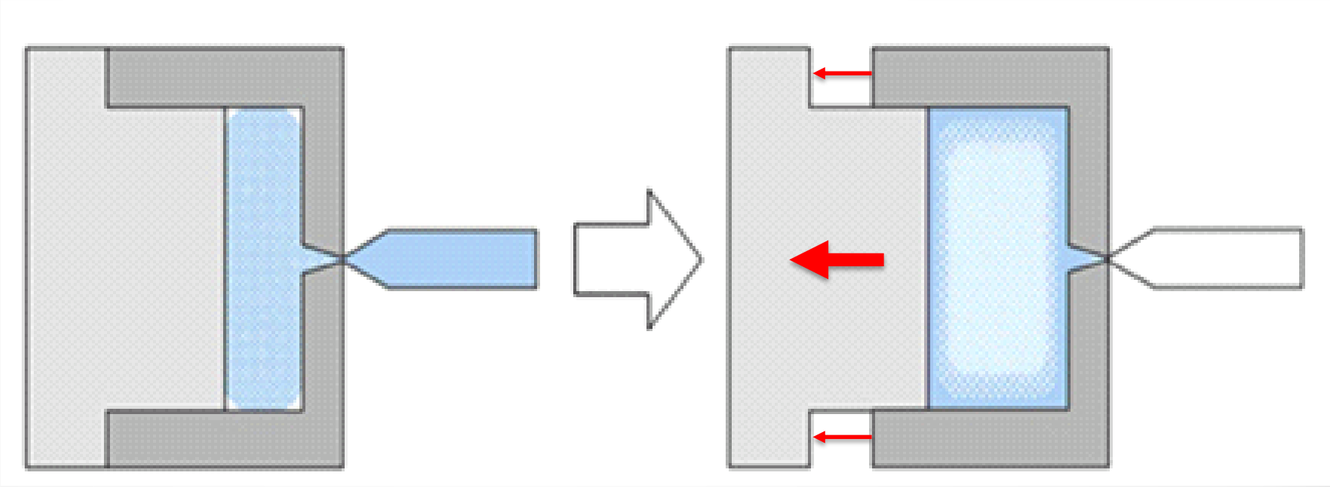
3D Cool analysis for Gas Injection Molding

- Cool (FEM)
  - An initial Flow (Gas) analysis is done to determine the gas core
  - Conduction or Flow on Every Iteration for part temperatures



Core-back for Microcellular Injection Molding

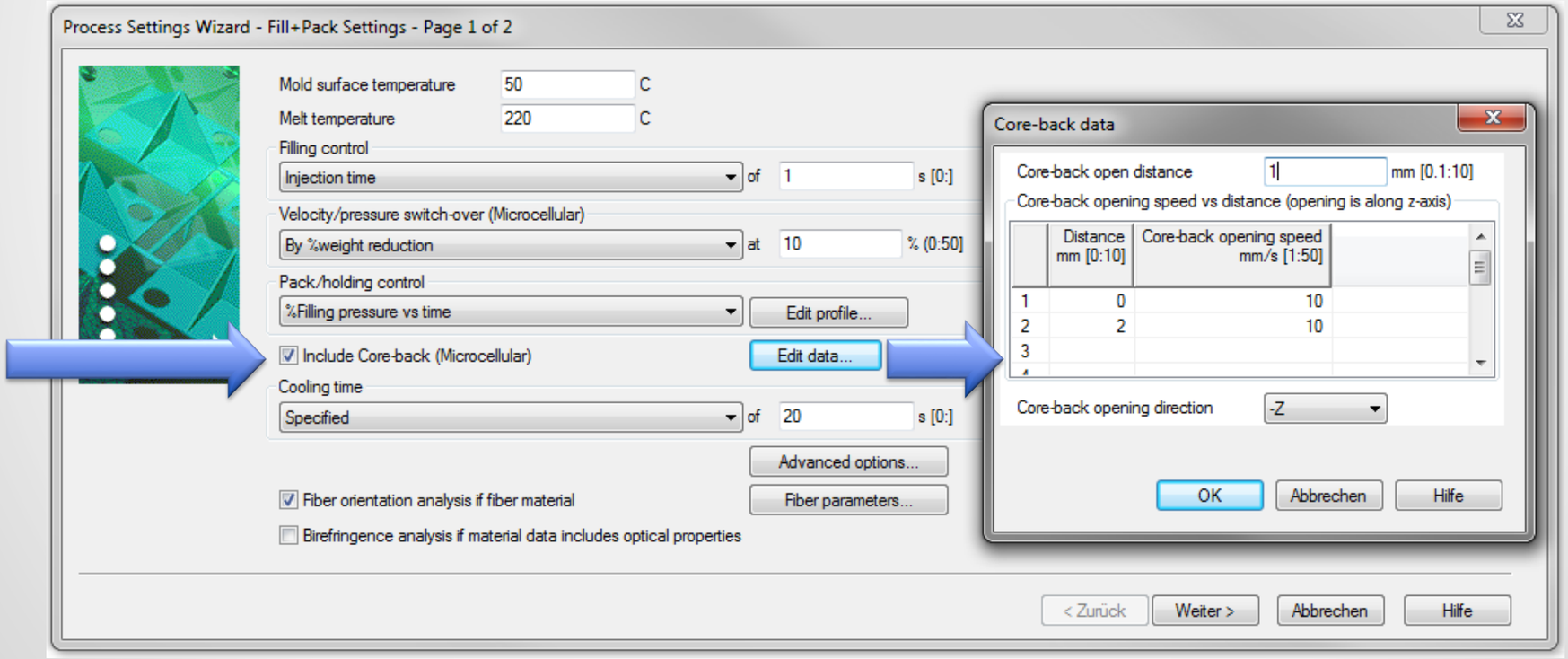
- Complete filling & packing before mold opening
- Partial Mold opening triggers Bubble nucleation and growth



- Advantages:
  - Better surface quality
  - Higher part expansion ratio

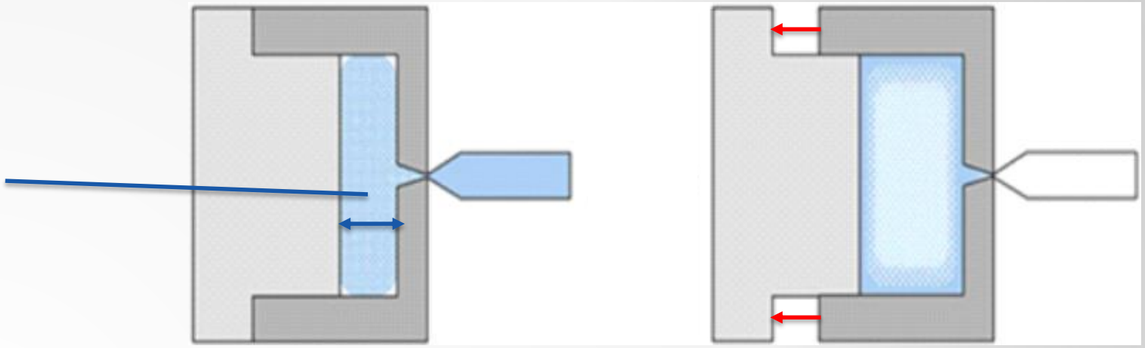
Simulation of Core-back Process for foaming

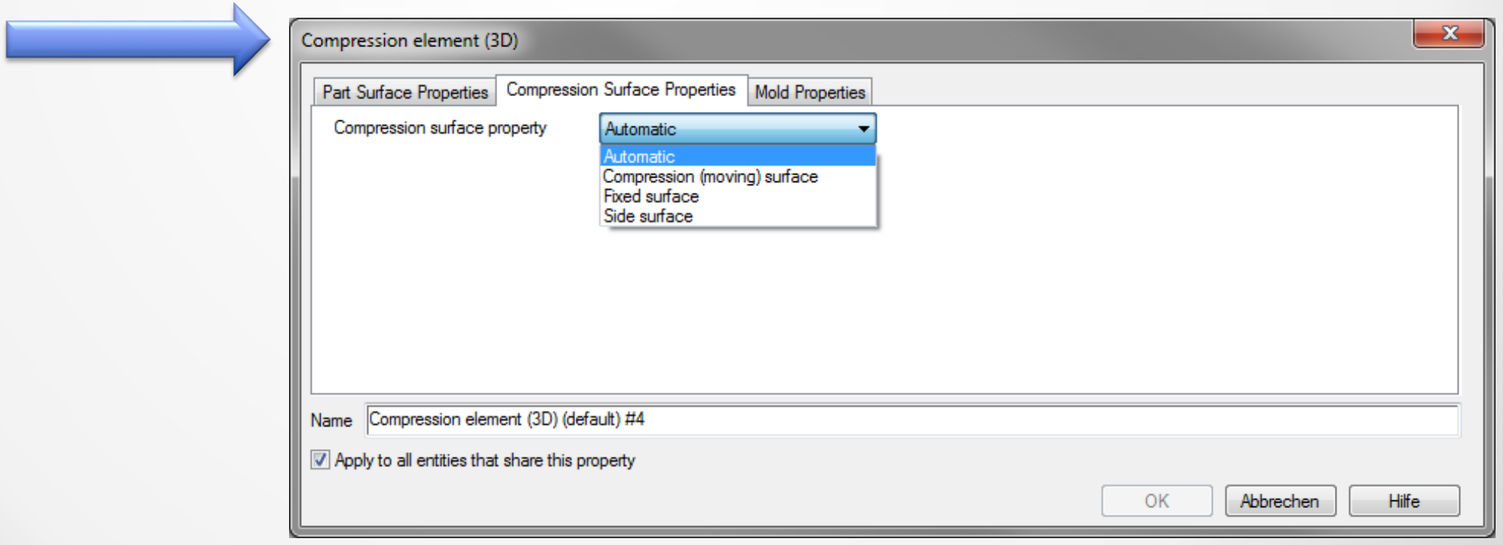
- New option for core back analysis "Include Core-back (Microcellular)"
- Input data for the core-back simulation (distance, speed & direction)
- The core-back mold opening will start at the end of packing phase.



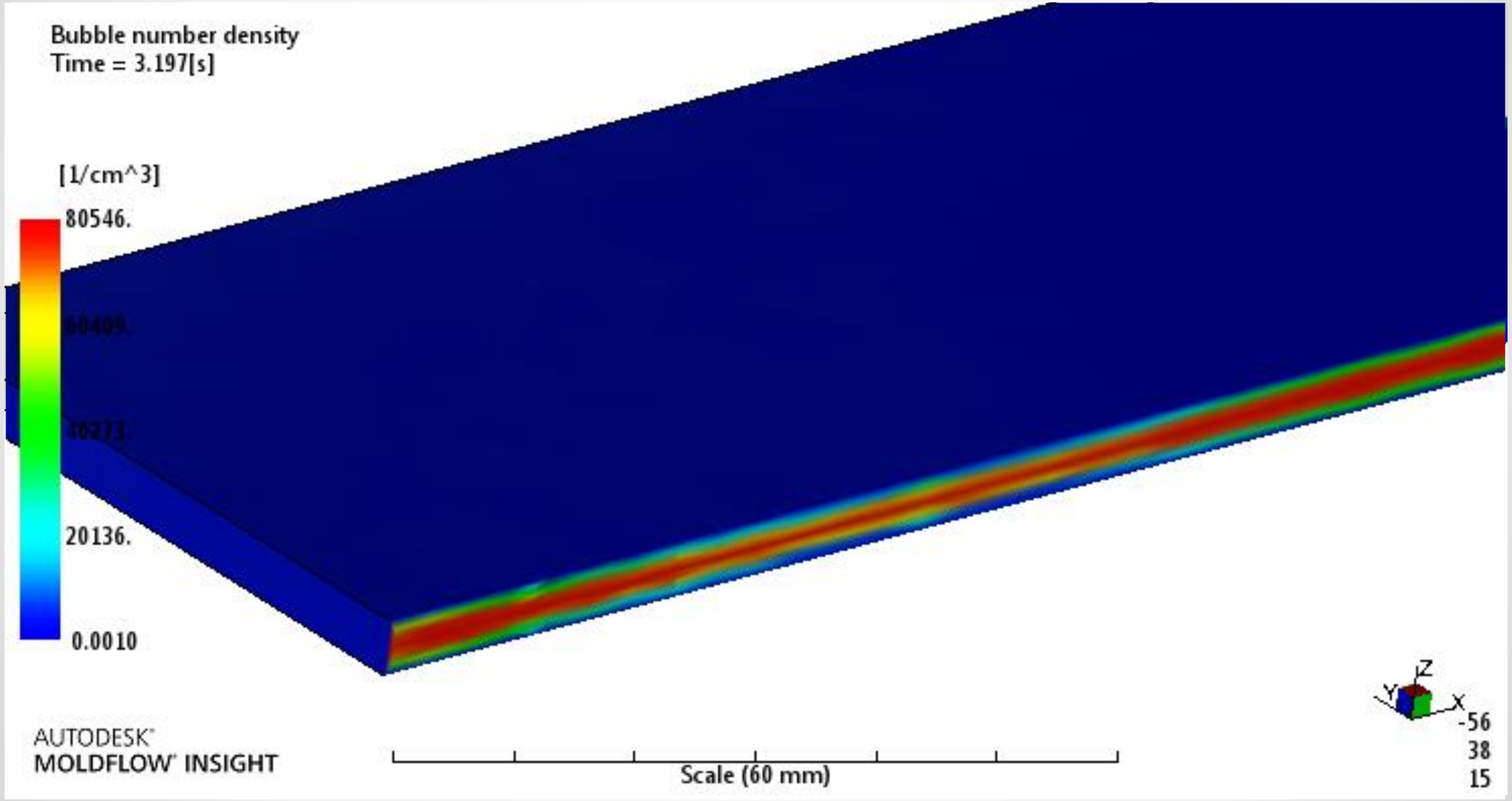
Simulation of Core-back Process for foaming

- 3D only
- The meshed geometry is the cavity before mold opening
- Use "Compression (3D)" element type



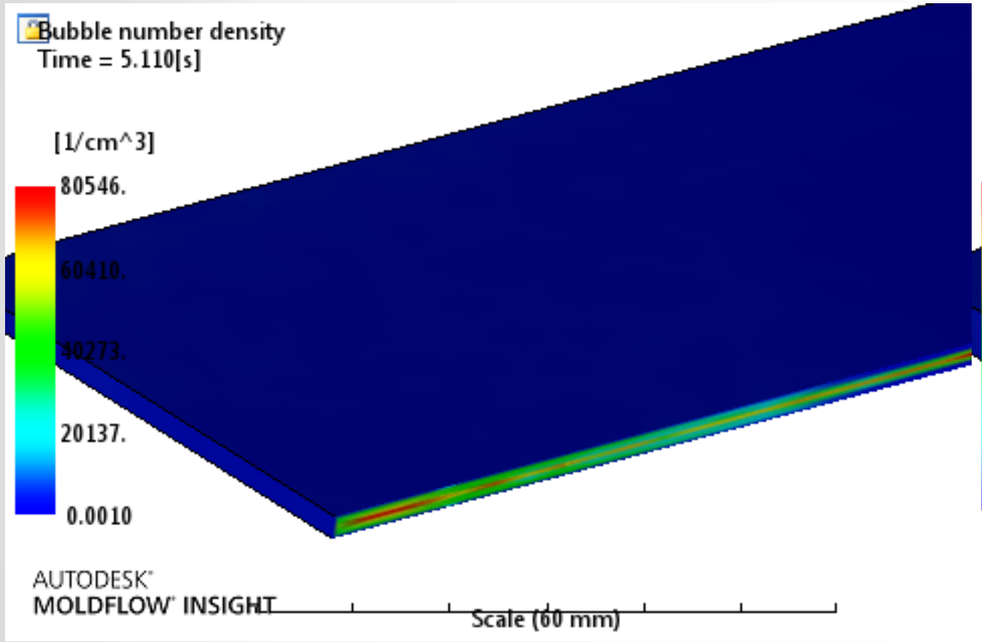


Core-back during Foaming: Bubble Density Result

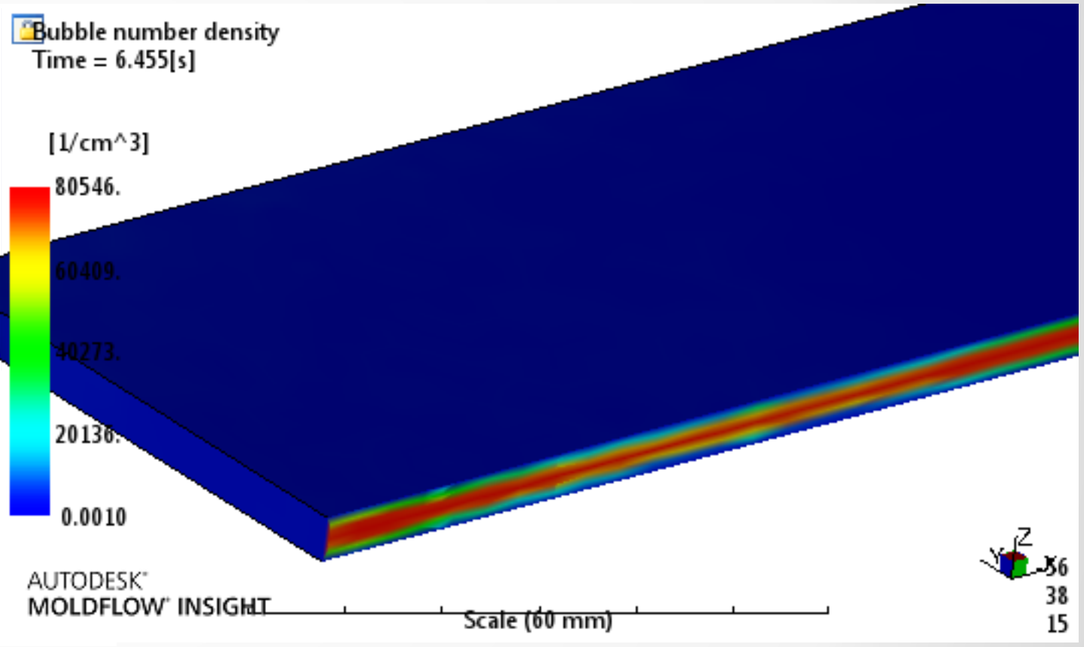


More Bubbles with Core-Back

No Core-Back

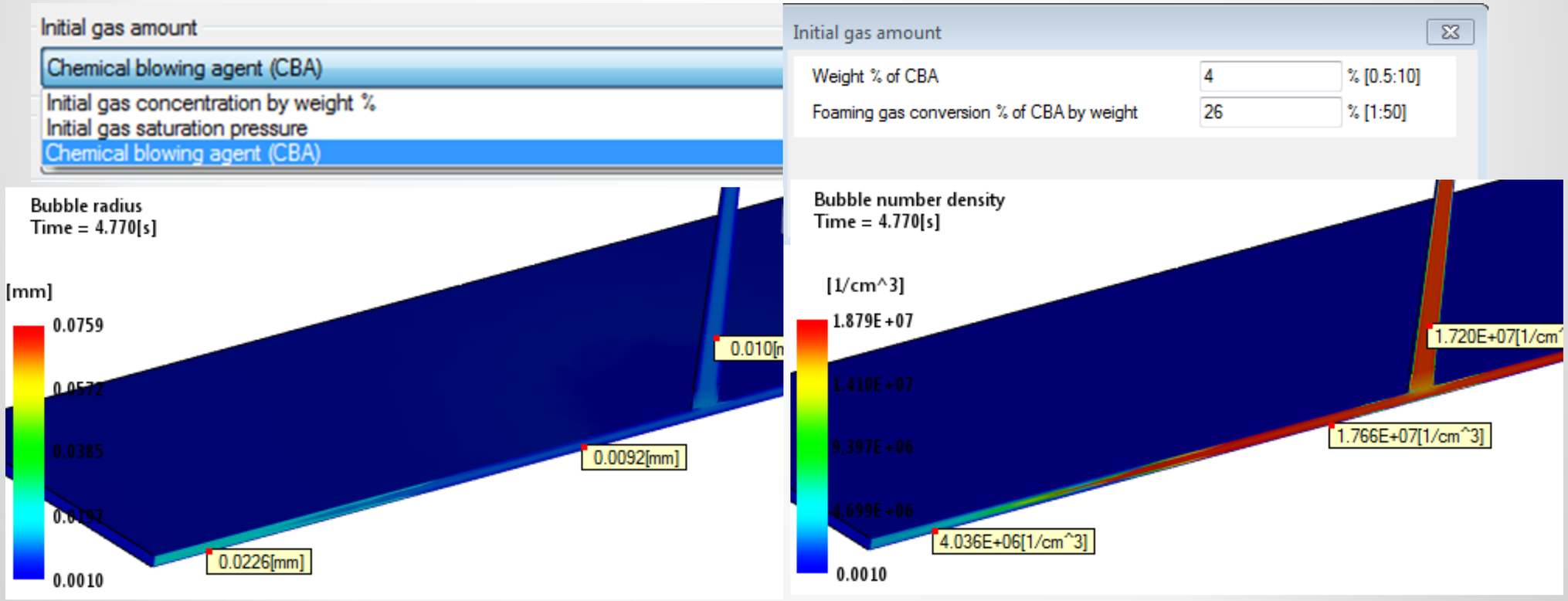


With Core-Back



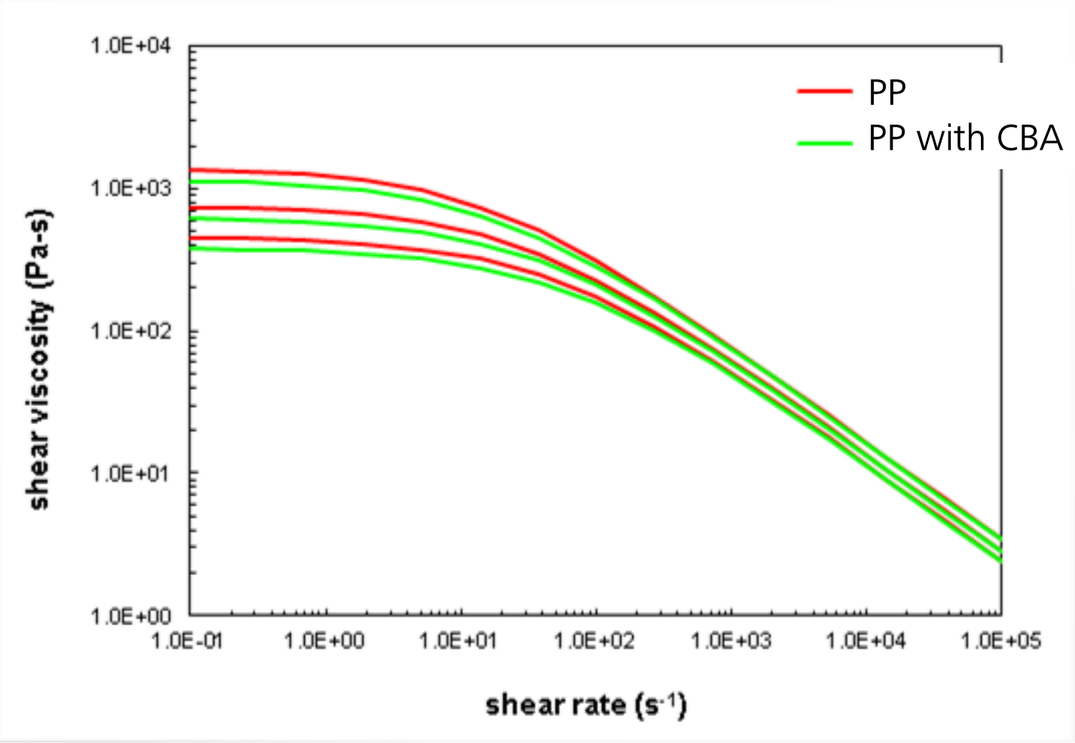
Foaming by Chemical Blowing Agent

- Chemical reaction in the barrel produces CO_2 in solution
  - Assume reaction is fully complete in the barrel



Foaming by Chemical Blowing Agent

- Research Project: Tested viscosity for a PP with 4wt% Chemical Blowing Agent (CBA)
  - Injection Molding Rheometer with shutoff valve

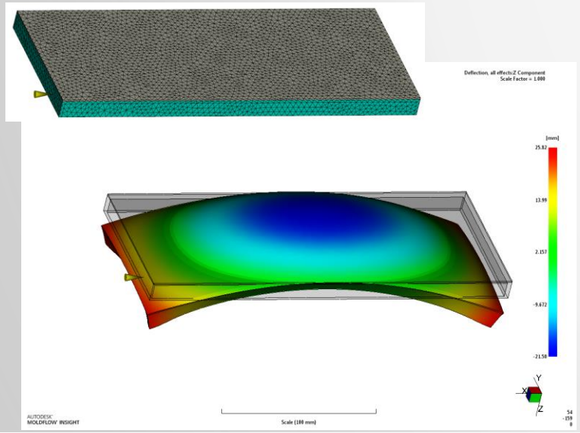


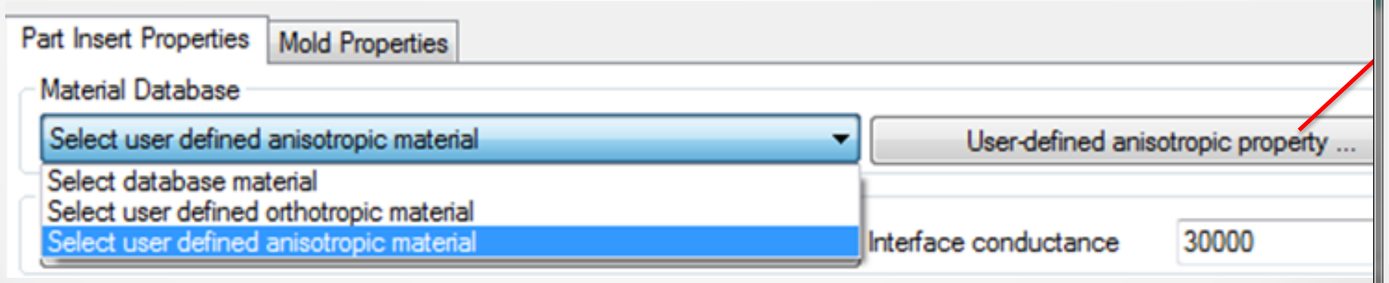
Gas content: 1wt%
Only a small effect on shear viscosity

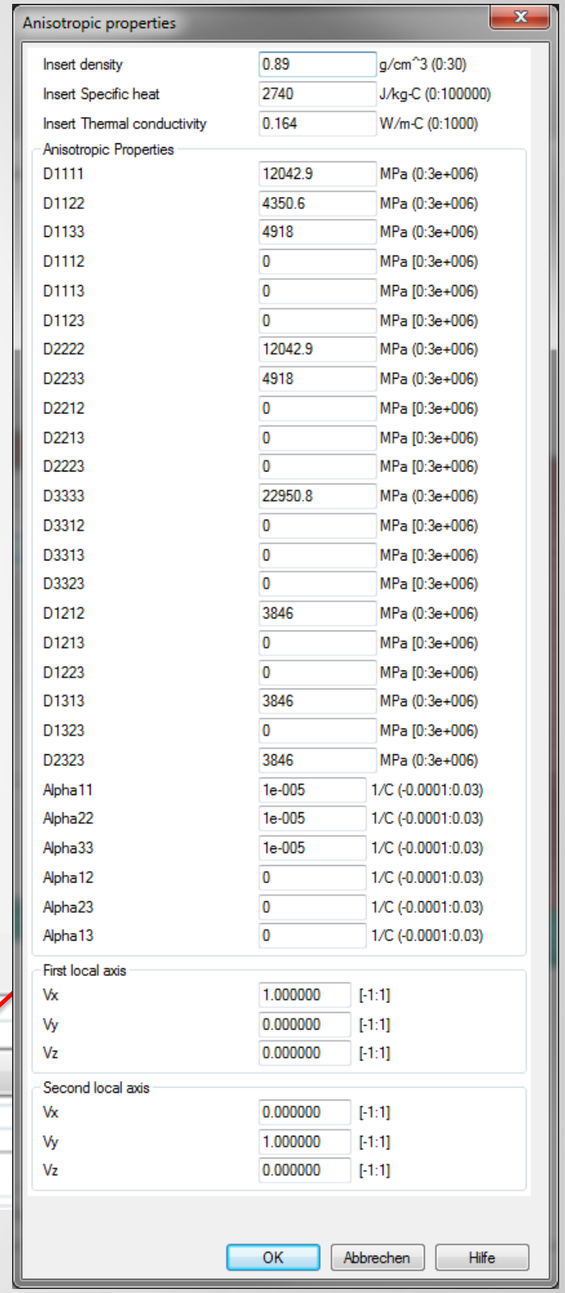
$$\eta = \eta_r(1-\phi)^{v_1}\exp(v_2 c + v_3 c^2)$$

Anisotropic Part Inserts

- Use anisotropic properties in Core-shift and 3D Warp
  - Elastic and Thermal Expansion
  - Useful for composite inserts from draping processes
  - Used to describe <u>any</u> local material properties
    - Local - Can be per element

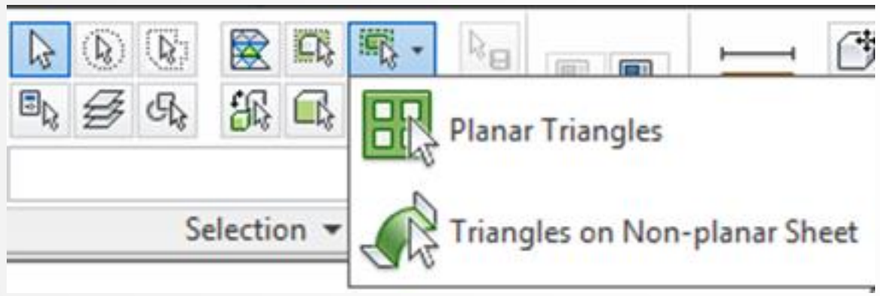


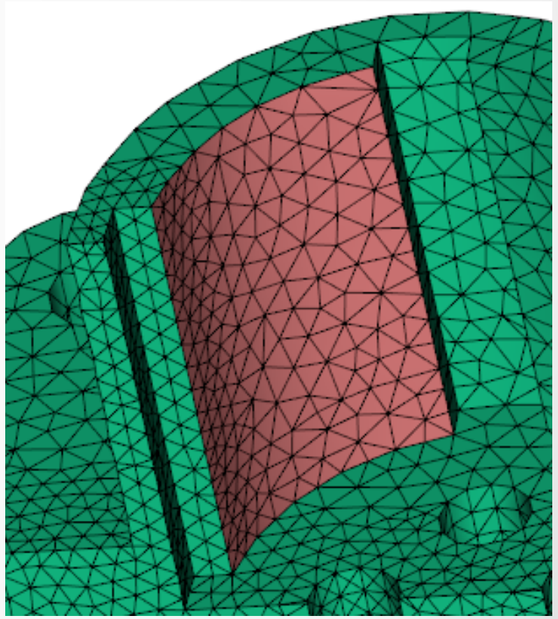




Mesh Editing:
Select Elements on Non-planar Surface

- First Select an element
- Use these tools to expand the selection for the entire surface

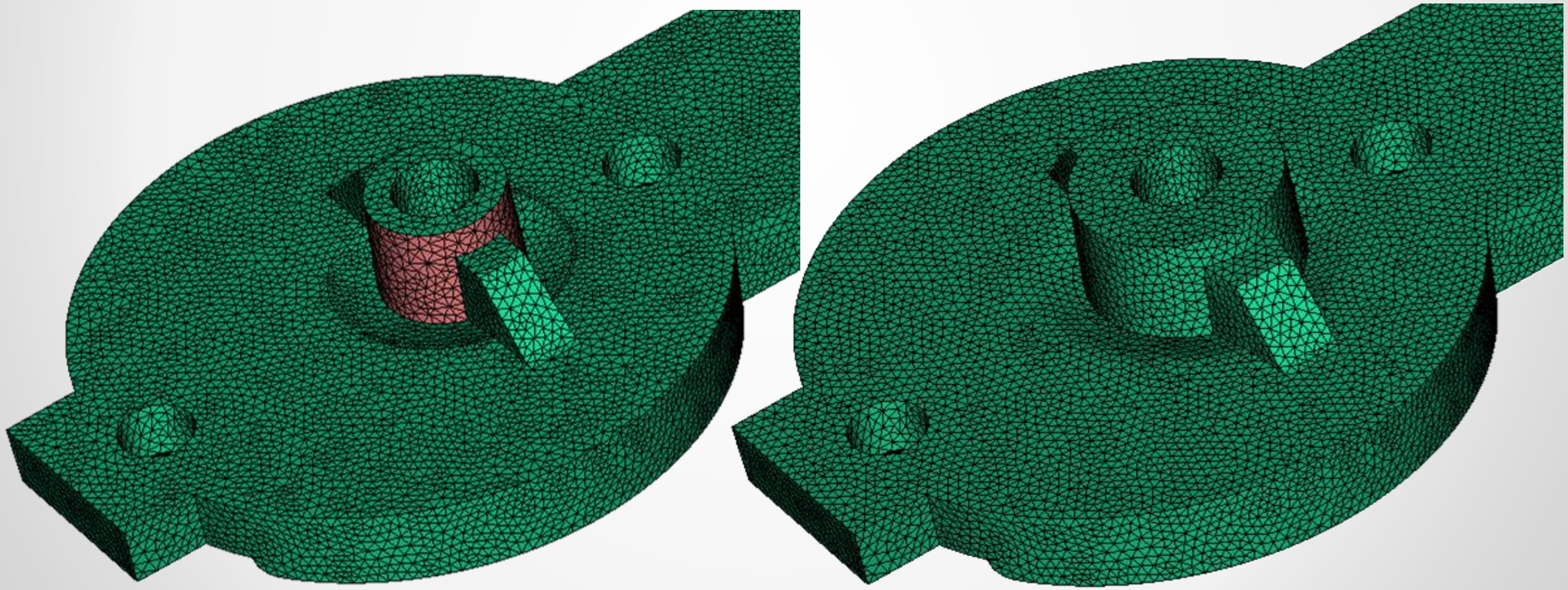




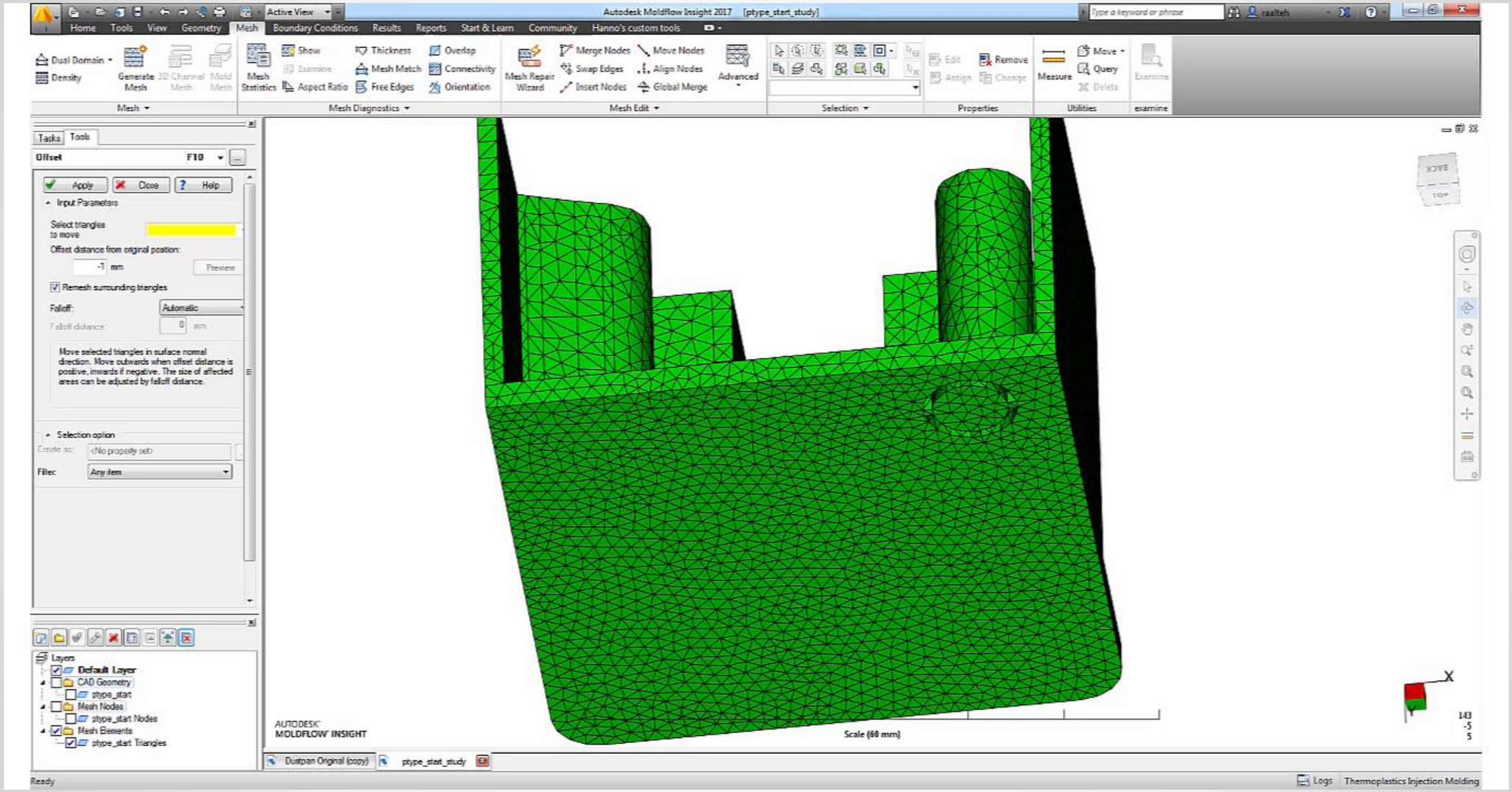
- Can select multiple elements on multiple surfaces

Geometry Modification by Mesh Editing: Offset

- Modify Surface Mesh to change dimensions or thicknesses
  - Remesh or stretch neighbouring elements

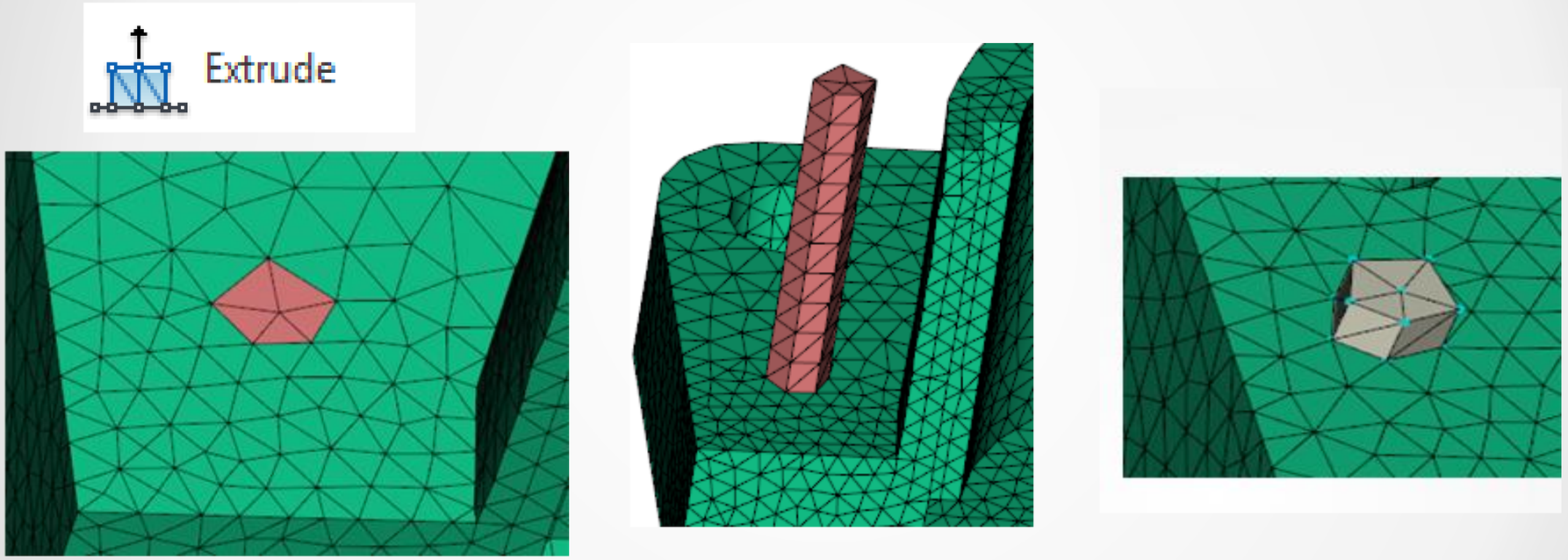


Selection and Modeling Tools Demo



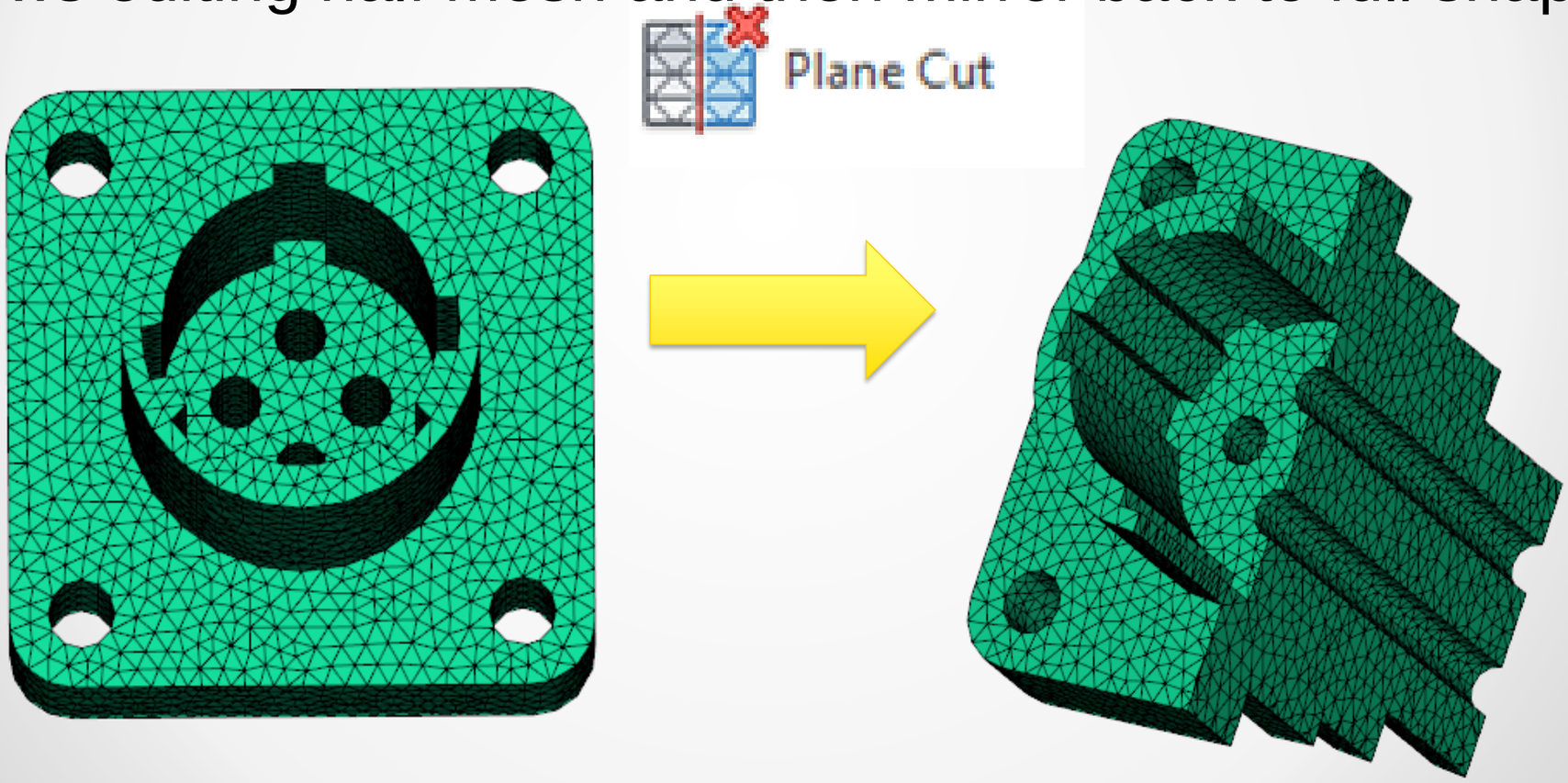
Geometry Modification by Mesh Editing: Extrude

- Either modify an existing body, or create a new body



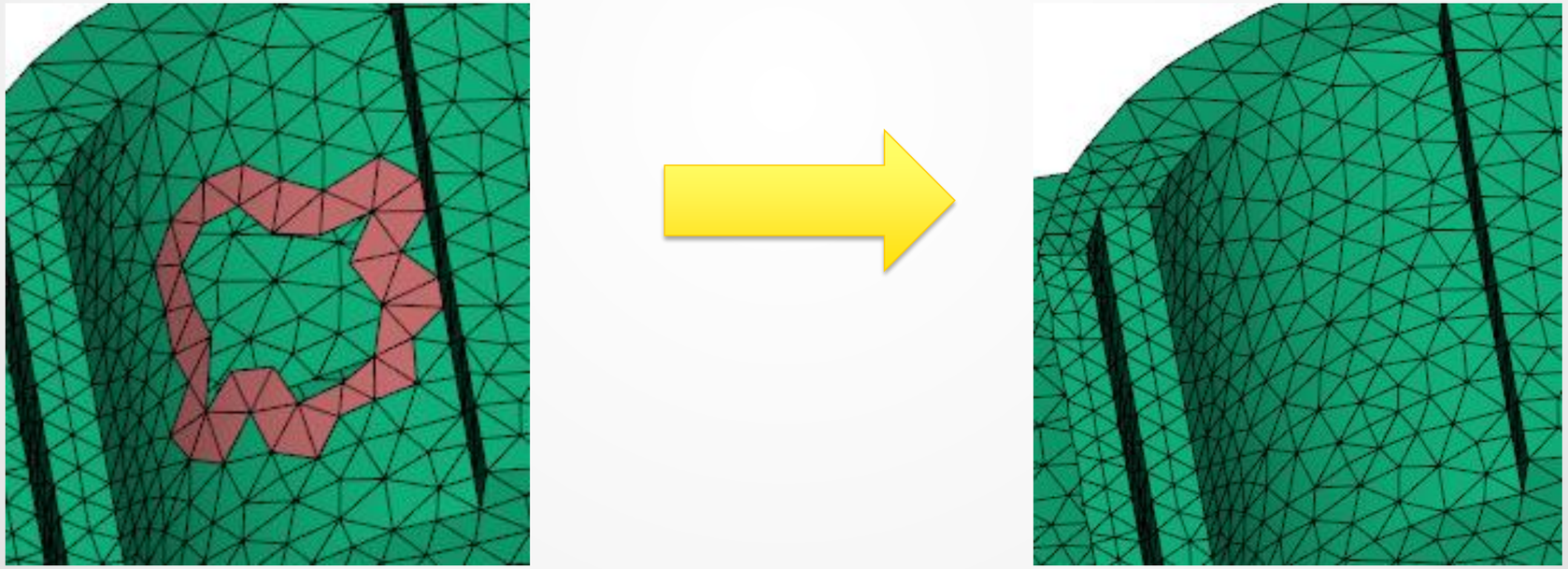
Geometry Modification by Mesh Editing: Plane Cut

- Optional: Fill (mesh) the hole after cutting
  - Allows editing half mesh and then mirror back to full shape



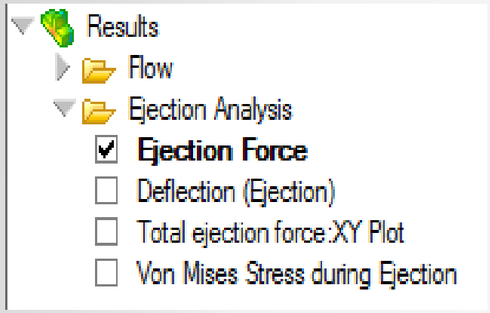
Geometry Modification by Mesh Editing: Fill Hole

- Search to highlight all elements around the hole
  - Will follow curved surface shape

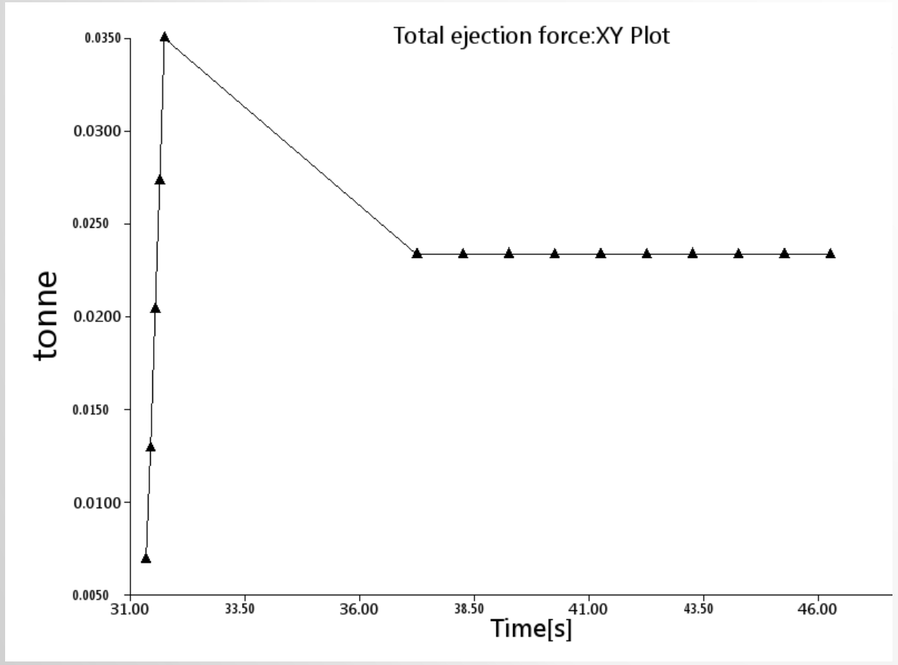


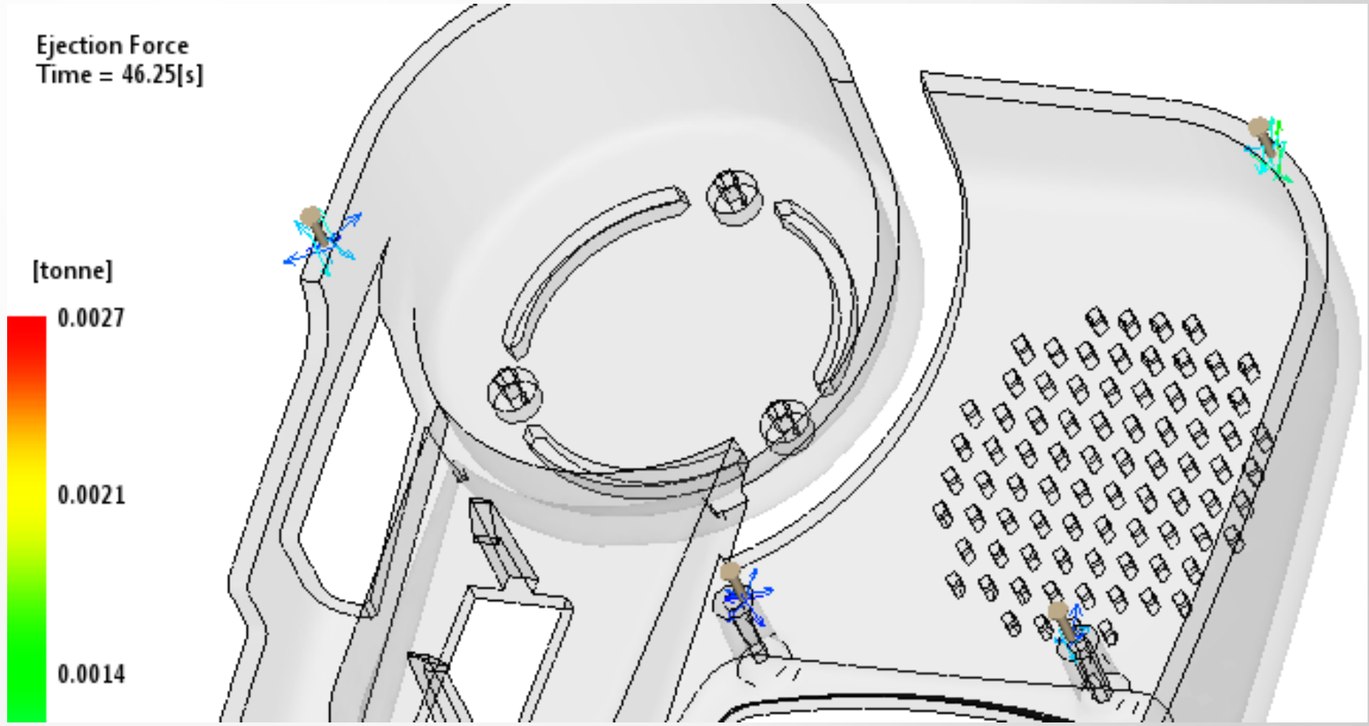
Ejection Analysis: Force from Ejectors

Scandium Only



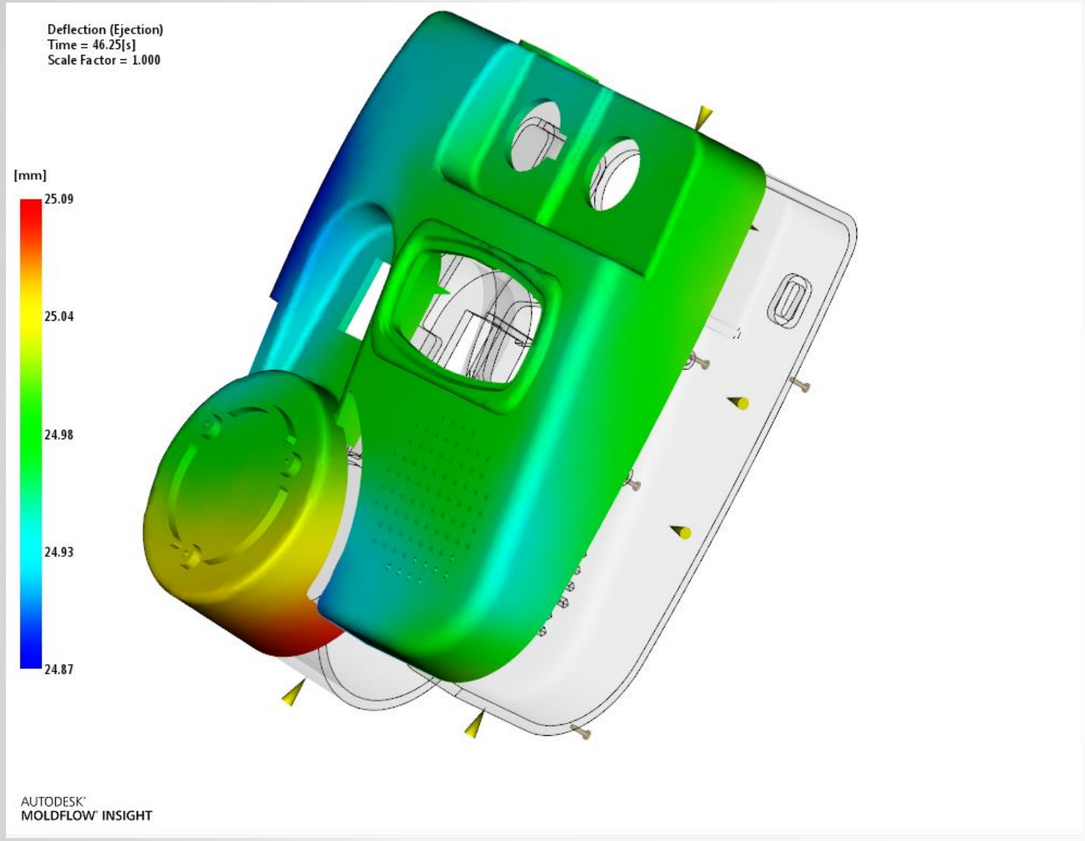
- Using embedded Nastran FEA solution
- Useful to check for balanced ejection and avoid visible stress marks



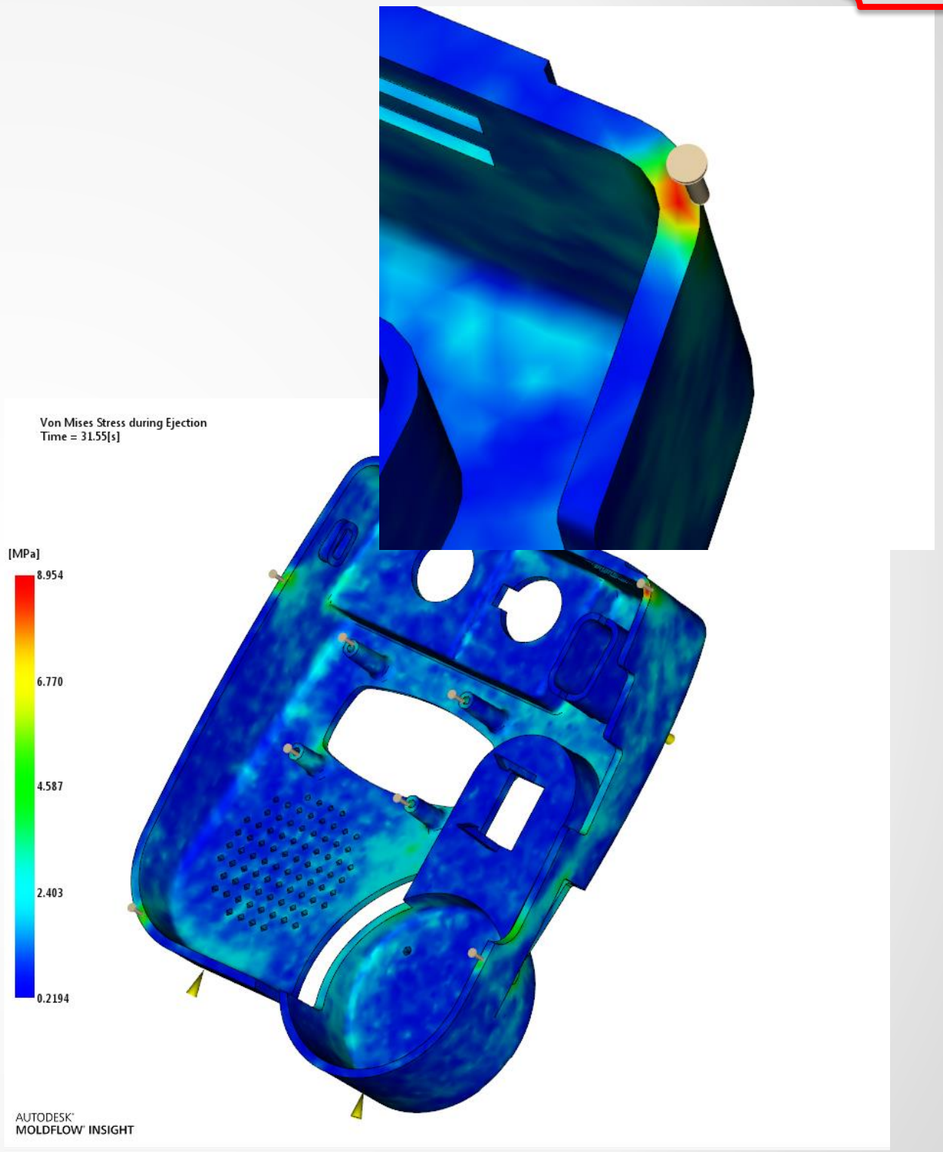


Ejection Analysis

Scandium Only



Deflection During Ejection

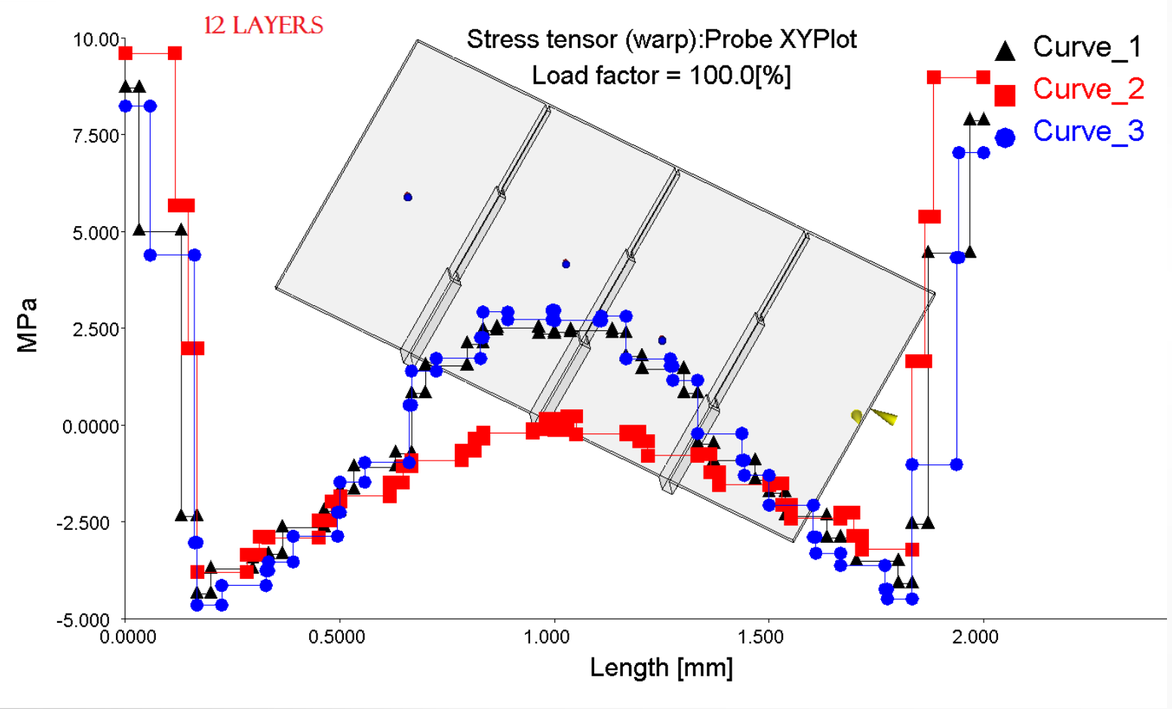


Von Mises Stress During Ejection

3D Residual Stress: Post-warp

Scandium Only

Phase 1: Assume full mold constraint



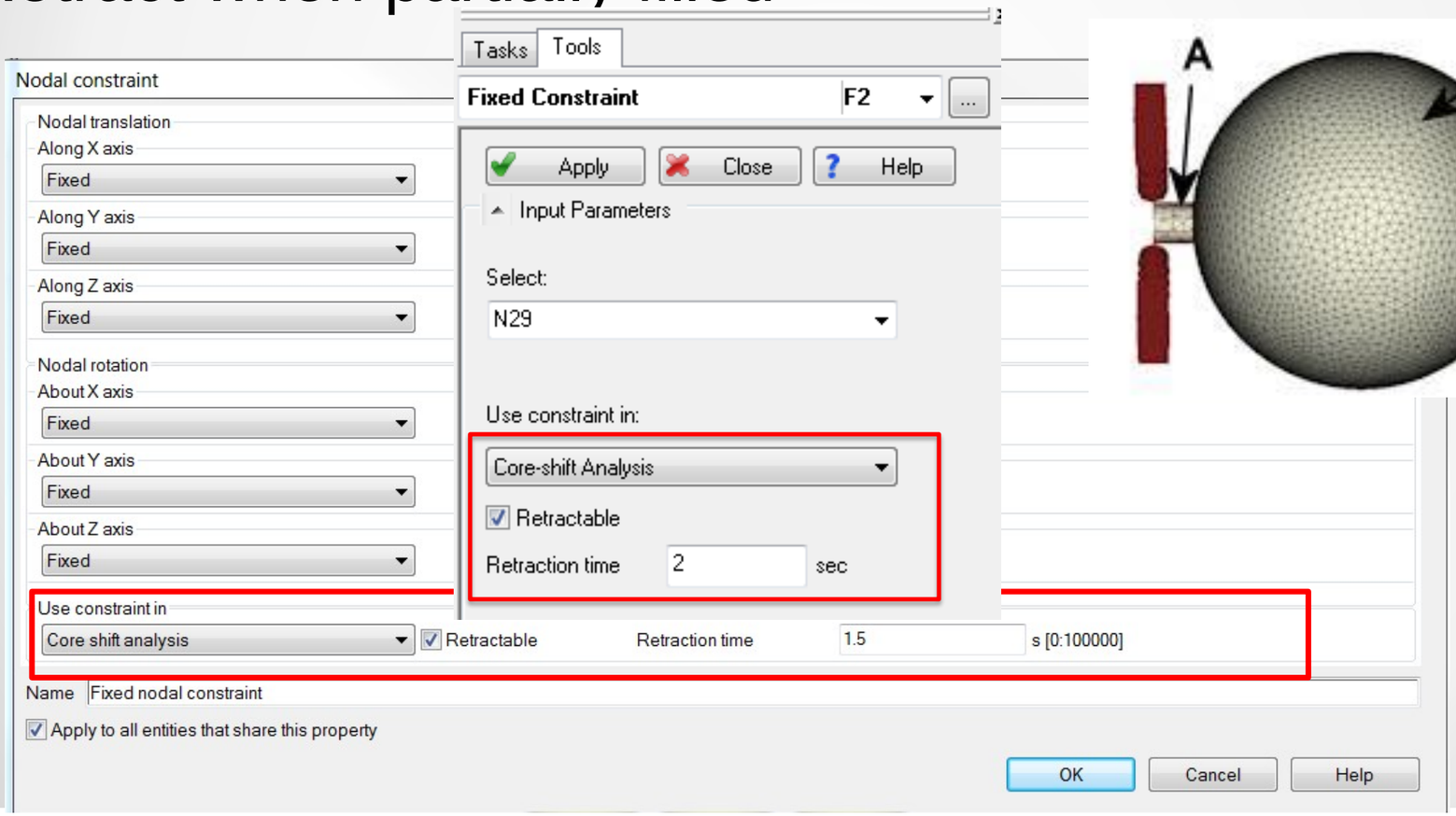
Next Phases: Stress evolution

- Detachment from mold (before ejection)
- Consider viscoelastic stress relaxation

Retractable Core pins

Scandium Only

- Supports part insert until pin is retracted
  - Retract when partially filled



How to get Scandium Technology Preview

- labs.autodesk.com
  - Search for “Scandium”

- Features
  - Cool for 2K-Overmolding
  - Cool for Gas
  - Core-back for Foaming
  - Chemical Blowing Agent
  - Anisotropic Part Inserts
  - Mesh (geometry) editing
  - Ejection Force
  - Residual Stress
  - Removable core pins
  - Wall-Slip

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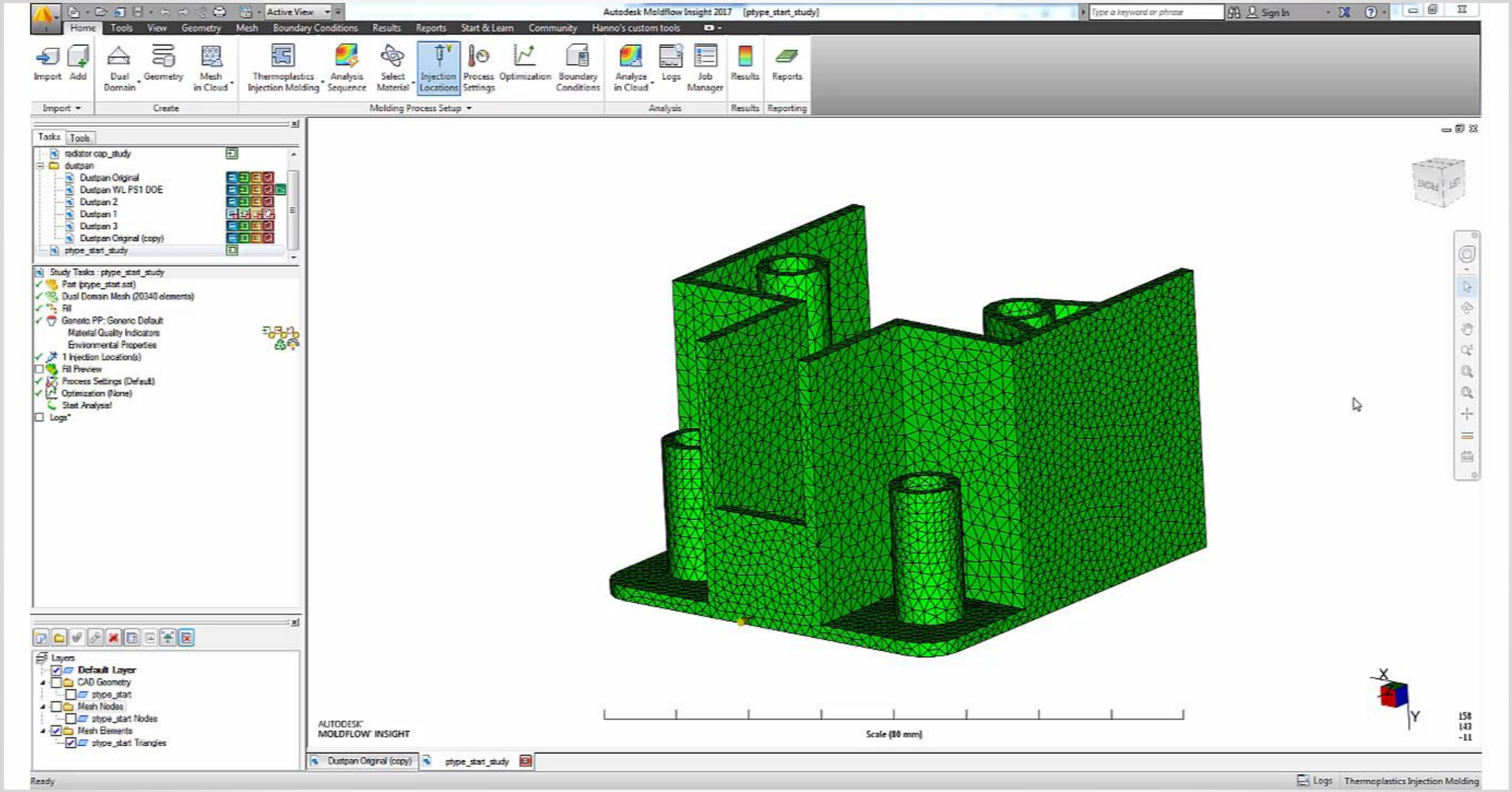
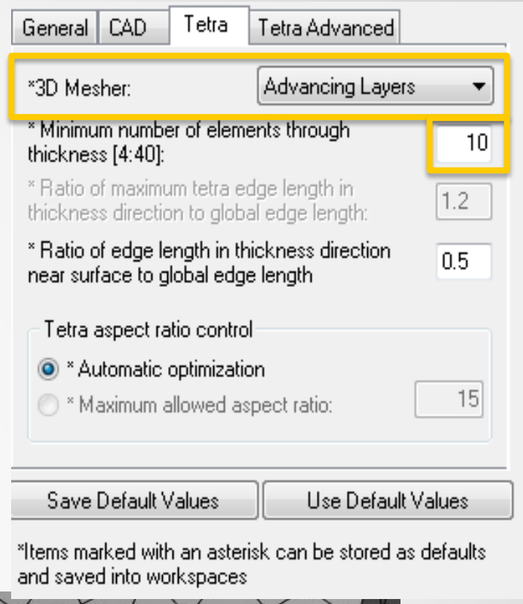
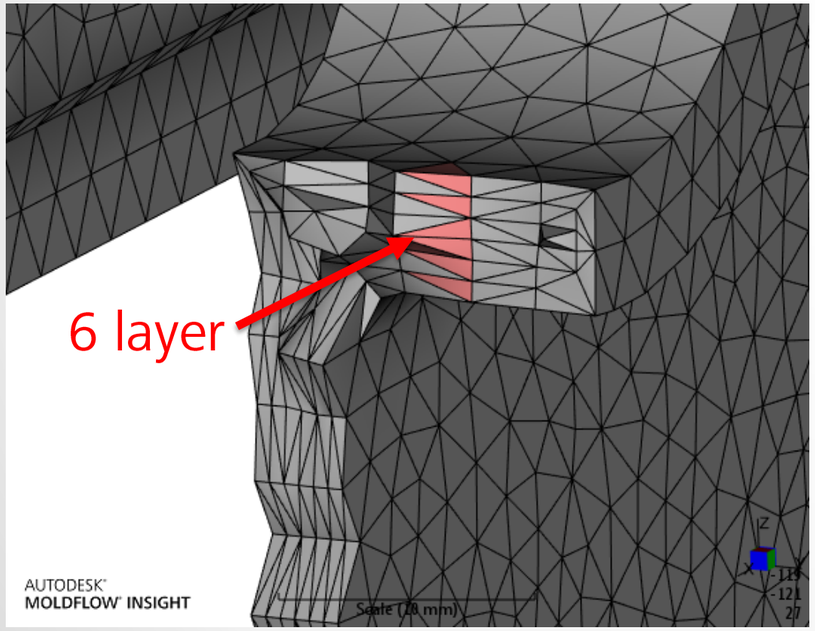
Local, Network and Cloud Solving and Meshing



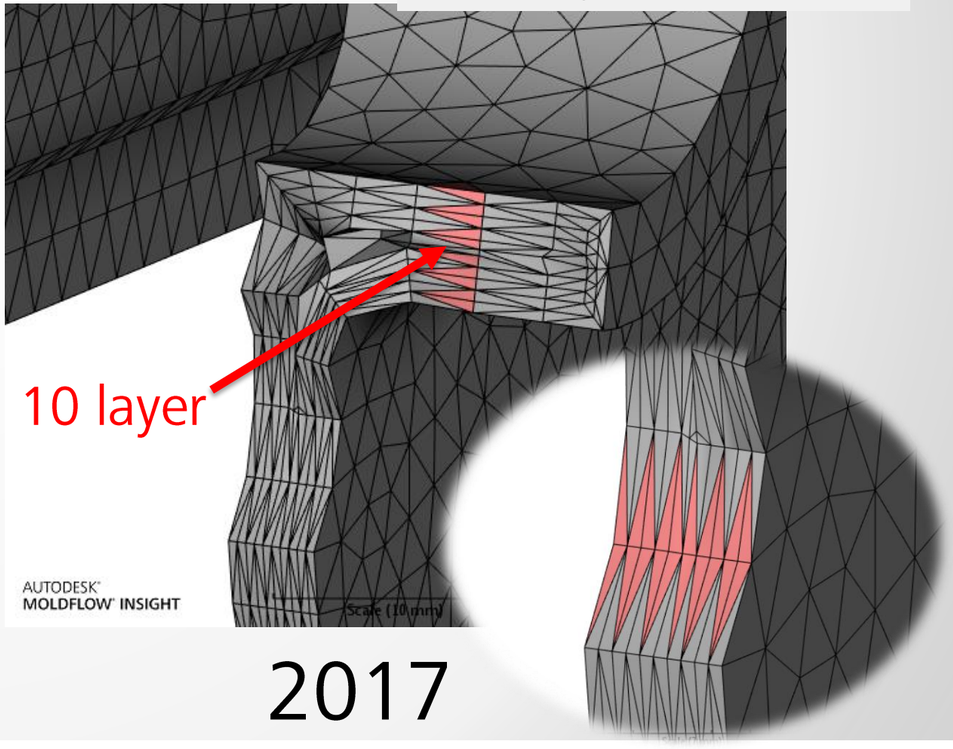
New 3D mesher: Advancing Layers

- Improved structure
- 10 layer Tet mesh by default.





2016



2017

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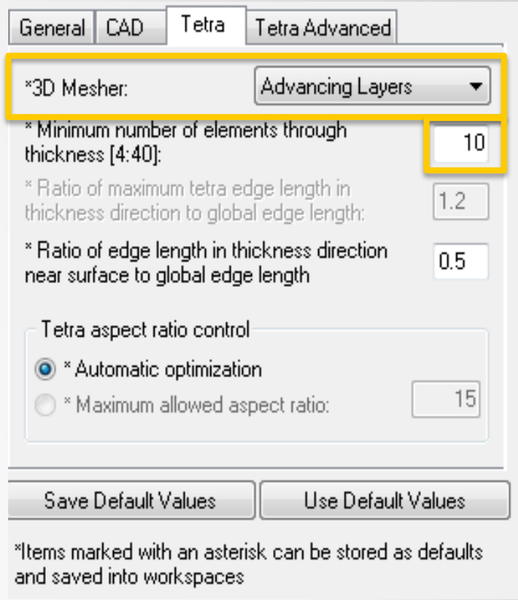
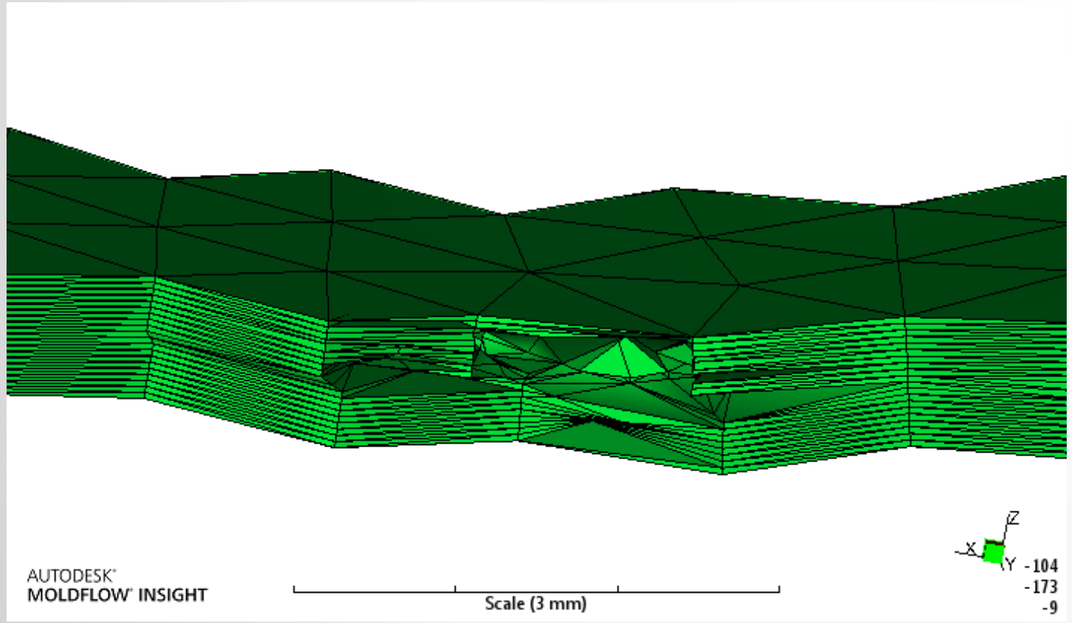
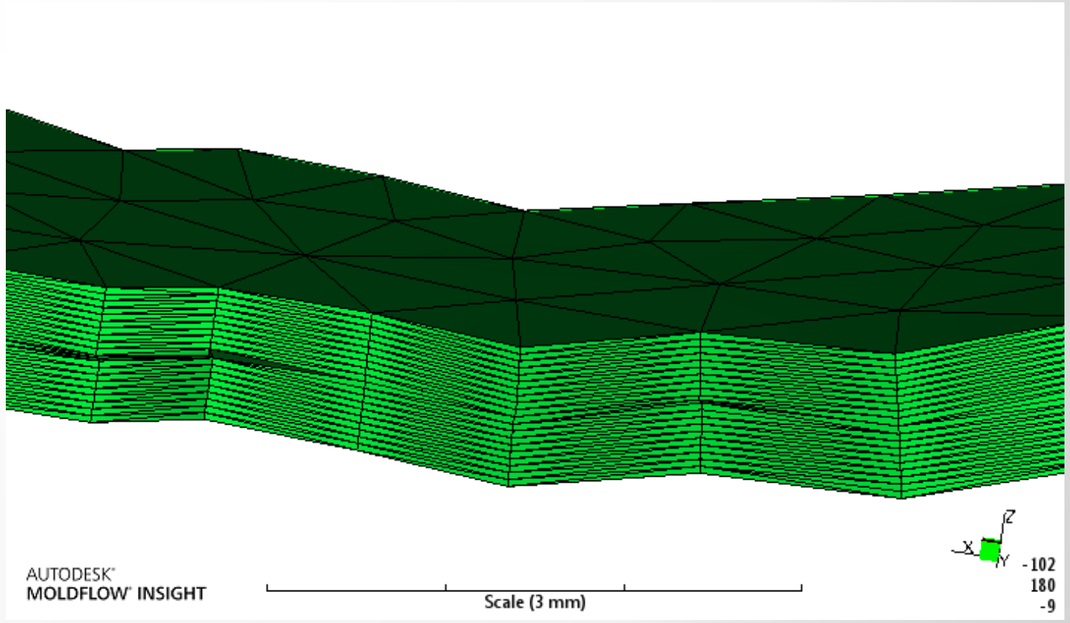




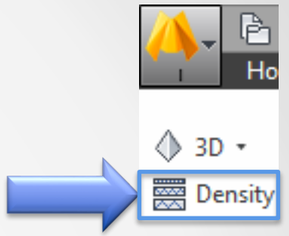
2016

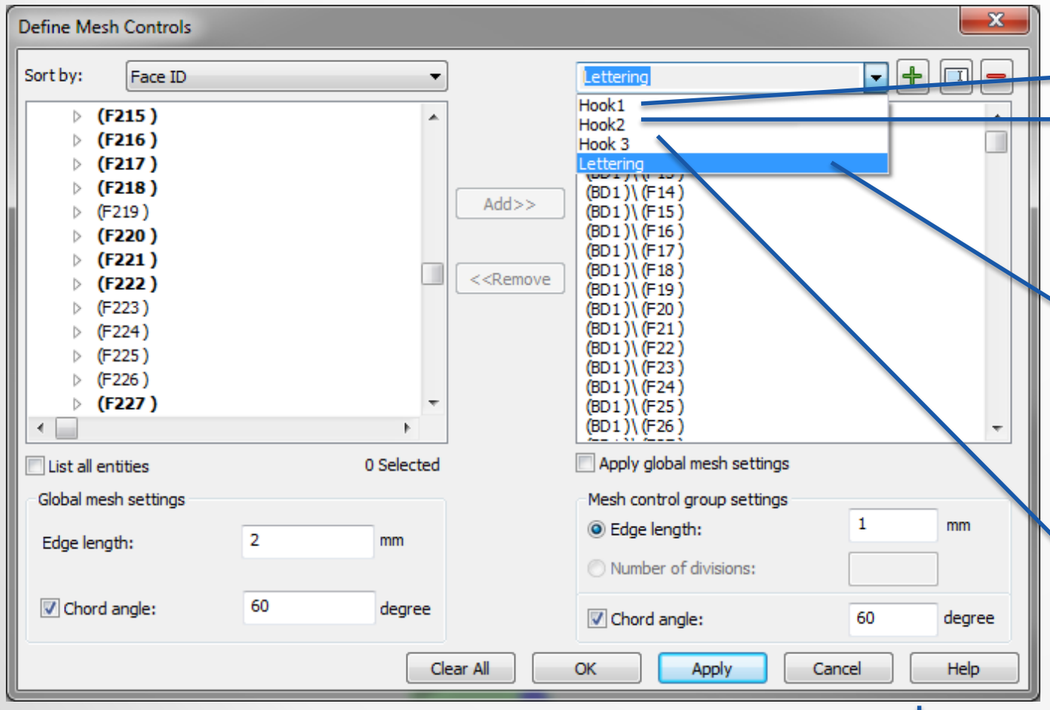


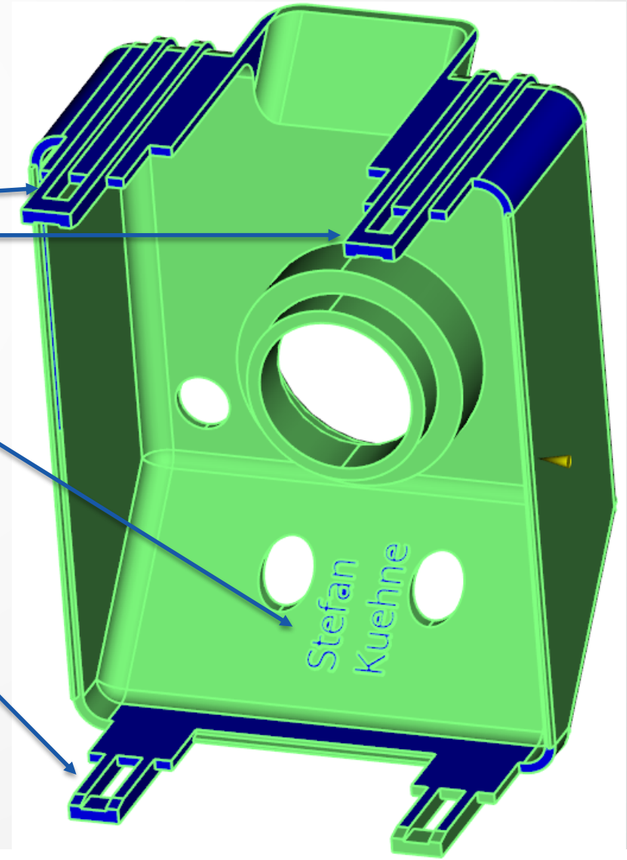
2017

Local mesh density assignment

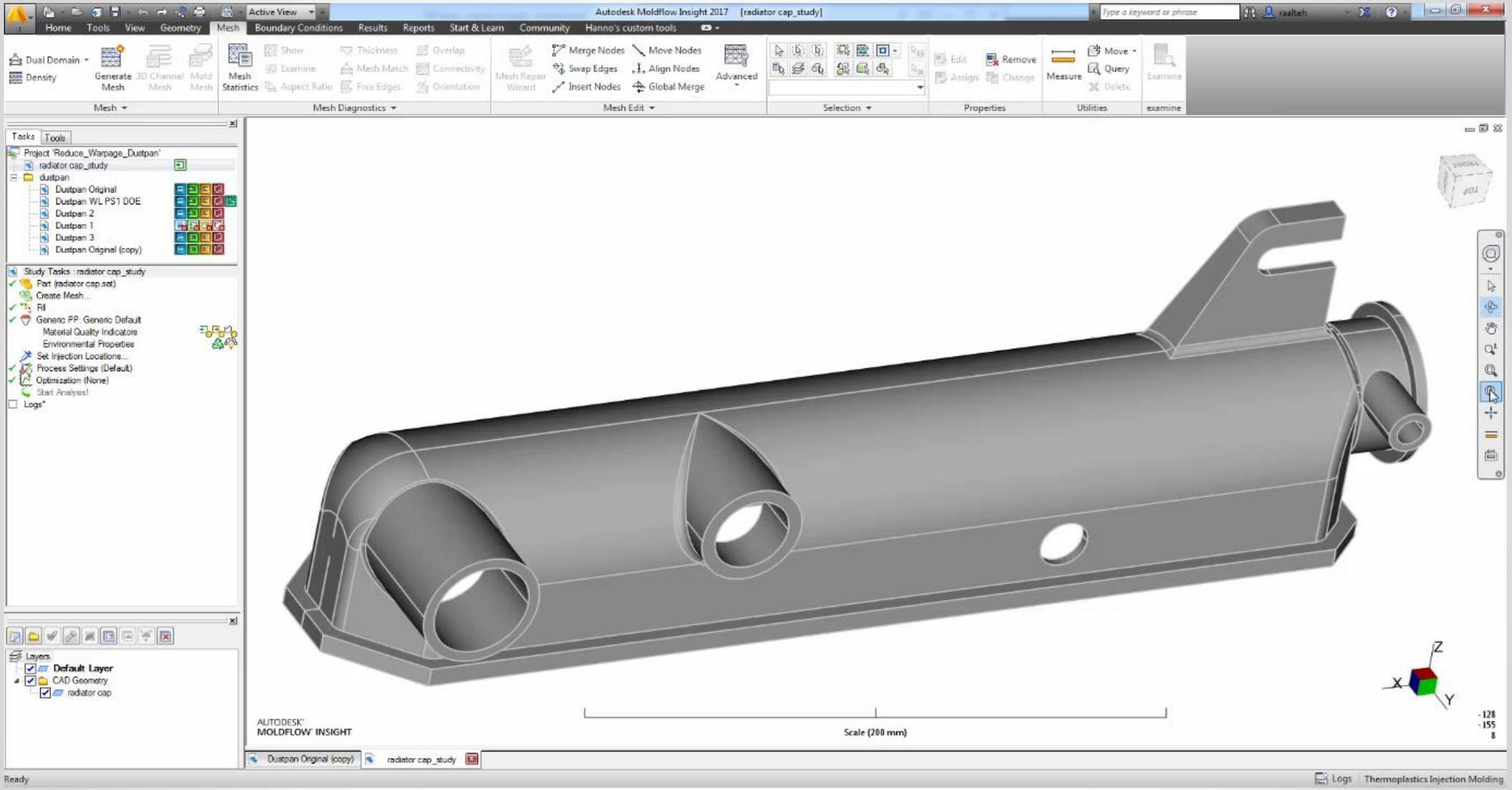
- Improved usability
  - Define several mesh density groups
  - Group will be highlighted



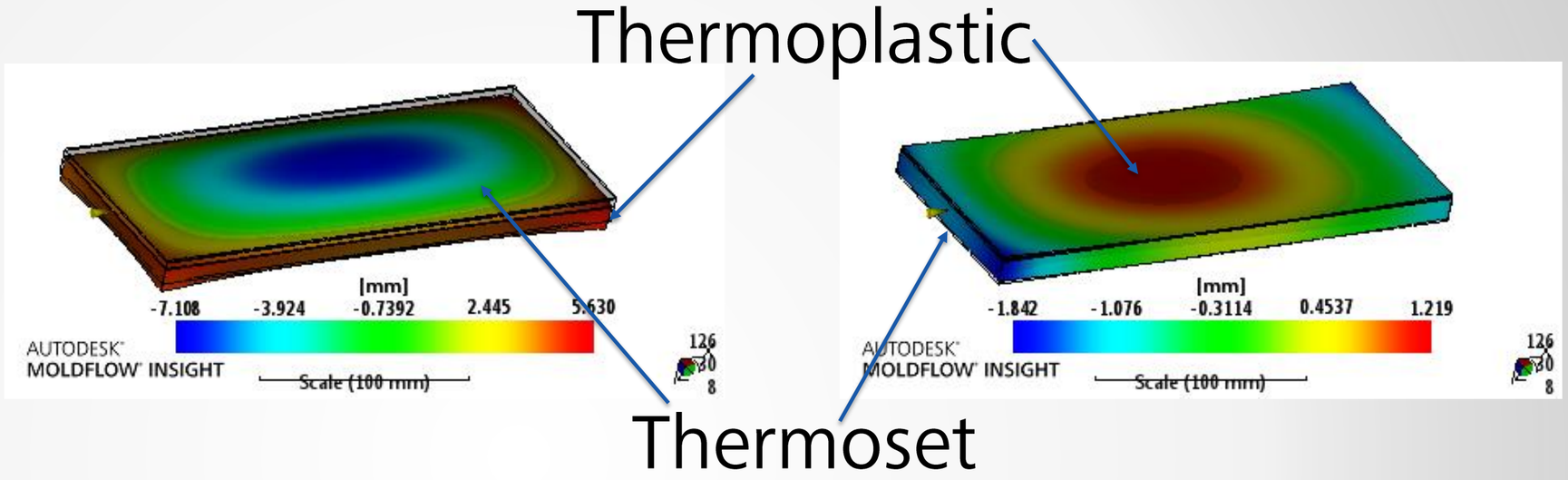


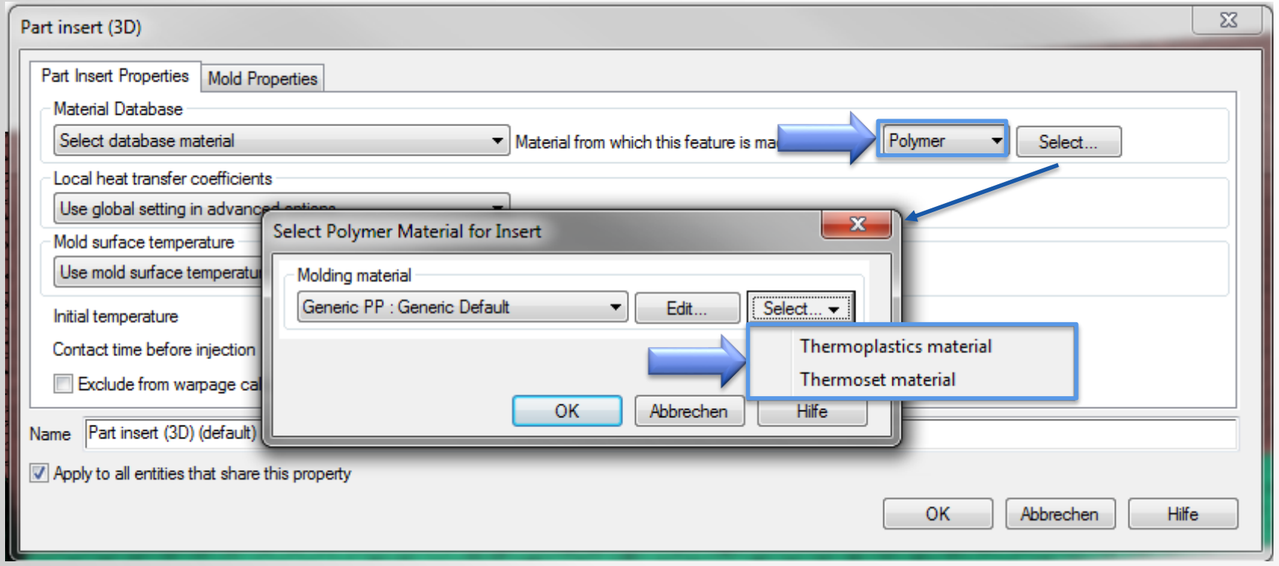


Local Mesh Refinement Redesign



Thermoplastic Insert in Thermoset Analysis and Vice-Versa





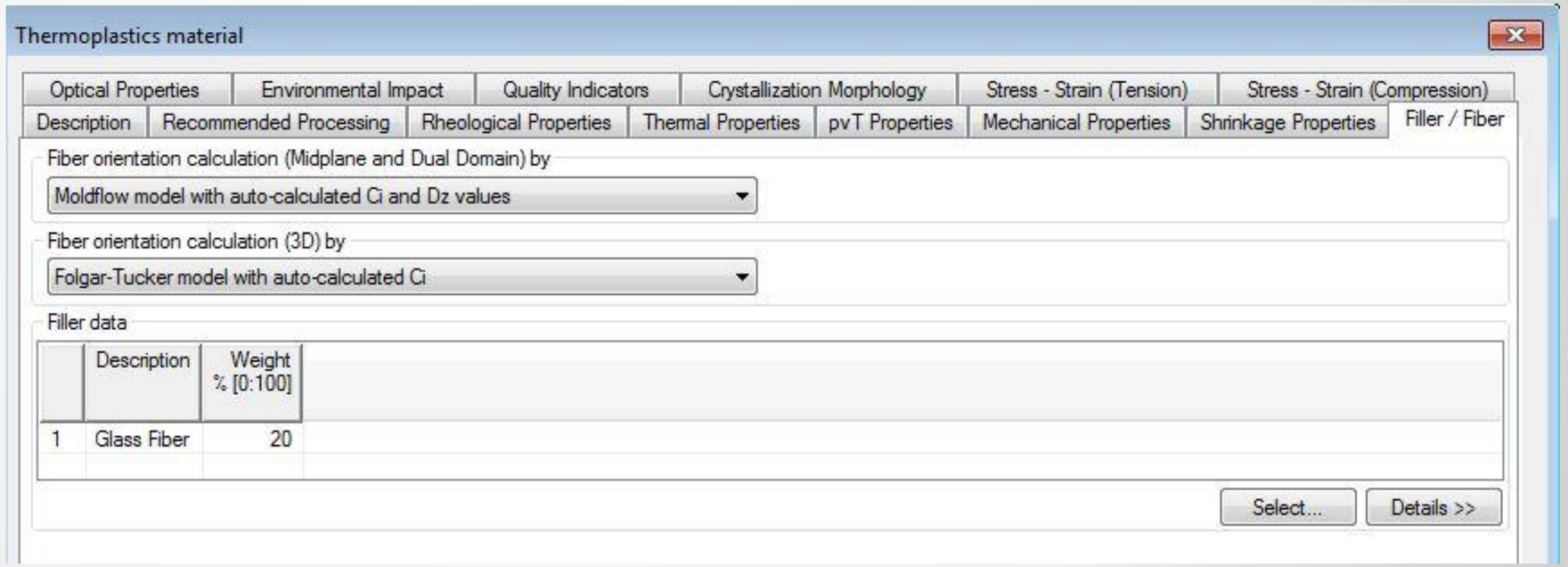
- Available for 3D

Fiber Model and Parameters now a Material Property

Select fiber orientation model & parameters in material properties

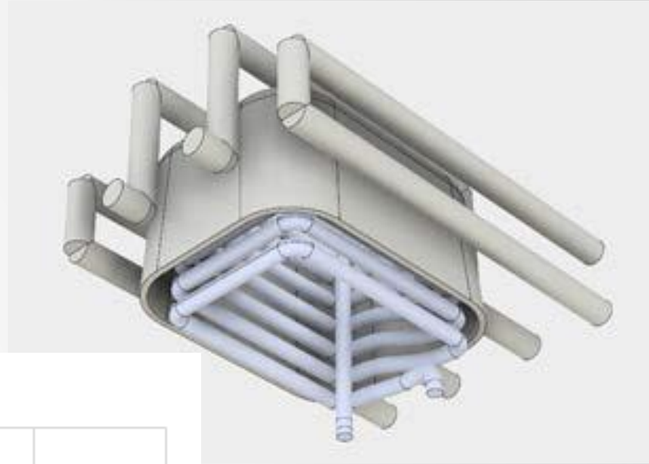
- Customize settings per material

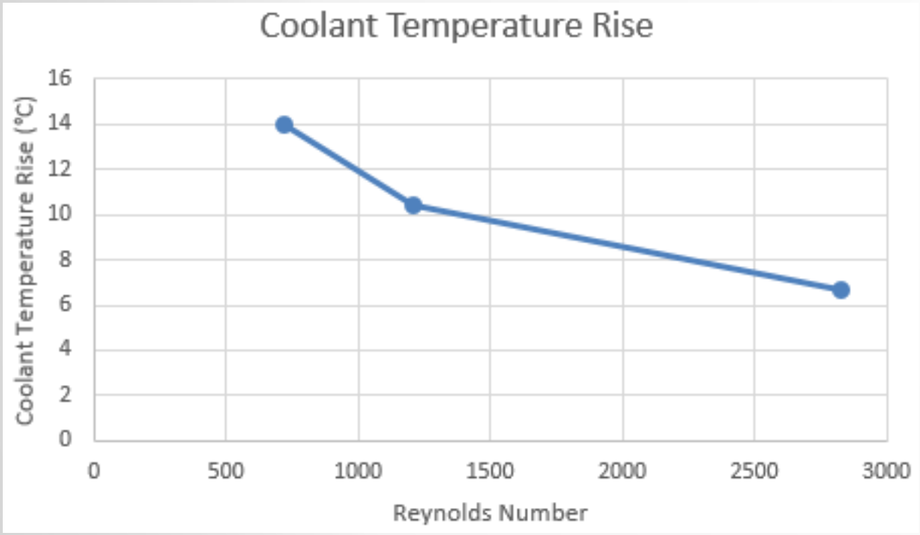
Fiber orientation model selection is removed from the Solver Parameters.

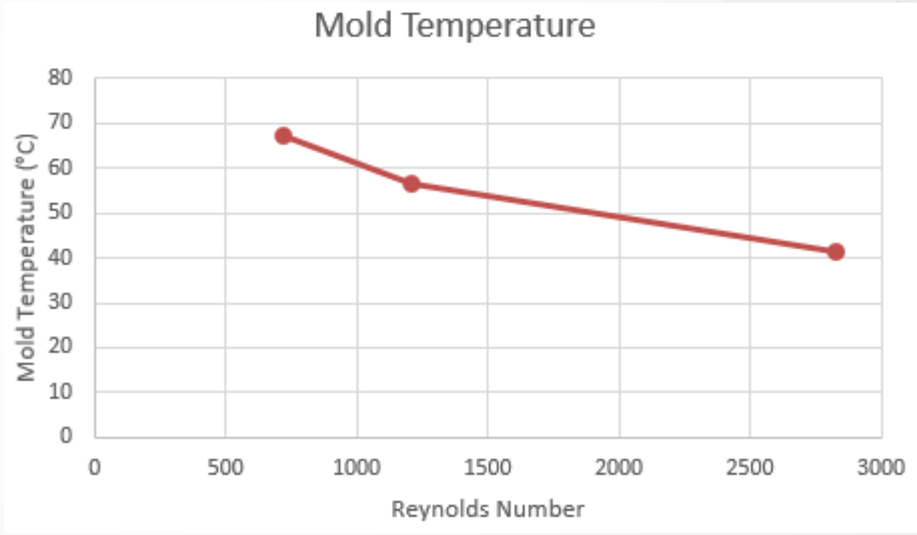


Coolant Heat Transfer for Low Reynolds Number

- Molding trials in the Instrumented Box Tool
  - Unfilled PP



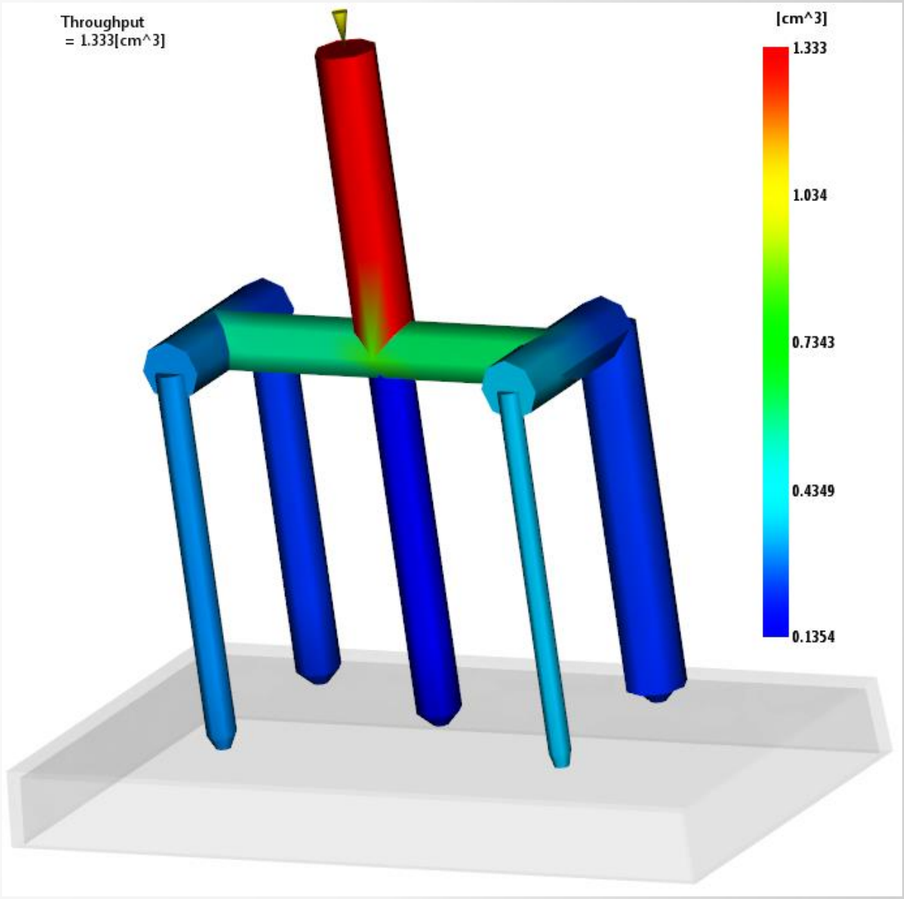




- Update the empirical relations for heat transfer coefficients from the cooling circuits at low/medium Reynolds numbers

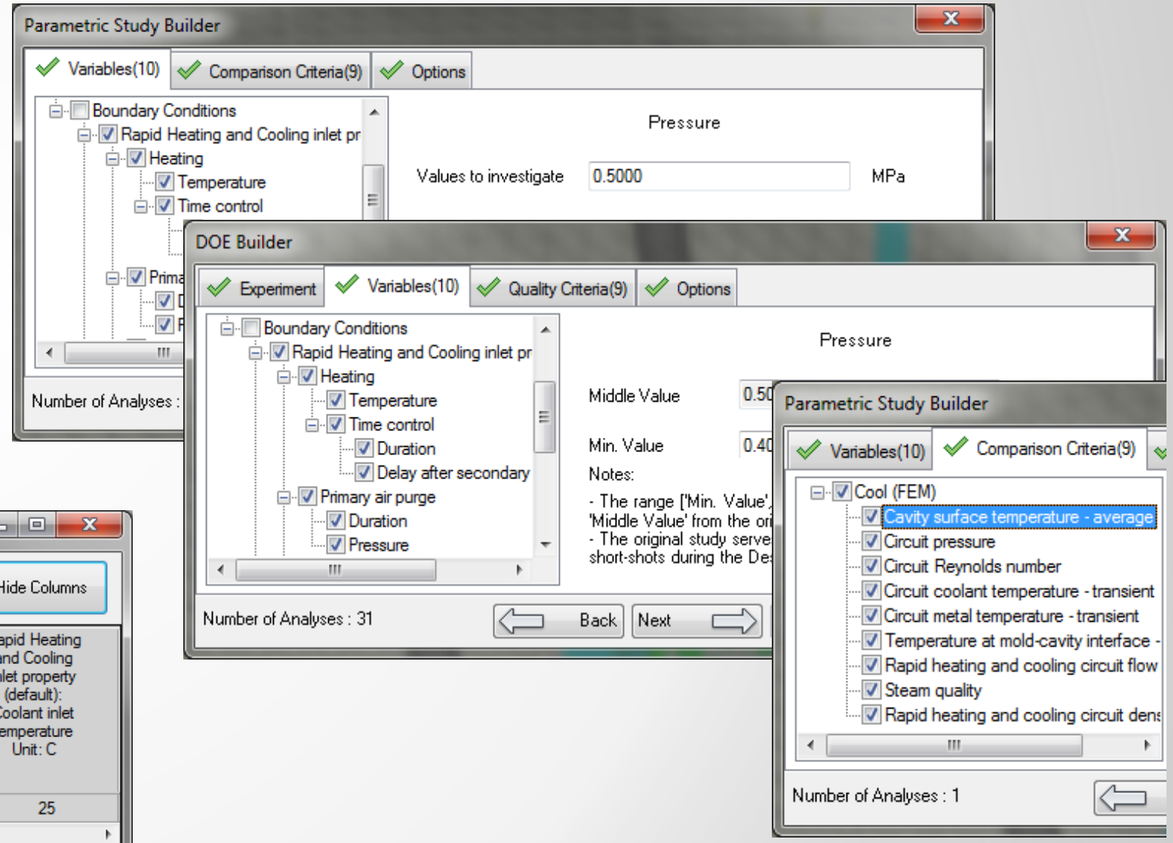
Throughput Result for 3D Flow Solver

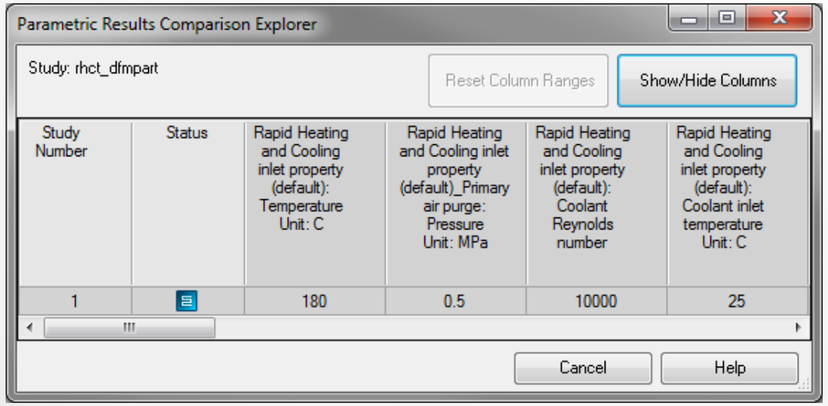
- Total volume of material that passed through each beam element
  - New for 3D
  - Already exists for the Midplane and DD



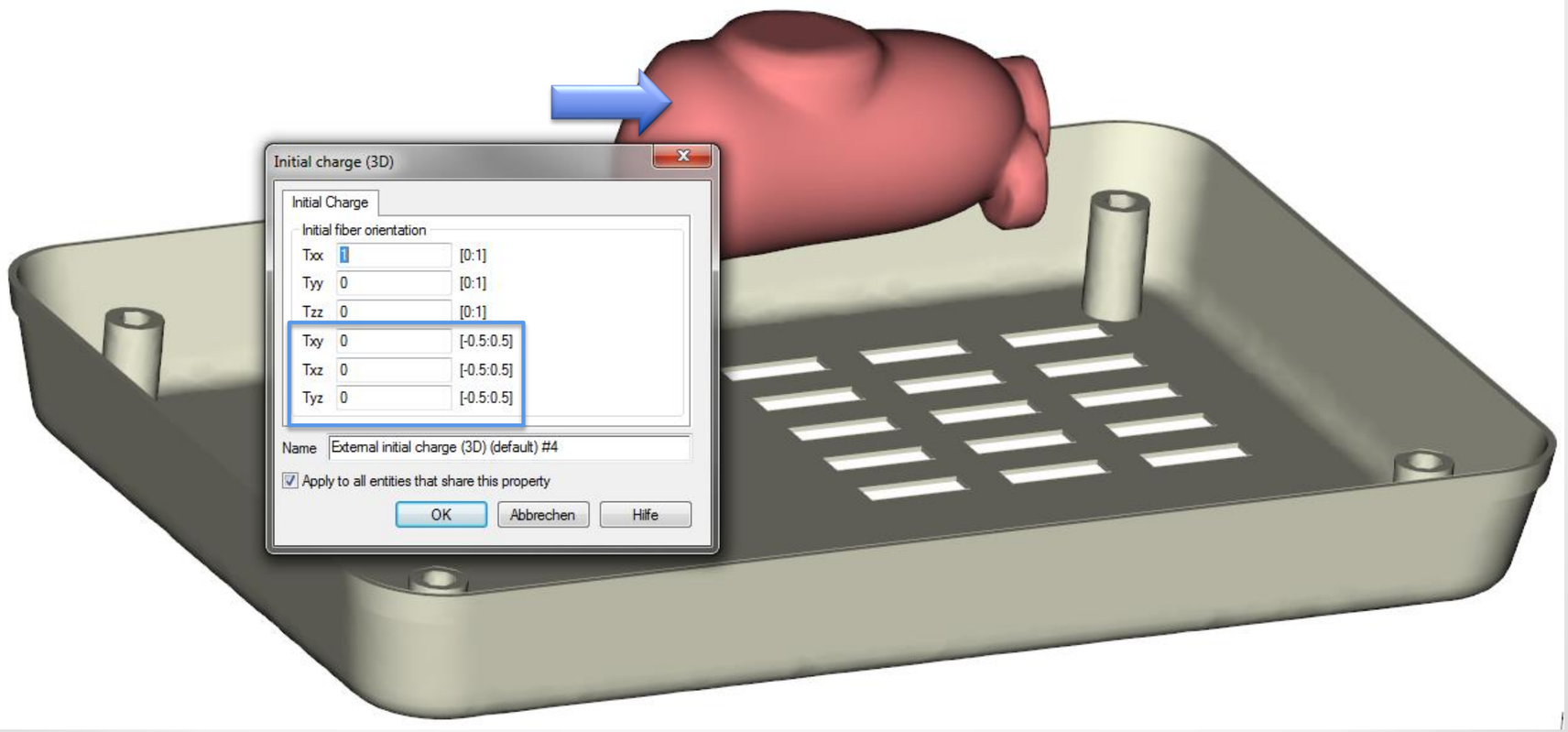
DOE and Parametric Analysis

- Extended for three process features:
  - Rapid heating and cooling
  - Venting
  - Gas
- Added
  - Input variables
  - Results



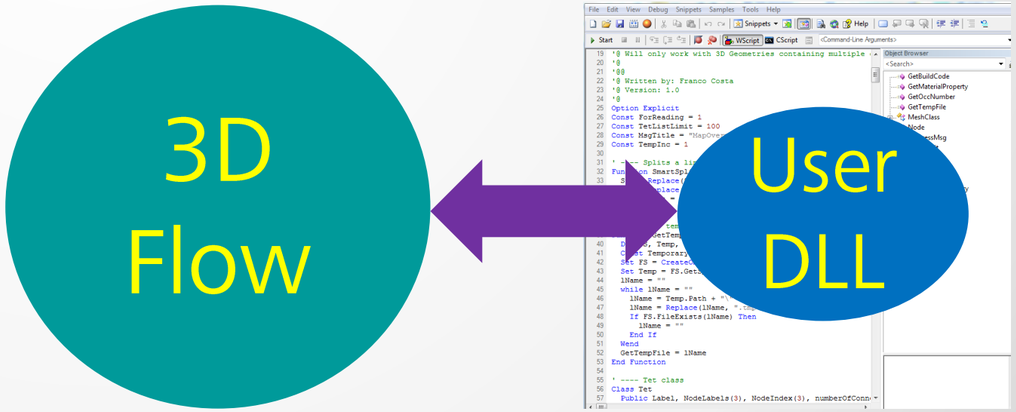


Full Fiber Orientation Tensor for Initial Charge in 3D Compression Molding

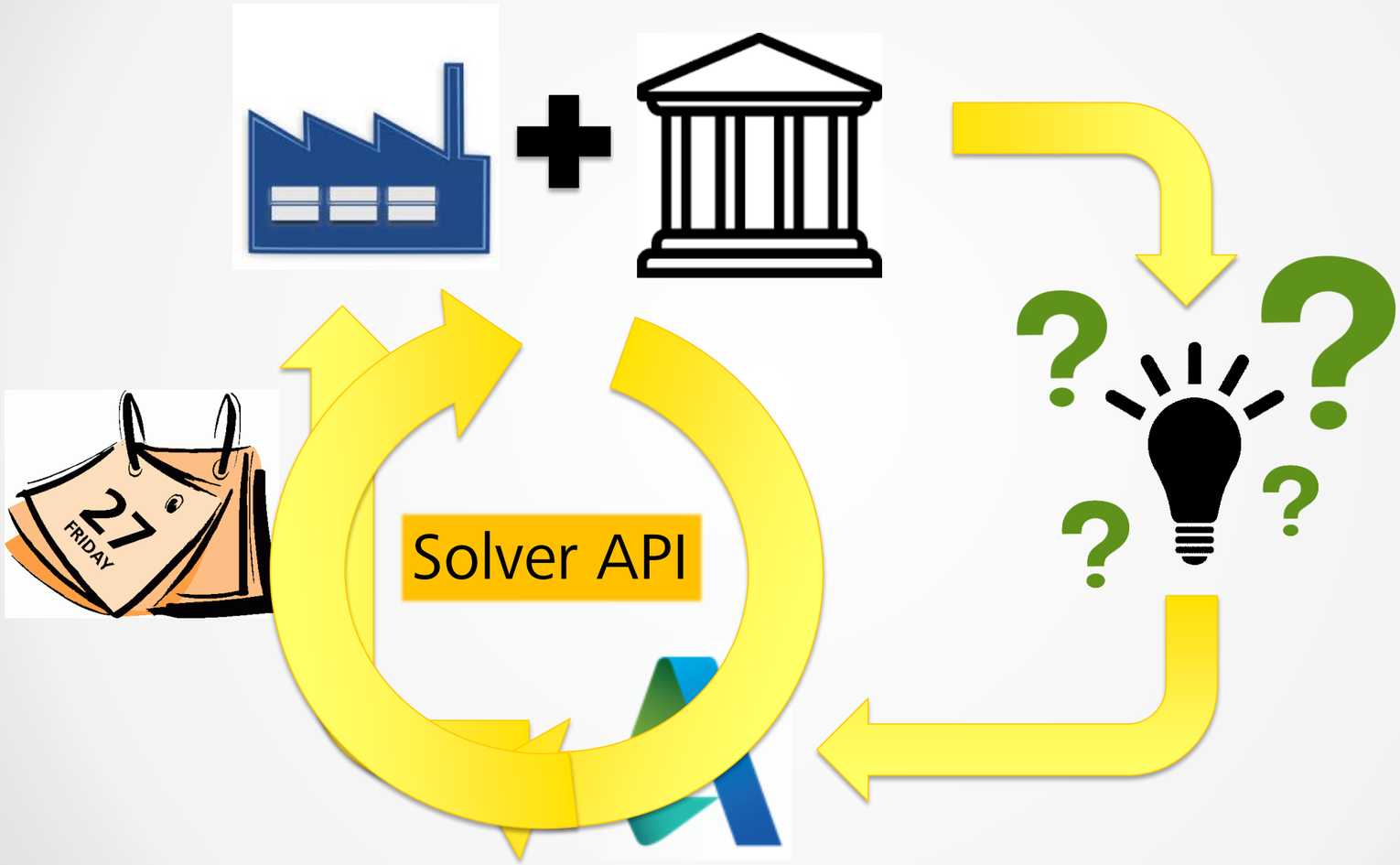


3D Flow “Solver API” Framework

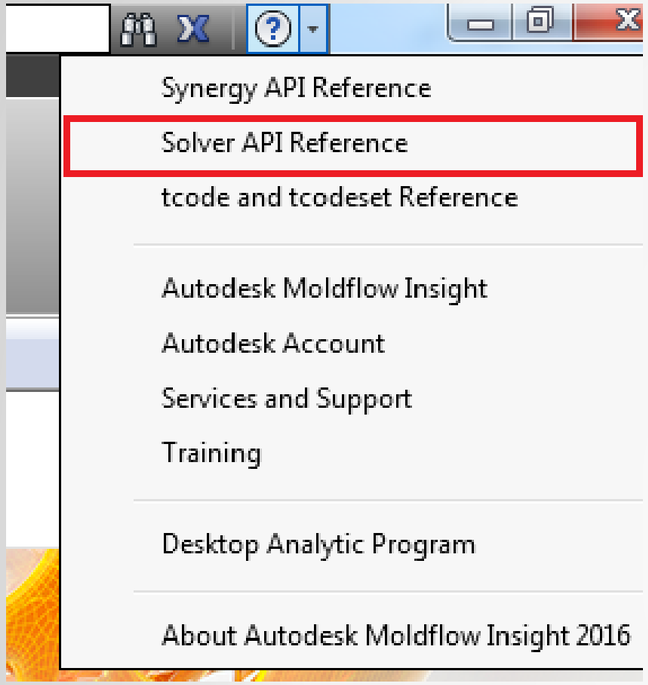
- Allow user routines for selected properties and calculations
  - User-coded routines in a DLL
    - Example Template provided
  - AMI 2016 : User viscosity routine
  - AMI 2017 Beta: PVT & Core-shift
  - Future:
    - Fiber Orientation ?
    - Curing ?

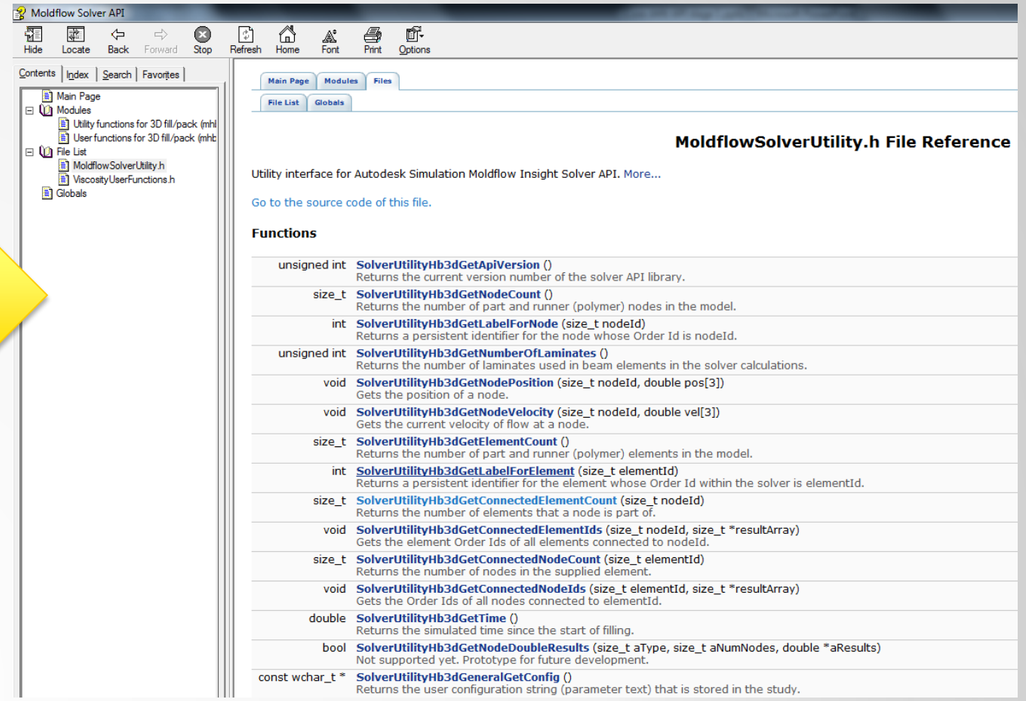


Motivation: Collaboration with Research Partners

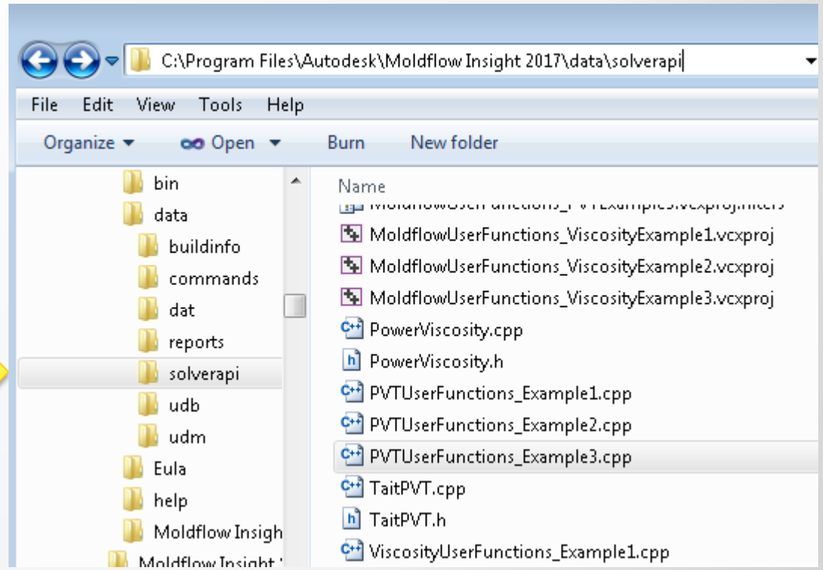


Starting with the Solver API



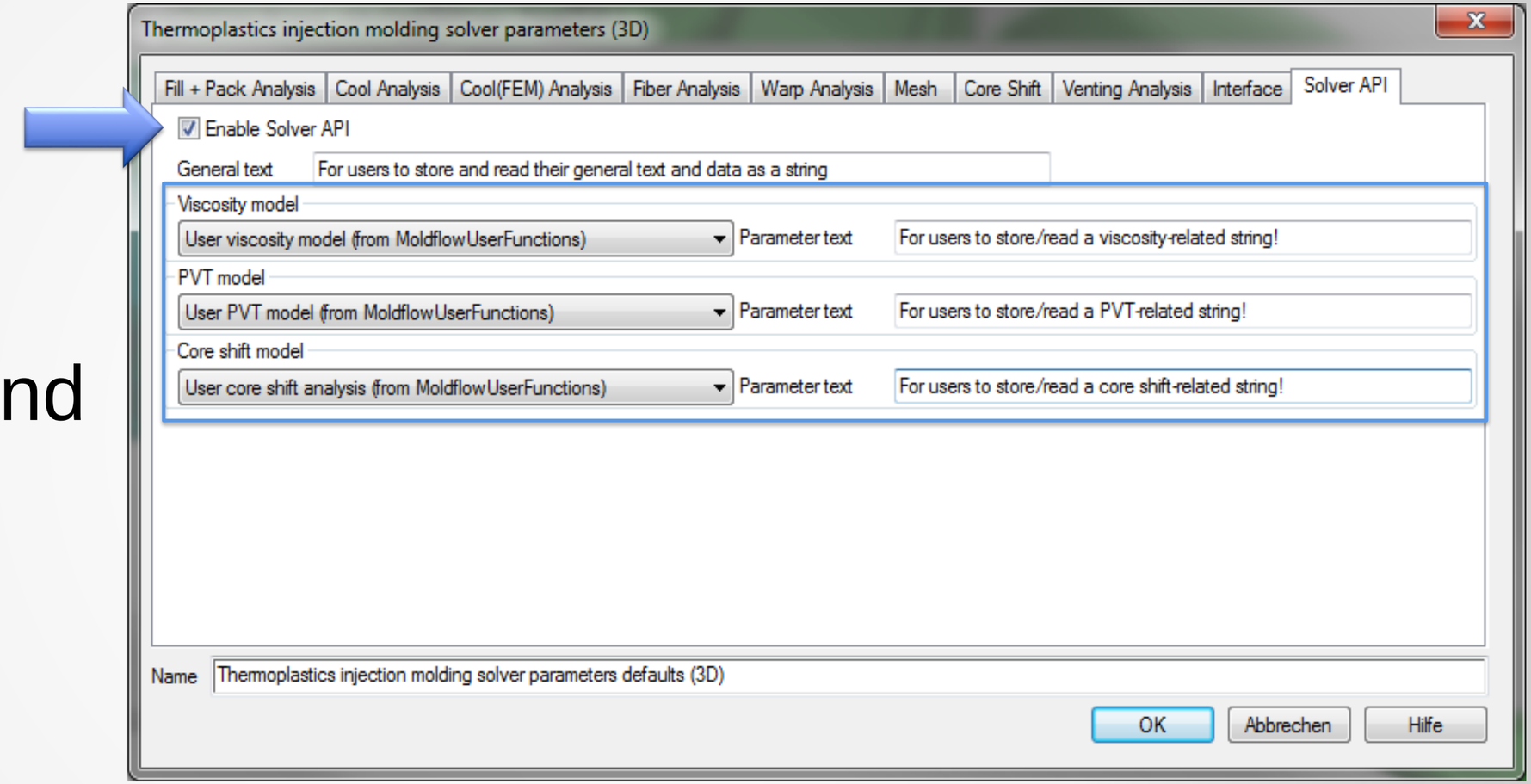


Sample code included in Moldflow installation



Solver API: Extended

- PVT
  - 3D Warp
- Core shift
- More mesh and result utilities



User DLL defined call-back functions

SolverUserHb3dInitialize

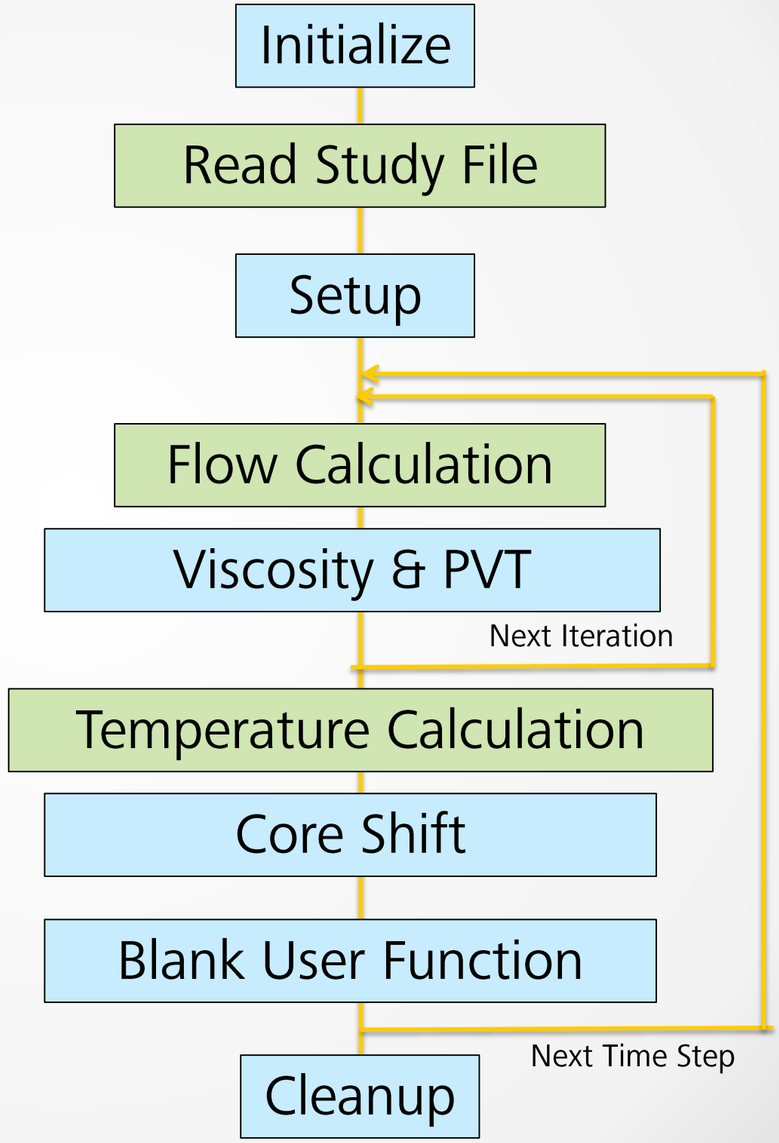
SolverUserHb3dAnalysisSetup

SolverUserHb3dViscosity &
SolverUserHb3dSpecificVolumeAtNode

SolverUserHb3dCoreShiftSolve

SolverUserHb3dTimeStepComplete

SolverUserHb3dCleanup



Two Groups of API Functions

- User functions: User needs to provide these
  - Only used if “User viscosity model …” is turned on

double SolverUserHb3dViscosity (double *temperature*, double *shearRate*, double *pressure*)

Return the viscosity of the material at a given temperature, shear rate and pressure. REQUIRED.

If this function is not exported and the study requests a user viscosity function, the solver will exit with a fatal error.

Parameters:

temperature Temperature of the material (unit: degrees Celsius).
shearRate Shear rate of the material (unit: reciprocal second).
pressure Pressure of the material (unit: Pascal).

Returns:

The viscosity (unit: Pascal-second).

Note: The 3D Flow solver regards frozen polymer (i.e. below the transition temperature) as having a very high viscosity, sufficiently large to

- Utility functions: Provided by the Moldflow Solver
  - Called by User functions to get information & output messages

void SolverUtilityHb3dInfo (const wchar_t * *message*)

Prints a message in the solver output and continues the analysis.

Parameters:

message The string to output to the solver log. The string is in the system's default wide character encoding and is null terminated. It should not contain any newline characters and must be no more than 256 characters long, including the trailing NUL byte.

Warning:

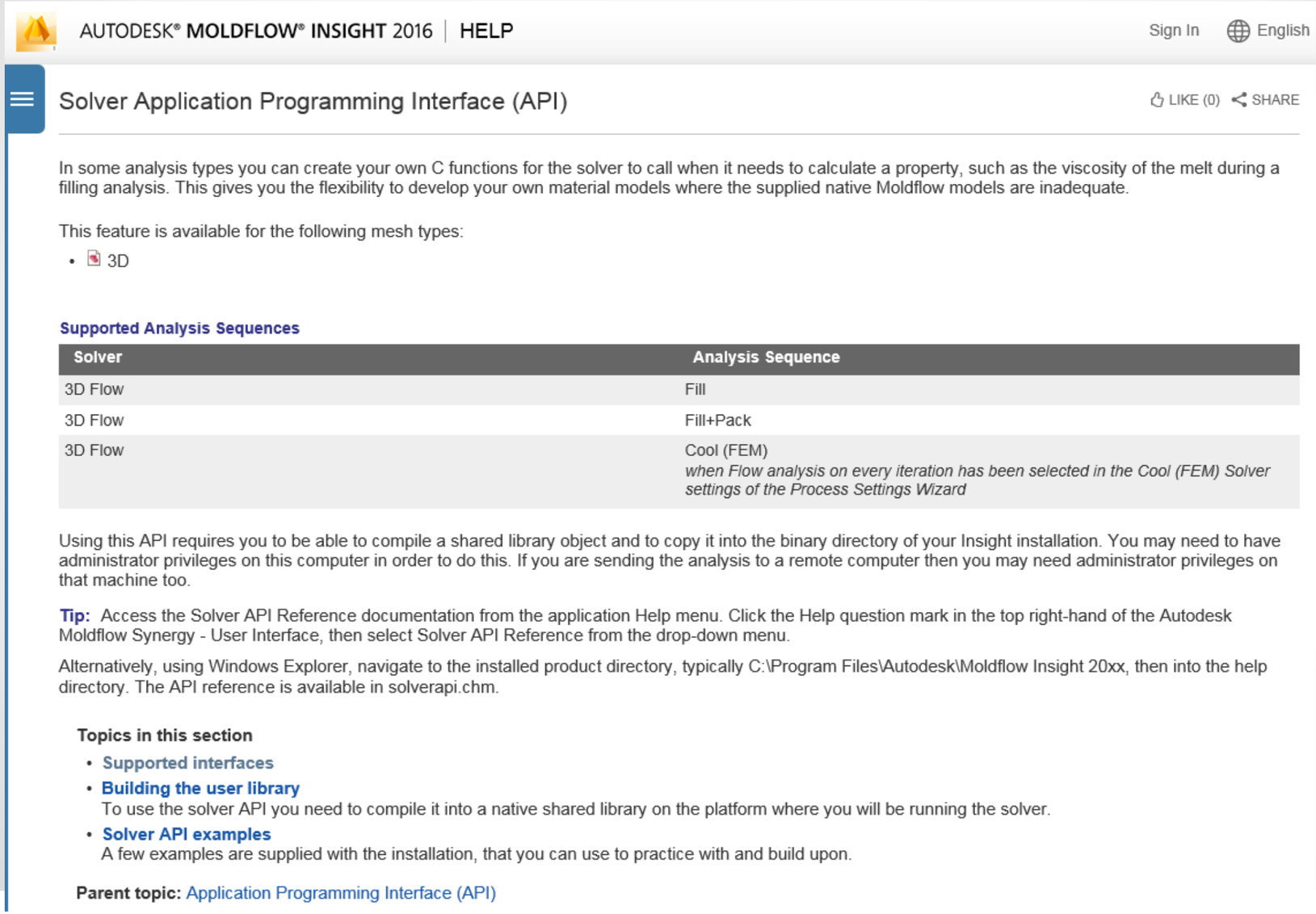
This function is not thread-safe. If called from multi-threaded code the output may be garbled.

Since:

API version 1.

Detailed Information in Online Help

- Search “Solver API” in regular Online Help



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Sign In English

Solver Application Programming Interface (API)

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In some analysis types you can create your own C functions for the solver to call when it needs to calculate a property, such as the viscosity of the melt during a filling analysis. This gives you the flexibility to develop your own material models where the supplied native Moldflow models are inadequate.

This feature is available for the following mesh types:

- 3D

Supported Analysis Sequences

Solver	Analysis Sequence
3D Flow	Fill
3D Flow	Fill+Pack
3D Flow	Cool (FEM) *when Flow analysis on every iteration has been selected in the Cool (FEM) Solver settings of the Process Settings Wizard*

Using this API requires you to be able to compile a shared library object and to copy it into the binary directory of your Insight installation. You may need to have administrator privileges on this computer in order to do this. If you are sending the analysis to a remote computer then you may need administrator privileges on that machine too.

Tip: Access the Solver API Reference documentation from the application Help menu. Click the Help question mark in the top right-hand of the Autodesk Moldflow Synergy - User Interface, then select Solver API Reference from the drop-down menu.

Alternatively, using Windows Explorer, navigate to the installed product directory, typically C:\Program Files\Autodesk\Moldflow Insight 20xx, then into the help directory. The API reference is available in solverapi.chm.

Topics in this section

- **Supported interfaces**
- **Building the user library**
  To use the solver API you need to compile it into a native shared library on the platform where you will be running the solver.
- **Solver API examples**
  A few examples are supplied with the installation, that you can use to practice with and build upon.

Parent topic: Application Programming Interface (API)

Compiling your User Code

- Install Microsoft Visual Studio (C/C++) 2012
  - Microsoft Visual Studio Express is a free download from http://www.visualstudio.com/en-us/downloads.
- Newer versions may also be used, but require their own runtime distributable to be embedded

Building the user library on Windows

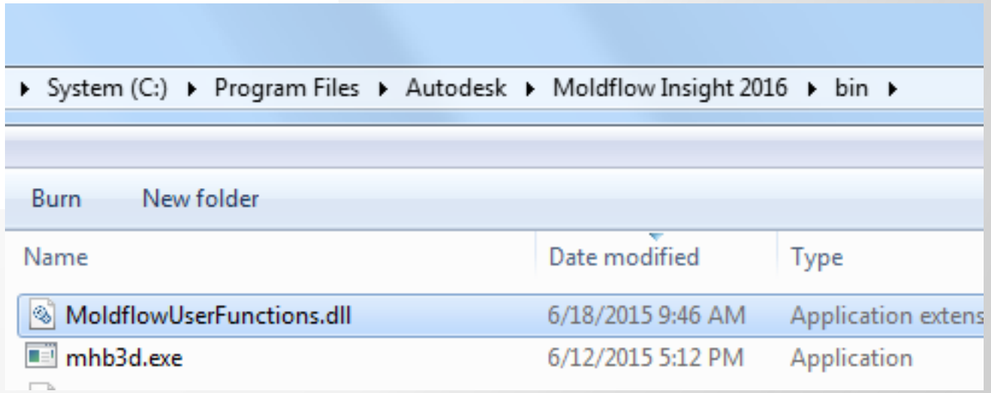
On Windows, build your library as a 64-bit Release DLL. The example Microsoft Visual Studio 2012 projects, MoldflowUserFunctions_xxx.vcxproj, can be compiled directly and installed with no changes.

The resulting DLL must be called MoldflowUserFunctions.dll and must be copied (by an administrator) to the same directory as mhb3d.exe, typically C:\Program Files\Autodesk\Moldflow Insight 20xx\bin. This DLL will be opened only if you have enabled the user library in the advanced solver parameters.

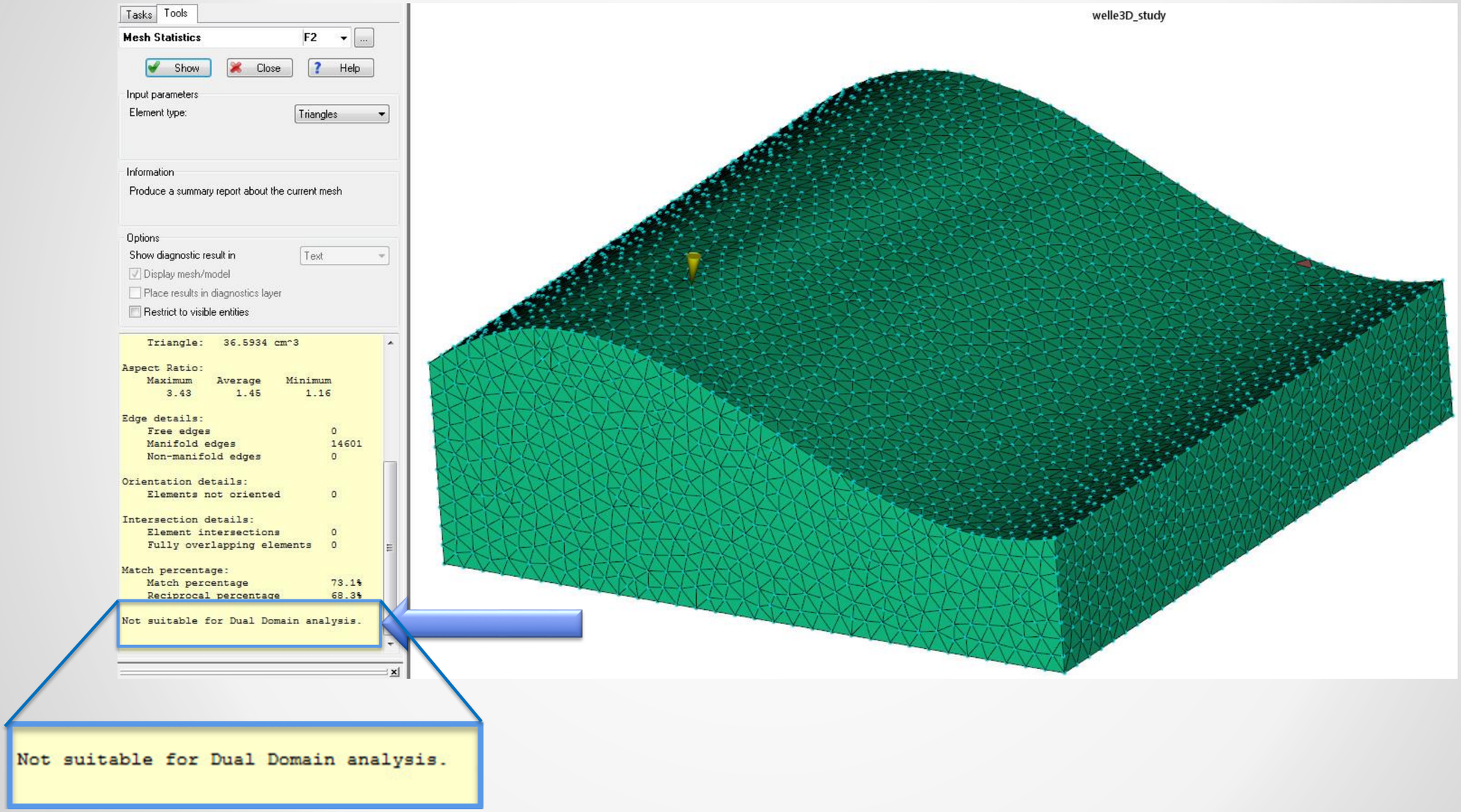
If you create a new Visual Studio project, ensure that the following options are set:

- General > Target Name = MoldflowUserFunctions
- General > Configuration Type = Dynamic Library (.dll)
- General > Character Set = Use Unicode Character Set
- C/C++ > Code Generation > Runtime Library = Multi-threaded (/MT)
- Linker > Advanced > Target Machine = MachineX64 (/MACHINE:X64)

Requires Administrator privilege to write to this folder

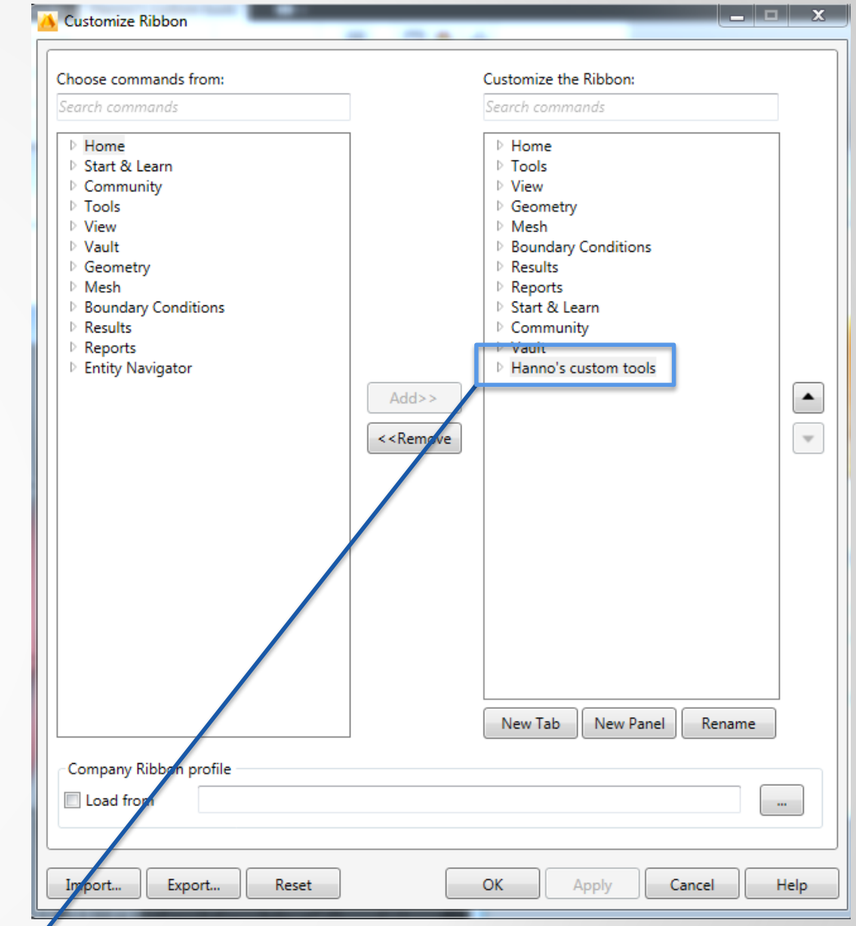


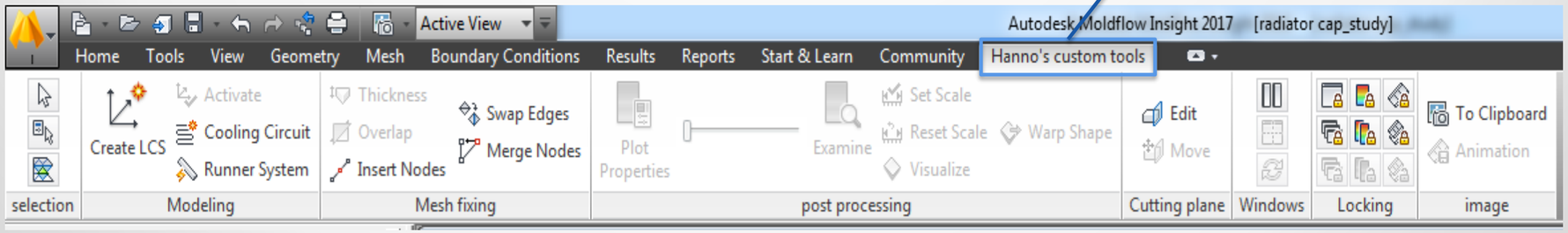
Mesh suitability in Mesh Statistics for DD Mesh



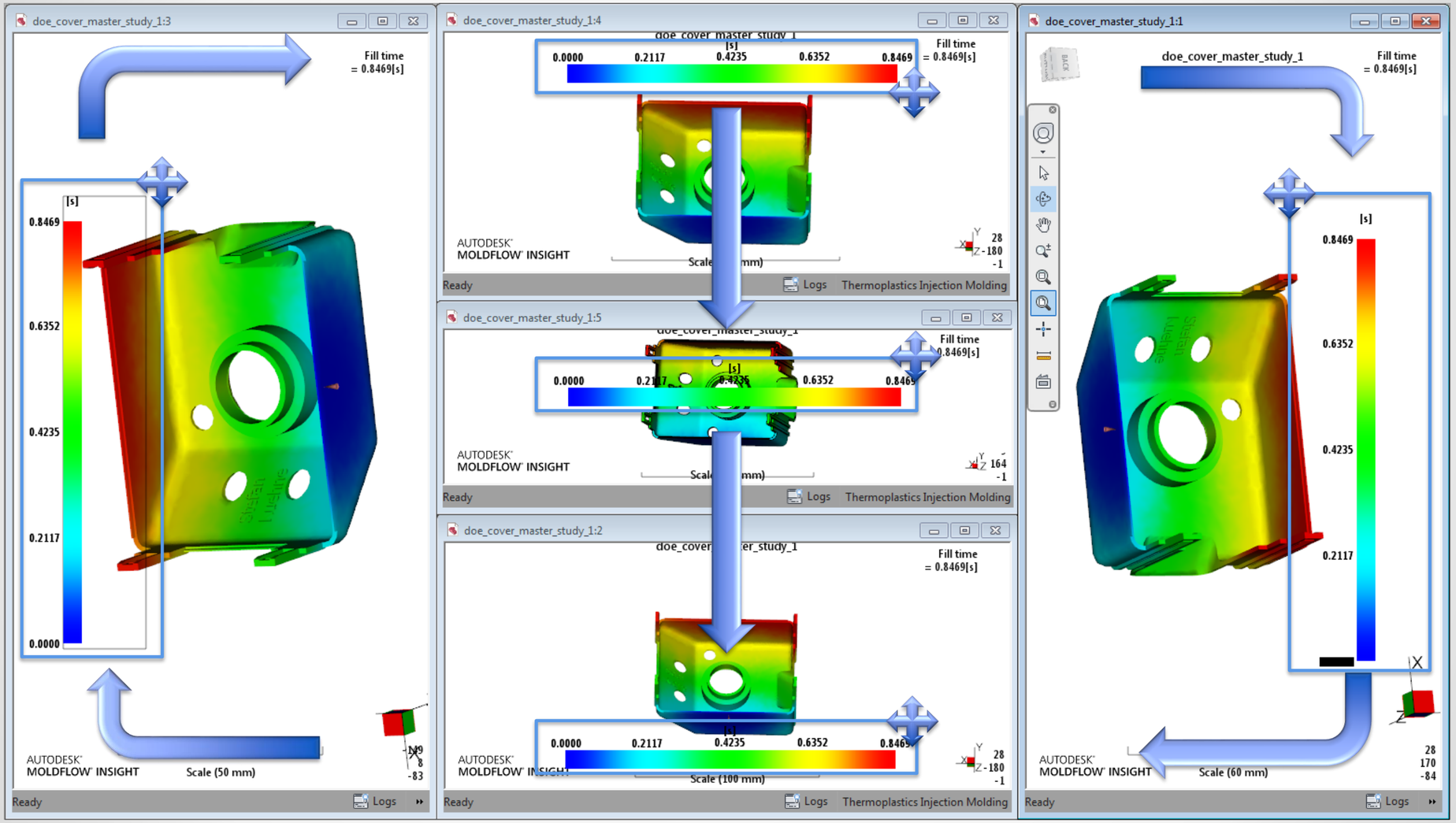
Ribbon Menu Customization

- Customize existing Ribbon Tabs
- Create your own Tab, Panels and your frequently used tools
- Save Export your tool bars

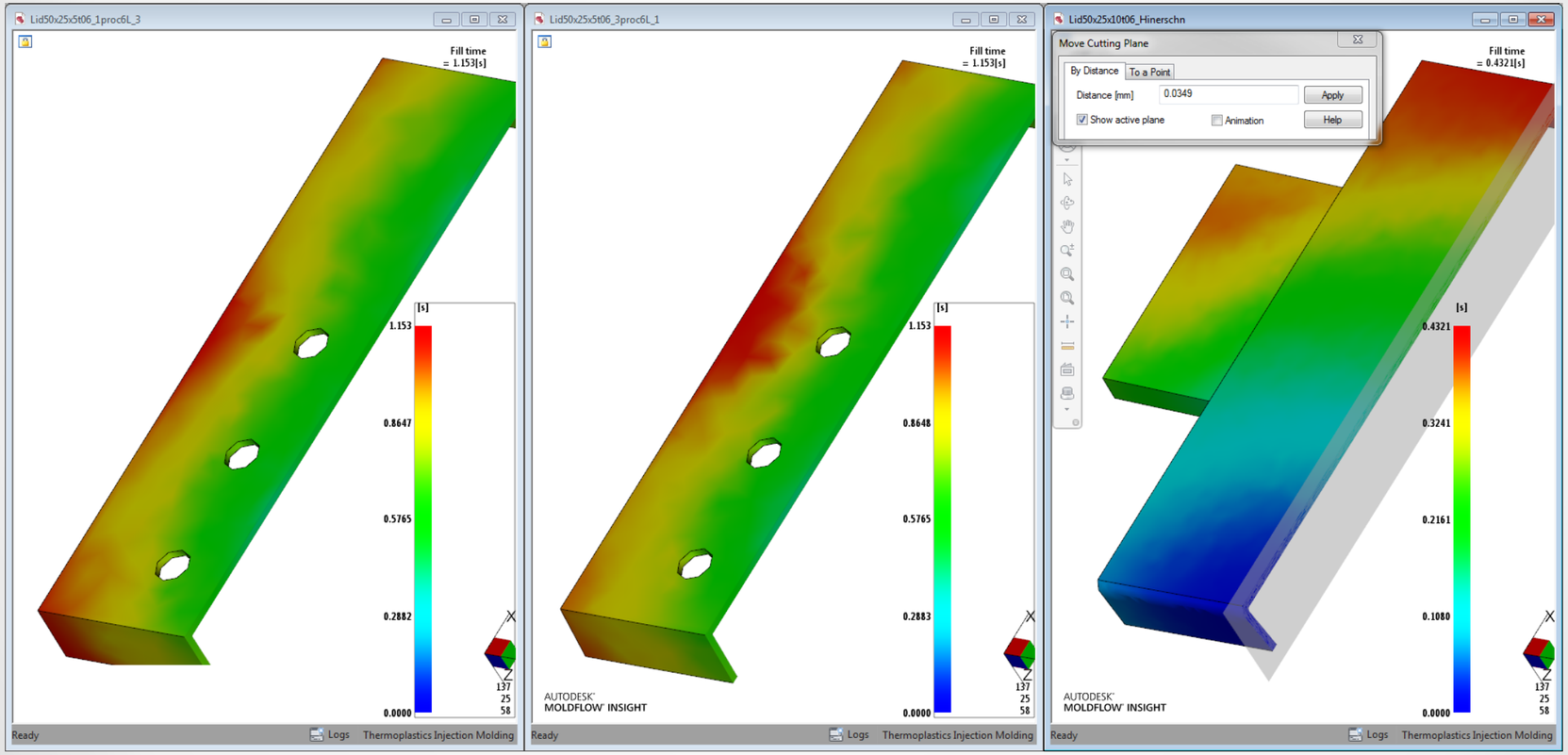




Movable and sizable result legend bar

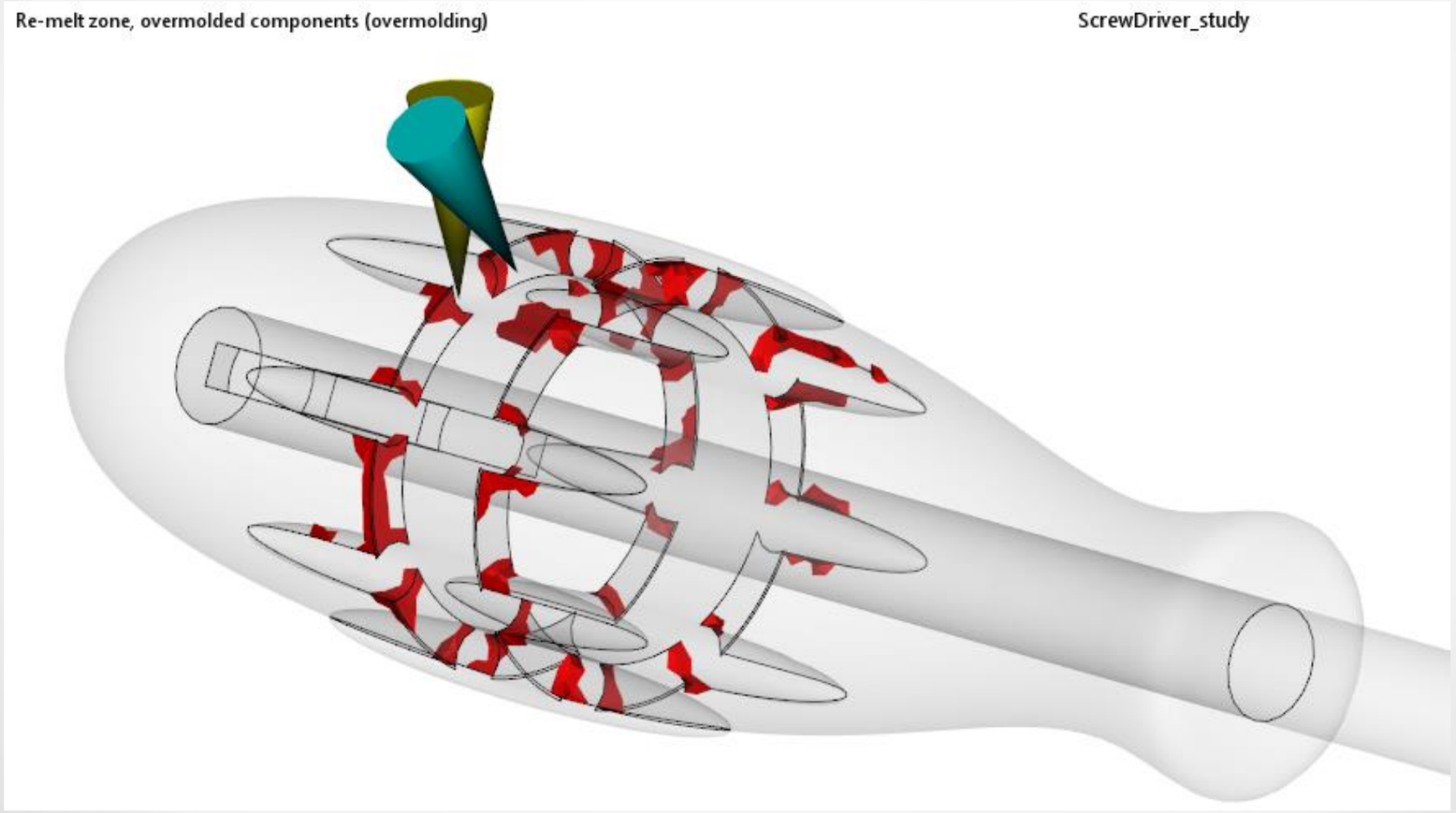


Synchronize cutting plane over all locked windows



New Default Plot Type for Re-melt Zone Plot

- Shaded plot by default

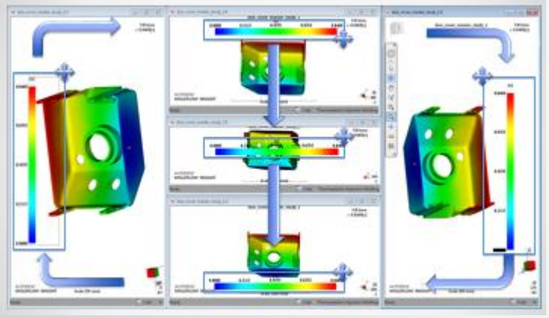


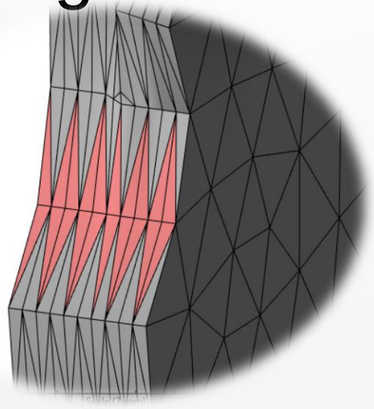
Other Improvements

- 3D Flow
  - Improve accuracy of fiber orientation around the gate.
  - Increase the upper limit of initial fiber length and allow up to 100 mm long fibers in the simulation.
  - RSC model can be used for disk-like fillers (aspect ratio less than 1)
- 3D Warp
  - Allow Mesh Aggregation when isolating causes of warp
- Induction Heating for foaming processes
  - (Microcellular and Chemical Blowing Agent)

Moldflow Insight 2017 (Beta)

- From Scandium T.P.:
  - Cool for 2K-Overmolding
  - Cool for Gas
  - Core-back for Foaming
  - Chemical Blowing Agent
  - Anisotropic Part Inserts
  - Mesh (geometry) editing





- Plus:
  - Local and Cloud Analysis
  - New 3D Mesher
  - Local Mesh Density Controls
  - Thermoset Inserts
  - Fiber Model Controls
  - Low Reynolds Number
  - Enhanced Results & DOE
  - Solver API extended
  - UI Customization

Class Outline

- Validation
- Scandium 2016
- Moldflow 2017 Beta
- Research Projects & Collaborations

Summary of Long Term Research Collaborations

- Long Carbon Fiber Injection Molding & Compression Molding (SMC)
- Long Fiber Breakage & Orientation
- Flow advancement at part edges
- Microcellular Foaming
- Composite Overmolding
- Viscosity Effects
- ….
- ….
- ….

Questions

- Validation
- Scandium 2016
- Moldflow 2017 Beta
- Research Projects & Collaborations