New Capabilities in Autodesk® Simulation
Moldflow® Insight and Research Directions

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This class reviews new functionality in Autodesk Simulation Moldflow Insight software and discusses recent and current research directions of Moldflow development. We cover the following capabilities: viscoelastic warp calculations, improved wall slip calculations, the influence of mold deflection, ejection force predictions, analysis of mold fatigue, flow imbalances (airflow), 3D compression molding, 3D conformal cooling, 3D hot runner elements, crystallization analysis, long fiber composites, and mesh preparation.
SM1869-P: Key learning objectives

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

- Identify when to use viscoelastic residual stress calculation
- Explain the influence of mold deflection on pressure, shrinkage, and warpage prediction
- Enable a wall slip calculation to simulate jetting effects
- Perform a 3D flow analysis which can capture shear heating induced flow imbalances
Content

- **Highlights of What’s New in Moldflow Insight 2014**
  - Conformal Cool, Compression, Productivity Improvements

- **Scandium Technology Preview (2014)**
  - Part Inserts, Compression, Accuracy, Meshing, New Physics

- **AMSI Beta**
  - Parametric, Fiber, Meshing, Crystallization

- **Research Topics**
2014: Simulating 3D Conformal Cooling Channels

- Complex 3D cooling channels
- Temperature control follows part shape
- May not be suited to simulation with beam elements
Use Autodesk Simulation CFD for Coolant 3D Meshing and Coolant Flow Solver

Meshing is optimized for low viscosity water flow

- Boundary layer meshing (Enhancement layer)
- Mesh refinement in areas of high curvature
Use Autodesk Simulation CFD

Powerful Computational Fluid Dynamics simulation of coolant flow in 3D cooling channel
  Identify dead-zone
  Eliminate hot-spots
Integrate this CFD solution into Moldflow Insight Cool (FEM)
Coolant Solution from CFD

Coolant Flow – Dead zone

Rapid Heat and Cool with Conformal channels
3D Heater Elements for Cool(FEM)

Beams or Tetra
Compression Moulding (3D)

3D Mesh Simulation for:

- Injection-compression molding
  - Cavity is partially filled by injection

- Compression molding
  - Initial charge placed into open cavity

- Thermoplastics or Thermoset.
3D Inj-Compression Fill Pattern Visualization

Pressure
Time = 0.0705[s]
Only one cavity has compression

Volumetric Shrinkage is lower in the cavity with compression
Fill Pattern & Fiber Orientation

CT Scan

Numerical Simulation
Tensile Modulus Comparison (GPa)
Other New Processes

- **Bi-Injection**
  - Thermoplastics Bi-injection molding where 2 different materials are injected at different locations with independent process control
  - Midplane Only
- **Multiple Gas Injection cylinders (3D)**
  - Can have different pressure & delay
  - Was already available in Midplane
New 3D Frozen Layer Fraction Result

- Frozen Layer fraction over thickness
  - Equivalent to midplane/DD result
- Cured Layer Fraction result
  - Reactive (Thermoset)
Other New Results

3D Flow ‘Ram position: XY plot’

Crystal Size

‘Grow from’ for 3D

‘Total part weight’ XY plots
CAD Model Translators included for Free

- Sterolithography (*.stl)
- Moldflow MFL (*.mfl)
- Moldflow 3D (*.m3d)
- C-MOLD (*.cmf)
- Autodesk Inventor Part (*.ipt)
- Autodesk Inventor Assembly (*.iam)
- Study files (*.sdy)
- MPI 2.0 Projects (moldflow.prj)
- IDEAS Universal (*.am)
- Ansys Prep 7 (*.ans)
- Nastran (*.na)
- Nastran Bulk Data Format 7 (*.bdf)
- Patran (*.pdat)
- Patran out (*.out)
- Fami (*.fam)
- IGES (*.igs,iges)
- Parasolid (*.x_t, x_b)
- SAT(*.sat)
- Pro/E Part (*.prt, pwp)
- Pro/E Assembly (*.asm,asm *)
- SolidWorks Part (*.slidprt)
- SolidWorks Assembly (*.slidasm)
- CATIA V5 Part (*.part)
- CATIA V5 Assembly (*.catproduct)
- STEP (*.step)
- NX (*.npt)
- Rhino (*.3dm)
- Alias (*.wire)
- ASCII/Unicode Model (*.udml)
- Autodesk Shape Manager Files (*.amz,amb)

* Alias and Rhino not applicable for Adviser and DFM
Fillet Sizing Control

Efficient mesh around small features

- No Chord Angle Control
- 15,000 triangles
- Poor definition around hole

- Chord Angle Control
- 37,000 triangles
- Good definition around hole

- Chord Angle and Fillet Sizing Control
- 23,000 triangles
- Good definition around hole
- More efficient number of elements
Other Productivity Improvements

- Mucell: Up to 7x faster computation by coding improvements
- 3D Flow: Reduced computation time for 3D Mapping to surface
- Mesh generation 50% faster
- 2 x faster Thickness display
Examine Flatness and Roundness after Warp

- New Macros which report the part flatness and roundness before and after deflection
  - roundness.vbs & flatness.vbs
  - Installed in C:\Program Files\Autodesk\Simulation Moldflow Synergy 2014\data\commands

- Initially posted on Beyond Moldflow Insight blog:
  - http://autodesk.typepad.com/beyondmoldflowinsight/
Extract 3D Gas Core Shape

- ExportGasCoreSTL.vbs
  - Exclude element totally filled by Gas
  - Export STL surface of the Gas Core
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- Research Topics
Scandium Technology Preview 2014

- Free download
  - `//labs.autodesk.com/utilities/scandium`
- English, Windows only
- Requires Autodesk Moldflow Insight 2014 license
- Provides extended functionality and new prototype features for testing and user feedback

No guarantee that these features will survive or graduate to the official release
Orthotropic properties for Part Inserts (3D)

- Warp with Orthotropic Part Inserts
  - Overmolding of fiber filled sheets, wood, fabrics and other woven substrates
Displaying Orthotropic Properties after setup

- Run: DisplayOrthotropicProperties.vbs
  - Not part of Scandium Install (download from class materials)
One-sided constrains for core-shift

- Part inserts “core-shift”
  - Free to move in one direction
  - Blocked from moving in the opposite direction

Spring constraints also supported for core-shift

Image: Wekona GmbH
Compression Molding Enhancements

- Part Inserts now supported
- Add Cooling analysis for Compression Molding & Injection Compression Molding
  - Both Cool (BEM) & Cool (FEM) are supported
- Injection + Injection-Compression Over-Molding
  - For thermoplastic only
Reactive Compression Molding Enhancements

- Add wire sweep to microchip compression molding
- Reactive injection-compression / compression molding
  - Add core-shift
  - Add Venting
Gate Freeze Accuracy improvements

- Improved prediction of solidification process in the gate area
- Important for Warpage Accuracy
New Results

- Flow Front Speed at Center (Midplane and DD)
- Shear Stress at Wall (3D)
- Maximum Hold Pressure (3D)
Gate Refinement

- Automatic refinement of 3D mesh near gate
  - Assign gate location on CAD geometry before meshing
  - Specify the amount of refinement relative to global mesh size
  - Both internal and surface mesh will be refined
Other Meshing Enhancements

- Remesh Area upgraded:
  - smoother transitions
  - Matching surface meshes
- Global Merge: squeeze node and element numbers
- Dual-Domain Thickness calculation done once at end of meshing
  - Avoid to repeat many times for each solution
Racetrack Validation Study (AU2011)

- Racetrack in single cavity
- Refine Mesh in Gate
- Use beam elements in feed system to get shear heating
- Increase Absolute Maximum Melt Temperature
- Specify small time step size
- Temperature convection
- Hot perimeter
- Racetrack predicted
Improved Flow Front Temperature Calculation

- Flow front temperature now preserves the upstream shear heating

ASMI 2014

New Result
Improved Flow Front Temperature Calculation

- Flow front temperature now preserves the upstream shear heating
- Improves race-track prediction
- Does not require the small time step

New Result

ASMI 2014
Viscoelastic Warpage

Stresses arise from mechanical and thermal strains according to the a viscoelastic stiffness tensor

\[ \sigma_{ij} = \int_0^t c_{ijkl}(\xi(t) - \xi(t')) \left( \frac{\partial \varepsilon_{kl}}{\partial t'} - \alpha_{kl} \frac{\partial T}{\partial t'} \right) dt' \]

The stiffness tensor changes according to time and temperature

\[ F(t) = \sum_{k=1}^{N} g_k \exp \left( -\frac{t}{\lambda_k} \right) \]
Dynamic Modulus Time-Temperature Superposed

- Visco-elastic data used for Birefringence and Viscoelastic Residual Stress Calculations
- Measured on parallel-plate rheometer
Viscoelastic Warpage for MP and DD

- Implemented in Midplane and Dual-Domain in Scandium Technology Preview
- Requires viscoelastic material data to be measured
- Viscoelastic simulation gives more realistic process sensitivity to packing pressure and packing/cooling time variation
- Validate using Shrinkage molding data
Viscoelastic Warpage on Tagdie Moldings

Examine trend with respect to Packing Pressure variation

Uncorrected (no CRIMS) shrinkage in the flow direction for an Amorphous non-fiber material. (HIPS) Perpendicular Shrinkage shows a similar trend.
Wall-Slip for 3D Flow

- Summary: Simulate wall slip to allow for more accurate prediction of jetting.
- Available in Scandium Technology Preview
- Allows free slip at wall if:
  - Local Pressure is below Pressure Threshold, or
  - Local Wall Temperature is above Temperature Threshold
Wall-Slip for 3D Flow

No Slip

With Slip
Wall Slip in an LCP Connector

No Slip

With Slip
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Disclaimer

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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.
Parametric Study (Optimization)

- Study molding parameters vs. product quality
- Supported for all processes
- Result can be filtered and sorted to reveal the optimal solutions.
More Chord Angle Controls

ASMI 2014

ASMI 2015 Beta

New options for:
• Curvature sizing
• Growth Rate

23,000 triangles

20,000 triangles
Other Meshing Enhancements in 2015 Beta

- Surface mesh optimization
  - Avoid sharp triangles
- 3D Mesh optimization
  - Avoid large elements in mold meshes, smoother size transitions
- Mesh statistics
  - Report 3D volume of components
- Advisers: 4 resolution levels
  - Previous HAR equivalent to:
    - Level 1 (3D)
    - Level 2 (DD)
3D Fiber Orientation Improvement

- Oscillations in results found for low values of RSC factor
  - Implementation improvements around deformation rate calc
Crystallization Modeling: Improved pressure decay

Algorithmic improvements to the temperature / growth rate coupling

Thickness: 2mm

Focus on start of pressure decay
Material Quality Indicator: Adjustments

- Manufacturers can confirm data is still current
- Data focus rather than source

- Warp Indicator: Gold level if it has either...
  - Shrinkage test data, OR
  - Used by MP/DD
  - Measured mechanicals
  - Important for 3D
User specified tolerance bands for easy visualization
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Research Topics
Mold Fatigue Analysis with Autodesk Mechanical Simulation

- Mold Fatigue Analysis
  - Using temperature & stress history on mold from the Moldflow analysis
  - Use core-shift analysis
  - Use transient mold thermal analysis (Cool (FEM))

- Autodesk Mechanical
  - Thermal mold stress (cyclic)
  - Linear static stress
    - Polymer pressure
    - Clamp tonnage
  - Fatigue Wizard
Ejection Force Calculation with Autodesk Mechanical Simulation

- Ejection Force Calculation
  - Consider:
    - Friction of part sliding on core
    - Residual stress / pressure in the part
    - Temperatures of the part
    - Ejector position and direction
    - Ejector speed profile
  - Predict:
    - Deformation of plastic part during ejection
    - Force required to eject

- Use to:
  - Minimize part deformation
  - Avoid excessive force (damage ejectors)
  - Optimize placement of ejectors
Ejection Force Example

- Plastic box (HDPE)
- Metal Core (P20)
Ejection Configurations

- Top: 100 kN
- Bottom: 22 kN
- Unbalanced: 135+ kN
Mold Deflection Effect

- Cavity Pressure increase the cavity thickness slightly
  - Mold plate bending
  - Mold steel compression
  - Tie-bar stretch
- When cavity pressure decreases:
  - Mold halves close back together
  - Pressure decay is partly compensated

(Deformation Scaled x20)
Effect of Mold Deflection on Pressure Decay and Shrinkage

- Cavity Pressure decays once gate is frozen
- Pressure at time of freezing controls shrinkage and warp

CRIMS shrinkage correction not used here
(Some slides withheld. Please attend the class)