Autodesk® Moldflow® Insight 2012

AMI Reactive Molding Analysis Results

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Reactive Molding analysis results

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This help topic specifies the results generated by a Reaction Injection Molding (RIM) analysis, and a Resin Transfer Molding (RTM) or a Structural Reaction Injection Molding (SRIM) analysis, using a thermoset material.

Text based results

The following table lists the text results generated for a Reaction Injection Molding analysis.

Results
Reactive Molding analysis log on page 12
Results Summary
Analysis Check

Graphical results

The following table lists the results generated for a Reaction Injection Molding (RIM) analysis, and RTM or SRIM analysis, and indicates whether each result is supported for the following technologies:

- Midplane
- Dual Domain
- 3D

For more information about a result, including how to interpret the display, click on the result name.

Flow (Fill+Pack / filling and curing phase) results	Analysis technology
Fill time	
Clamp force	
Pressure	
Flow rate, beams	
Average velocity	
Orientation at core	

Flow (Fill+Pack / filling and curing phase) results	Analysis technology
Orientation at skin	
Shear rate, bulk	
Shear stress at wall	
Bulk conversion at end of process result on page 6[1]	
Bulk temperature at end of fill	
Bulk temperature, nodal[1]	
Cured layer fraction result on page 10[1]	
Pressure at end of fill[1]	
Air traps[2]	
Pressure at injection location[2]	
Pressure at V/P switchover[2]	
Temperature at flow front[2]	
Volumetric shrinkage[2]	
Volumetric shrinkage (3D)	
% Shot weight[2]	
Bulk conversion result on page 5[2]	
Bulk temperature[2]	
Frozen layer fraction[2]	
Grow from[2]	
In-cavity residual stress in first principal direction[2]	
In-cavity residual stress in second principal direction[2]	

[1] For Midplane and Dual Domain analysis technologies, these results are produced only when you have selected an analysis sequence that includes the Incompressible solver.

[2] For Midplane and Dual Domain analysis technologies, these results are produced only when you have selected an analysis sequence that includes the Compressible solver.

Flow (Fill+Pack / filling and curing phase) results	Analysis technology
Sink index[2]	
Throughput[2]	
Volumetric shrinkage at ejection[2]	
Weld lines[2]	
Weld and meld lines[2]	
Air traps, including air vents [3]	
Conversion at node result on page 7	
Density	
Extension rate	
Polymer filled region	
Shear rate (3D)	
Shear rate, maximum	
Temperature (3D)	
Unfilled cavity	
Velocity (3D)	
Vent region pressure [3]	
Viscosity	
Mat orientation result on page 11[4]	
Volume change (Runner balance)	

[3] This result is available only when the option to Perform venting analysis is selected in the solver parameters.

[4] The Mat orientation result is specific to the RTM and SRIM processes. The RTM and SRIM processes are not supported by 3D analysis technology.

Warp results	Analysis technology
Deflection, all effects [2]	

Bulk conversion result

2

The Bulk conversion result shows the average material conversion (cure) across the part thickness, calculated over the entire molding process (filling + curing phases).

This result is generated from a Midplane and Dual Domain Reactive Molding analysis.

Using this result

Premature conversion is a typical molding problem and occurs when the material solidifies (cures) in the mold cavity before the curing phase is complete. If the material pre-cures, you will see an acceleration of the melt, followed by strong hesitation, that is, viscosity suddenly decreases because the material is too hot and then abruptly increases as material pre-cures.

If pre-cure occurs, increase the specified curing time until conversion throughout the entire part reaches the recommended Ejection conversion value for the material.

TIP: This value is provided in the material database. To find the Ejection conversion value, right-click on the selected material in the **Study Tasks** pane, then select **Details... > Recommended Processing** (tab).

As a rule of thumb, thermosets should reach 80% conversion at the end of the process; however, for less expensive products, and depending on the material, 50% conversion, or less, may suffice.

NOTE: Animate the Bulk conversion result to check for late-curing areas.

Things to look for

Pre-cure	Increase cure time or decrease melt and/or mold temperature and re-run. Longer cure times impart more heat resistance and a longer life to the product.
Flow rate	If the flow rate is too high, the material will shear heat and conversion will have progressed too much when material enters the mold. This will cause the material to cure completely too early.

NOTE: For example, when reading this plot, "Bulk conversion at Time = 54 (s) is 0.42 means that the material has reached 42 % conversion (cure) at the end of curing.

Bulk conversion at end of process result

3

The Bulk conversion at end of process result is generated from a Midplane and Dual Domain Reactive Molding analysis, and shows the average material conversion (cure) across the part thickness, calculated at the end of the filling phase.

The Bulk conversion at end of process result is generated from a Midplane and Dual Domain Reactive Molding analysis, and shows the average material conversion (cure) across the part thickness, calculated at the end of the filling phase.

Using this result

Premature conversion is a typical molding problem and occurs when the material solidifies (cures) in the mold cavity before the curing phase is complete. If the material pre-cures, you will see an acceleration of the melt, followed by strong hesitation, that is, viscosity suddenly decreases because material is too hot, then abruptly increases as material pre-cures.

If pre-cure occurs, increase the specified curing time until conversion throughout the entire part reaches the recommended Ejection conversion value for the material.

TIP: This value is provided in the material database. To find the Ejection conversion value, right-click on the selected material in the **Study Tasks** pane, then select **Details... > Recommended Processing** (tab).

Things to look for

- The material continues to cure after the end of filling, until the end of the curing phase. Therefore, be sure to view the Bulk conversion result, which shows % conversion until the end of the curing phase.

Conversion at node result 4

The Conversion at node result shows the actual material conversion (cure) at a node, calculated over the entire molding process (filling + curing phases).

This result is generated from a 3D Reactive Molding analysis.

Using this result

Premature conversion is a typical molding problem and occurs when the material solidifies (cures) in the mold cavity before the curing phase is complete. If the material pre-cures, you will see an acceleration of the melt, followed by strong hesitation, that is, viscosity suddenly decreases because material is too hot, then abruptly increases as material pre-cures.

If pre-cure occurs, increase the specified curing time until conversion throughout the entire part reaches the recommended Ejection conversion value for the material.

TIP: This value is provided in the material database. To find the Ejection conversion value, right-click on the selected material in the **Study Tasks** pane, then select **Details... > Recommended Processing** (tab).

As a rule of thumb, thermosets should reach 80% conversion at the end of the process; however, for less expensive products, and depending on the material, 50% conversion, or less, may suffice.

TIP: Animate the Conversion at node result to check for late-curing areas.

Things to look for

Pre-cure Increase cure time or decrease melt and/or mold temperature and re-run. Longer cure times impart more heat resistance and a longer life to the product.

Flow rate If the flow rate is too high, the material will shear heat and conversion will have progressed too much when material enters the mold. This will cause the material to cure completely too early.

NOTE: For example, when reading this plot, Conversion at node at Time = 54 (s) is 0.42 means that the material has reached 42% conversion (cure) at the end of curing.

Conversion result

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The Conversion result shows the conversion value (degree of cure) at a particular part thickness over the duration of the entire molding process. This part thickness is the normalized thickness.

The Conversion result is generated from a Midplane or Dual Domain Reactive Molding analysis if the Number of profiled results specified in the solver parameters is not 0.

Using this result

Premature conversion is a typical molding problem and occurs when the material solidifies (cures) in the mold cavity before the curing phase is complete. If the material pre-cures, you will see an acceleration of the melt, followed by strong hesitation, that is, viscosity suddenly decreases because material is too hot, then abruptly increases as material pre-cures.

If pre-cure occurs, increase the specified curing time until conversion throughout the entire part reaches the recommended Ejection conversion value for the material.

TIP: This value is provided in the material database. To find the Ejection conversion value, right-click on the selected material in the **Study Tasks** pane, then select **Details... > Recommended Processing** (tab).

Normalized thickness values range from 0 to 1, where 0 is the center of the part and 1 is the plastic/metal interface (mold wall). The Conversion result shows the degree of cure at the selected normalized part thickness.

Select the normalized thickness by right-clicking on the Conversion result in the **Study Tasks** pane, select **Properties > Animation** (tab), and select the required thickness in the **Normalized Thickness** drop-down list.

NOTE: It is very important to keep track of the conversion distribution and profile in thickness during the filling phase, especially at the melt front where the resin experiences fountain flow.

Things to look for

Pre-cure	Increase cure time or decrease melt and/or mold temperature and re-run. Longer cure times impart more heat resistance and a longer life to the product.

Flow rate If the flow rate is too high, the material will shear heat and conversion will have progressed too much when material enters the mold. This will cause the material to cure completely too early.

Cured layer fraction result

6

The Cured layer fraction result shows the fraction of thickness where the degree of cure is higher than the gelation conversion.

The gelation conversion indicates the onset of gelation, where the material viscosity reaches an infinite value in a Reactive Molding analysis.

The Cured layer fraction result is generated from a Midplane and Dual Domain Reactive Molding and Microchip Encapsulation analysis.

Using this result

The value of cured-layer fraction can range from 0-1 to indicate the thickness fraction of the cured layer. A higher value indicates a thicker cured layer (or thinner flow channel) and higher flow resistance. During fill, the cured layer in the areas with flow does not increase as rapidly as in the areas where flow has already stopped. This is because the heat transfer from the mold wall is balanced with the cold resin coming from up-stream. Once the flow stops, the heat transfer from the mold wall and the heat released by the reaction completely dominate the area. A rapid increase in the thickness of the cured layer can be seen.

Cured-layer thickness has a significant effect on flow resistance because the thickness of the flow channel is reduced as thickness of the cured layer increases. The effect of the thickness reduction can be roughly estimated by the definition of fluidity. Fluidity is proportional to the cubic power of part thickness.

A fifty percent reduction in thickness reduces fluidity by a factor of eight (or increases the flow resistance by a factor of eight). In fact, this factor becomes sixteen in the case of runners.

Things to look for

- When the curing reaction has progressed to the gelation conversion or beyond, the resin will behave like a solid and stop flowing. Pre-mature gelation is one of the causes of molding problems associated with flow, strength, and part appearance.
- When excessive curing occurs, unreasonably high pressure is required to fill the part, and short shot may occur.

Mat orientation result

7

The Mat orientation result shows the effect of the fiber-mat preform (fiber-mat) properties on the advancement of the melt-front.

This result is generated from a Midplane and Dual Domain resin transfer molding (RTM) or structural reaction injection molding (SRIM) analysis.

Using this result

In RTM and SRIM processes, resin is forced to flow through a cavity in which reinforcing fiber mat (also called preform) is present. The flow type, characterized by the properties of the fiber mat, may be isotropic or anisotropic, depending on the structure of the mat. The resistance of a resin to flowing through the mat also depends on the resin properties and flow rate.

The Fiber-mat orientation result indicates the principal direction 1 of an anisotropic fiber mat. This is the preferential flow direction that the resin follows during the filling phase. This direction corresponds to the major axis of an elliptic flow front, determined by the measurement of the fiber-mat permeabilities.

8 Reactive Molding analysis log

The Analysis Log is a text report that lists the inputs that you used for the Reactive Molding analysis, including solver parameters, material data, process settings an model details, followed by the analysis progress tables.

There is a separate table for the filling phase, and for the curing phase of the analysis. The Analysis Log is generated by the Reactive Molding analysis.

Using the Analysis Log

The Analysis Log for a Reactive Molding analysis can be used to determine whether the part filled completely during injection before the curing phase began.

Look at the analysis progress table for the injection phase and check whether 100% of the cavity volume filled. If this did not occur, then you may see a message stating that the maximum machine injection pressure was reached and a short shot occurred.

Things to look for

Short shot If this problem occurs, try changing the following process settings (in the order presented) and re-run the analysis.

1. Melt and mold temperatures (primary).
2. Fill time (primary).
3. Pressure (secondary).