Autodesk® Moldflow® Insight 2012

AMI Cool Analysis Results

Autodesk®

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Cool analysis results

1

This topic specifies the results generated by a Cool analysis for a thermoplastic material. These results can be customized to specific requests for part troubleshooting.

Text based results

The following table lists the text results generated for each Cool analysis.

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Summary
Analysis Check

Graphical results

The following table lists the graphical results generated for a Cool analysis and indicates whether each result is supported for the following analysis technologies:

The following table lists the graphical results generated for a Cool analysis, regardless of the solver, and indicates whether each result is supported for the following analysis technologies:

- Midplane
- Dual Domain
- 3D

Results generated only for the Cool (FEM) solver are listed in the next table. Some results, such as Improper part-mold contact, are accessed via **(Results tab > Plots panel > New Plot)**.

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

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Cool (FEM)

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Average temperature, cold runner result

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The Average temperature, cold runner result is the average temperature of the temperature profile across the cold runner, calculated at the end of cooling time.

This profile is based on the average mold surface temperatures for the cycle, which includes the clamp open time.

Using this result

In some cases where there are thick runners, the average temperature will be very high, possibly above the ejection temperature. This indicates the runners may control the cycle time. The cycle time of a mold should be based on the part and not the runner.

To reduce the average temperature and cooling time of the runners, consider reducing the runner diameter. Adding cooling channels around the runners or reducing the coolant temperature for the circuits cooling the runners will also reduce the average temperature.

NOTE: Most parts can be ejected with the runners 50% frozen and thick parts 80% frozen.

Things to look for

- Check that the average temperature is below the ejection temperature.

Average temperature, part result

3

The Average temperature, part result is the average temperature of the temperature profile across the part thickness, calculated at the end of cooling time.

This profile is based on the average mold surface temperatures for the cycle, which includes the clamp open time.

Using this result

The average temperature should be about half way between the target mold temperature and the ejection temperature for an optimized mold. There should be only a small variation in average temperature in the part. Areas of high average temperature may be thick regions of the part or areas that are poorly cooled. Consider adding cooling channels near these areas.

Things to look for

- Check that the average temperature is well below the ejection temperature for the material at the end of cooling, so that the part can be ejected successfully.

Circuit coolant temperature result

4

The Circuit coolant temperature result shows the temperature of the coolant inside the cooling circuit.

Using this result

The Cool analysis log contains the change in coolant temperature from coolant-in to coolant-out. If the increase is unacceptable, (greater than 2–3°C), use the circuit coolant temperature result to determine where the greatest increase in temperature occurs.

In parallel circuits, even though the final increase in coolant temperature from coolant-in to coolant-out is small, the coolant may have reached a high temperature in some sections of the cooling channels.

The following events occur when coolant flows through one channel:

- The temperature of the coolant increases.
- The high-temperature coolant mixes with low temperature coolant.
- The coolant leaves the circuit.

When this occurs, the end temperature is not the maximum coolant temperature; therefore, you should always look at the circuit coolant temperature result in parallel circuits.

Things to look for

When viewing the coolant temperature result, look for the following:

- The inlet to outlet temperature rise should be no more than 2–3°C. Higher values may indicate a wider mold surface temperature range, which is of primary importance.
- Hot spots.

Circuit flow rate result

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The Circuit flow rate result shows the flow rate of the coolant inside the cooling circuit.

Using this result

This result is used in conjunction with the Circuit Reynolds number result to determine whether the flow rate that is required to achieve turbulent coolant flow can be achieved.

Use this result if you have set a minimum Reynolds number. This can be set by right clicking on the **Cooling Circuit(s)** in the **Study Tasks** window and selecting **Set Coolant Inlets**. Click **Edit** and enter a specific Reynold number.

NOTE: The flow rate itself is not the dominant factor in heat extraction, but it should be the minimum required to achieve the necessary Reynolds number. The flow rate is constant for a series circuit, but not for a parallel circuit.

Things to look for

When viewing the circuit flow rate result, check that the sum of the coolant flow rates in each circuit is less than the coolant pump capacity. The information obtained from this result is also available in the analysis log.

Circuit metal temperature result

6

The Circuit metal temperature is an elemental result averaged over the cycle, and shows the temperature of the metal cooling circuits.

Using this result

The temperature distribution should be evenly distributed on the cooling circuits. The temperature will increase where the circuit nears the part, and these hotter regions will also heat the coolant. The temperature should be no more than 5°C greater than the inlet temperature.

If the circuit temperature is too hot in these areas, consider the following resolutions.

- Increase the flow rate of the coolant.
- Make the cooling circuit larger and increase the flow rate of the coolant to maintain the Reynolds number.
- Add cooling channels in the area of the hot metal temperature.

Things to look for

When viewing the circuit metal temperature result, consider the following:

- Circuit coolant temperature result.
- Mold hot spots.

7 Circuit Reynolds number result

The Circuit Reynolds number result shows the Reynolds number of the coolant in the cooling circuit.

Using this result

When turbulent flow has been achieved, an increase in flow rate makes little difference to the rate of heat extraction; therefore, flow rate should only be set to achieve the ideal Reynolds number with minimum variations.

If you enter a minimum Reynolds number, use 10,000 as a minimum, and then check this result to ensure minimum variation. Do not aim for a Reynolds number that is greater than 10,000.

If you have parallel cooling channel circuits, it may be difficult to achieve minimum variation of the Reynolds number throughout all branches of the parallel circuit. If this is the case, consider changing the circuit layout. A Reynolds number below 4000 can be laminar and this will be less effective at removing heat from the cavity.

If there is a large variation in cooling channel diameter, there may be excessive variations in the Reynolds number. If this occurs, either adjust the cooling channel diameter, or reduce the minimum Reynolds number, ensuring the Reynolds number is always greater than 4000.

Things to look for

When viewing the Circuit Reynolds number result, watch for the following:

- The Reynolds number should be greater than 4,000 for lines actively involved in cooling the part to ensure there is turbulent flow within the circuits and hence efficient cooling.
- The ideal Reynolds number to achieve is 10,000.

Cool analysis log

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The Cool analysis log contains the change in coolant temperature from coolant-in to coolant-out.

The analysis log contains a record of the analysis and can be accessed by selecting the **Logs** check box at any time during or after the analysis.

External iteration The analysis first assumes an initial temperature distribution for the circuit metal temperatures, and performs a circuit Cool analysis based on these temperatures. It then performs a boundary element Cool analysis on the part and mold using the data obtained from this circuit network distribution. From this boundary element Cool analysis, new temperature distributions are obtained for the circuit metal temperatures. Based on these circuit metal temperatures, another circuit network analysis is performed and new boundary conditions are obtained for the boundary element analysis. Another iteration of the boundary element analysis is then performed and these iterations are continued until convergence is reached.

Cycle time(s) This is the sum of the filling, packing, cooling, and mold-open time. When an automatic Cool analysis is performed, the cycle time is the result of the analysis along with the relevant temperature distributions.

Avg temp iteration The boundary element method solves the average temperature distribution in the part. This average temperature is dependant upon the heat fluxes coming from the part into the mold, on the heat being extracted into the circuits, and heat loss from the outer boundaries. The heat flux solution and the average temperature solution are coupled and various iterations between the two solutions occur. The number of iterations between the flux and temperature distributions before internal convergence are recorded here.

Avg temp deviation A solution tolerance is set in the advanced settings of the Cool analysis Process Settings Wizard, with a default of 0.1° degrees. The iterations will continue until the temperature solution is accurate to within this tolerance. You can monitor the rate of convergence of the average temperature equation by looking at this number. If the solution does not converge, then this number will never go below the specified value.

Dif temp iteration The temperature difference equation is only applicable to Midplane part models or Dual Domain/3D models with inserts and parting planes. Midplane part models solve the average temperature of the part and the temperature difference across the part. Form this information, the top and bottom temperatures are obtained. The same is applicable to inserts and parting planes. The temperature difference equation is coupled to the average temperature, heat flux and coolant temperature difference solutions within an iteration. This value just gives you the rate of convergence of this equation, and if it is not converging, this parameter will indicate it. Convergence will occur when this value is smaller than the specified value.

Dif temp deviation Provides an indication of the number iterations required by the temperature difference solver for internal convergence.

Circ temp residual The coolant network solution is solved in conjunction with the boundary element method. This parameter tells you how much the coolant temperature distribution changes with every external iteration. As this parameter tends to zero, it shows that the coolant temperature distribution does not change much with successive boundary element iterations and a solution is near. The coolant tolerance is much tighter than the one for the part and at the end of the analysis the final error is printed out.

Circuit heat removal efficiency result

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The Circuit heat removal efficiency result provides a measure of the effectiveness of each cooling channel section in extracting heat from the mold during the molding cycle.

This quantity shows the relative efficiencies within the cooling system.

In most cases, the cooling channels are cooling the mold, and the plot values are positive. The section with the highest efficiency is assigned a value of 1. All other heat removal efficiencies are represented as a fraction less than 1.

In cases where the cooling channels are heating the mold, the plot values are negative. The section providing the most heat input is assigned a value of -1, and all other heat input efficiencies are represented as a fraction greater than -1.

Using this result

The circuit heat removal efficiency values are derived from the following parameters:

- Distance of channel from part—The closer the cooling channel to the part, the higher the heat removal efficiency.
- Circuit Reynolds number—The higher the Reynolds number in the cooling channel, the higher the heat removal efficiency.
- Temperature difference between the coolant and the channel-mold metal interface—The greater the temperature difference, the higher the heat removal efficiency.

In general, the relationship between the individual parameters and the heat removal efficiency are non-linear, so the overall relationship is complex. All of the above parameters, apart from the distance of the channel from the part, are available as separate, individual plots to further show their contribution to cooling efficiency.

Things to look for

The Circuit heat removal efficiency result helps identify which channels are extracting more heat relative to the others. Channels with a heat removal efficiency of close to zero are not participating in cooling. If these channels are located in a region where there is no heat load, then such channels can be discarded altogether.

If a cooling channel with a very low heat removal efficiency is located in a region where there is a significant heat load, you need to take measures to improve the efficiency of the channels. That is, modify the cooling system design to move the channels closer to the part, or introduce bubblers or baffles, and/or change circuit parameters such as flow rate or coolant inlet temperature.

Circuit heat flux

10

The Circuit heat flux result displays a measure of the rate heat is extracted by each cooling channel during the molding cycle.

Values obtained are related to several factors.

- Mold metal temperature
- Coolant temperature
- Coolant flow rate
- Coolant properties
- Circuit geometry

In most cases, the cooling channels are cooling the mold and the plot values are positive.

In cases where the cooling channels are heating the mold, a negative flux value results.

NOTE: The Circuit heat flux result is not listed under the **Cool** results by default. To display this plot, click **Results tab > Plots panel > New Plot**, select **Circuit heat flux** from the list and click **OK**.

Using this result

For localized mold surface temperatures that are either hotter or colder than required, the impact of adjusting the coolant temperature or flow rate can be assessed.

If adjusting these values does not rectify the problem, either modify the existing cooling circuits or add new ones.

The amount of flux removed by a circuit can also be changed by altering the circuit diameter.

Things to look for

Channels with little Circuit heat flux values may be redundant. This is often the case with parallel circuits where one branch of the circuit has little coolant flow.

Verify that channels with areas of high heat flux have inlet and outlet coolant temperatures within 5ºC of each other.

The Circuit heat flux result can be used in conjunction with the **Circuit metal temperature**, **Temperature, part** and **Flux, part** results to understand how the cooling circuit is functioning.

Circuit pressure result

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The Circuit pressure result is generated from a Cool analysis to show the distribution of pressure along a cooling circuit, averaged over the cycle.

Using this result

The pressure inside the cooling circuits should remain evenly distributed from the inlet circuit pressure to the outlet circuit pressure. Large pressure drops in the cooling circuits are caused by cooling problems, such as the bubbler or the baffle dimensions being too small.

This result can be checked to determine the flow direction in parallel cooling circuits. The pressure will be highest at the coolant inlet and lowest at the coolant outlet.

The information obtained from this result is also available in the analysis log.

NOTE: This result does not take into account the pressure loss due to external cooling lines, fittings, and so forth.

Things to look for

When viewing the Circuit pressure result, check the following:

- The coolant pressure in each circuit is less than the coolant pump capacity.
- Large pressure drops (inlet–outlet pressure).

Criteria for assessing cooling performance

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Cooling circuit design is always a compromise between achieving reasonably uniform cooling and the shortest possible cycle time.

The most acceptable compromise will vary from part to part. In some cases, quality requirements mean that uniform cooling is most important, whereas in other cases cost requirements mean that minimizing the cycle time is the priority.

Cooling performance parameters

A number of parameters are listed below which enable you to draw some conclusions about the efficiency of the cooling system. General values to be used in the design of new molds are shown below.

Parameters	General Guideline
Max. variation between temperature across bottom face of part and target mold temperature	10°C
Max. variation between temp across top face of part and target mold temperature	10°C
Max. variation in temperature across thickness of part	The acceptable variation in temperature between the inside and outside of a plastic part at the time of ejection will depend on the local stiffness of the part and the percentage of the thickness frozen. Large flat areas with big temperature variations and which are not completely frozen are more prone to warping than structures that are stiffer. This is due either to their shape or their temperature at ejection.
Min. % of wall thickness frozen on both top and bottom faces of part	The amount of the wall thickness which must be frozen before ejection depends on the part's stiffness (as above), the degree to which the part is resisting ejection (due, for example, to mold finish or overpacking) and the design and position of the ejector system components.
Max. difference between the average temperature, part result and target mold temperature	The Automatic analysis attempts to reduce the average cavity temperature to within 1°C of the target mold temperature used in the original Fill+Pack analysis sequence. In some cases, this requirement creates excessively long cooling

Parameters	General Guideline
	times with the part being totally frozen and cooled to well below its ejection. This problem is normally caused by the coolant inlet temperature being too close to the target mold temperature specified in the process setting wizard. To rectify this problem, lower the coolant temperature or raise the target emperature. A typical difference between the coolant and average part surface will be between 10°C and 30°C for molds made from P20 steels.
Max. difference between coolant inlet temp and circuit metal temp in any circuit	5°C
Max. coolant temperature rise from start to finish of any circuit	2°C
Pressure required to circulate coolant	The pressure required to circulate the coolant must be within the available system pressure. This value will depend on whether the coolant is being supplied from a heater/circulator unit, from a cooling tower system, a chiller or from the mains. In the case of heater/circulator units, the manufacturers normally supply performance curves showing the pressures available at various flow rates.
Max. cycle time	Minimum possible

Flux, part (top) result 13

The Flux, part (top) result shows the average rate of heat flow across the top (blue) mold/part interface during the cycle.

The surface flux is affected by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: This is set in the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

This result is available for Midplane analysis technology only.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels.

14 Flux, part (bottom) result

The Flux, part (bottom) result shows the average rate of heat flow across the bottom (red) mold/part interface during the cycle.

The surface flux is affected by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: This is set in the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

This result is available for Midplane analysis technology only.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels.

15 Flux, part result

The Flux, part result shows the average rate of heat flow across the mold/part interface during the cycle.

The surface flux is affected by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: This is set in the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

This result is supported by the following analysis technologies:

- Dual Domain
- 3D

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. An area of high heat flux indicates that there is a large heat concentration in this section of the tool.

If there are hot or cool spots, you may need to adjust the cooling channels.

Frozen layer percentage, part (bottom) result 16

The Frozen layer percentage, part (bottom) result shows the thickness of the frozen layer on the bottom side of the element.

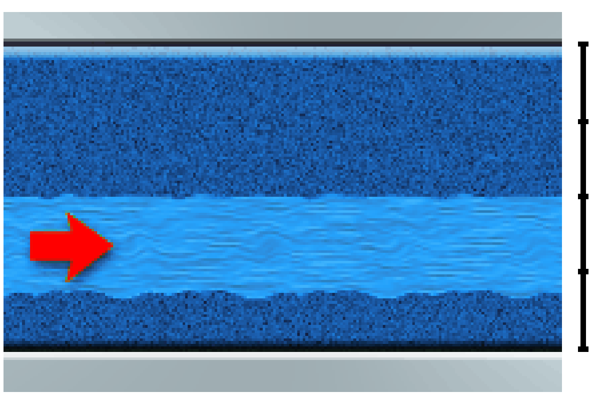
Use this result with the Frozen layer percentage, part (top) result to determine if the part froze uniformly.

Using this result

Ideally, the frozen layer thickness should be the same for both top and bottom surfaces to help achieve uniform cooling.

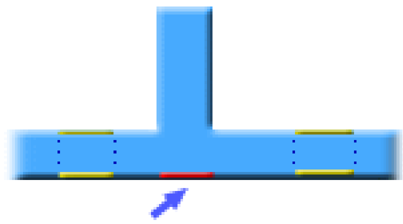
The amount of the wall thickness which must be frozen before ejection will depend on the part stiffness, the degree to which the part is resisting ejection (due for example to mold finish or overpacking) and the design and position of the ejector system components.

NOTE: This result is a fraction of the entire element thickness. In the following diagram, the top frozen layer thickness is 0.5 (the bottom frozen layer thickness is 0.2).



Things to look for

- The same frozen layer thickness for the top and bottom surfaces.
- Non-uniform cooling.



NOTE: When using Dual Domain analysis technology, this result will have no meaning for some elements. If an element does not have a matching element on the other side of the part, such as the element shown in red in the diagram above, then this result is meaningless.

Frozen layer percentage, part (top) result 17

The Frozen layer percentage, part (top) result shows the thickness of the frozen layer on the top side of the element.

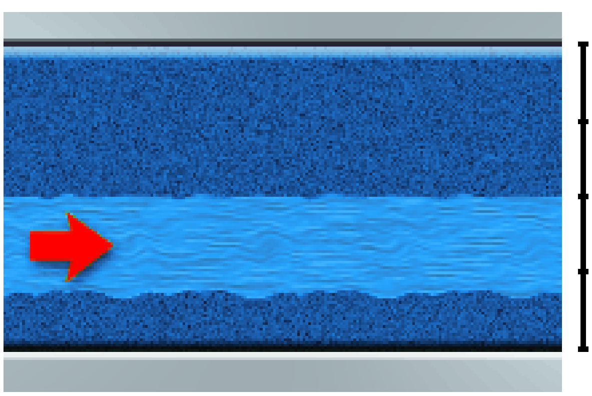
Use this result with the Frozen layer percentage, part (bottom) result to determine if the part froze uniformly.

Using this result

Ideally the frozen layer thickness should be the same for both top and bottom surfaces to help achieve uniform cooling.

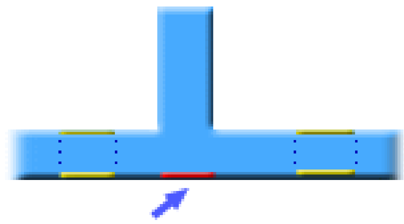
The amount of the wall thickness which must be frozen before ejection will depend upon the part stiffness, the degree to which the part is resisting ejection (due for example to mold finish or overpacking) and the design and position of the ejector system components.

NOTE: This result is a fraction of the entire element thickness. In the following diagram, the top frozen layer thickness is 0.5 (the bottom frozen layer thickness is 0.2).



Things to look for

- The same frozen layer thickness for the top and bottom surfaces.
- Non-uniform cooling.



NOTE: When using Dual Domain analysis technology, this result will have no meaning for some elements. If an element does not have a matching element on the other side of the part, such as the element shown in red in the diagram above, then this result is meaningless.

Maximum temperature position, part result

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The Maximum temperature position, part result is generated from a Cool analysis, and shows the position of the Maximum temperature, part result in a plastic element relative to the bottom side (value = 0.0) of the element during the cycle.

Using this result

- For uniform cooling in parts which are 100% plastic, the relative position of the peak temperature should equal 0.5.

NOTE: Thick plastic elements will normally take the longest to cool.

Things to look for

- Check that the part has cooled uniformly, or, that the part maximum temperature position is 0.5.

NOTE: For Cool analyses using Dual Domain analysis technology, the surface containing the specified element is assigned the value 1 and the opposite surface is assigned the value 0. Thus the value shown will depend on the side of the model being viewed.

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19 Mold-melt temperature difference (bottom), part result

The Mold-melt temperature difference (bottom), part result is generated at the end of a Cool analysis on a Midplane part.

It shows the difference in temperature between the part side and mold side of the part/mold interface on the bottom side of the part. The bottom side is defined by the orientation of the mesh elements.

The difference in temperature is determined by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: The HTC values are set in the **Mesh** tab of the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transer between the polymer and the mold.

Things to look for

Uneven part temperatures may result in warpage as the part cools after ejection. This may be because the mold surface is not conducting sufficient heat during molding.

To compensate for low mold conductivity, it may be necessary to add or alter cooling circuits to draw the extra heat away.

Mold-melt temperature difference (top), part result 20

The Mold-melt temperature difference (top), part result is generated at the end of a Cool analysis.

It shows the difference in temperature between the part side and mold side of the part/mold interface on the top side of the part. The top side is defined by the orientation of the mesh elements.

The difference in temperature is determined by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: The HTC values are set in the **Mesh** tab of the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

Things to look for

Uneven part temperatures may result in warpage as the part cools after ejection. This may be because the mold surface is not conducting sufficient heat during molding.

To compensate for low mold conductivity, it may be necessary to add or alter cooling circuits to draw the extra heat away.

Mold-melt temperature difference result 21

The Mold-melt temperature difference result is generated at the end of a Cool analysis for a 3D part.

It shows the difference in temperature between the boundary of the part and the mold. This may be significant if there is an air gap between the part and the mold.

NOTE: This result requires that you set each element to use **Heat transfer coefficient** in the part surface properties.

Things to look for

To compensate for low mold conductivity, it may be necessary to add or alter cooling circuits to draw the extra heat away.

Improper part-mold contact 22

Occasionally, the Cool (FEM) analysis results will not converge. Generally, when this is the case, the cause is poor matching between the mold elements and the part elements. This can be confirmed and the areas of poor matching can be studied using the Improper part-mold contact result.

The Improper part-mold contact result shows how well the tetrahedral elements of the mold match those of the part. If the elements do not match well, the analysis will fail.

Obtaining this result

This result does not appear in the Study Tasks pane by default. Instead you can create it as a *New plot* after the analysis has run by clicking **(Home tab > Results panel > Results)**, then clicking **New Plot** and selecting **Plots** from the drop-down menu. **Improper part-mold contact** is listedin the **Available results**.

Using this result

During the analysis, the solver checks the internal section of the mold to ensure that the mold mesh matches the part mesh. Where there is perfect mesh matching, the Improper part-mold contact result appears blue with a value zero (0). Where there is no contact the Improper part-mold contact result appears red, with a value one (1). For the Cool (FEM) analysis to run successfully, there should be no red areas of no contact.

If your Improper part-mold contact results shows red areas, remesh the mold and fix these areas.

NOTE: This result does not impact the design of the mold. It is simply an indication of how well the part and mold have been modelled and therefore how well the tetrahedral elements of the mold match the tetrahedral elements of the part.

Things to look for

- Check that there are no areas of red, indicating no contact.

Percentage frozen layer, cold runner result 23

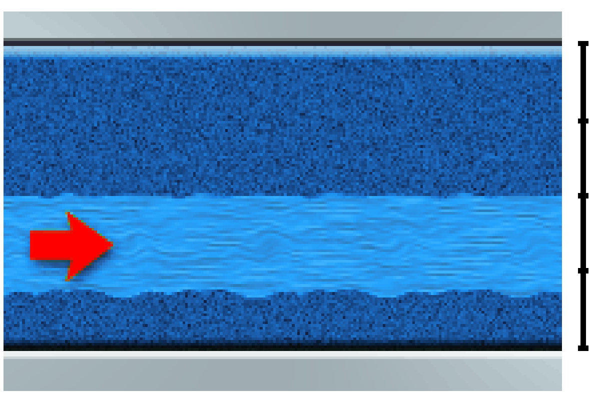
The Percentage frozen layer, cold runner result shows the thickness of the frozen layer on the cold runner surface at the end of the analysis.

Using this result

Ideally the frozen layer thickness on the outer surface of cold runners should be uniform to help achieve uniform cooling .

The amount of the wall thickness which must be frozen before ejection will depend on the part's stiffness, the degree to which the part is resisting ejection (due for example to mold finish or overpacking) and the design and position of the ejector system components.

NOTE: This result is a percentage of the entire part area thickness. In the following diagram, the top frozen layer thickness is 50% (the bottom frozen layer thickness is 20%).



Things to look for

- Non-uniform cooling.

Percentage frozen layer result 24

The Percentage frozen layer result is generated from a Cool analysis using 3D analysis technology and shows the percentage of polymer frozen at the time specified.

Using this result

3D parts often have thick sections that are difficult to cool. Some sections may freeze quickly, while thicker sections take longer to freeze. This result allows you to see which sections of the part are cooling quickly or slowly.

The percentage frozen layer should be very high, indicating that the part has been cooled sufficiently and has reached a solid state before ejection.

If the part is ejected before it has been cooled sufficiently in the mold, then the part will cool outside the mold and will be prone to warpage.

NOTE: A thick part should be sufficiently sound, structurally, to withstand the ejection process. Depending upon the ejection procedure, at least 80% frozen at ejection is a reasonable guideline.

Things to look for

- This result can be used to check whether the polymer has frozen off sufficiently before the part is ejected.
- Check the inverse result, the Percentage molten layer result.

Percentage molten layer result 25

The Percentage molten layer result is generated from a Cool analysis using 3D analysis technology and shows the percentage of polymer that has not frozen at the time specified.

This result is the inverse of the Percentage frozen layer result.

Using this result

3D parts often have thick sections that are difficult to cool. Some sections may freeze quickly, while thicker sections take longer to freeze. This result allows you to see which sections of the part are cooling more slowly.

The percentage molten layer should be very low, indicating that the part has cooled sufficiently. If the part is ejected before it has been cooled sufficiently in the mold, the part will cool outside of the mold and will be prone to warpage.

NOTE: A thick part should be sufficiently sound, structurally, to withstand the ejection process. Depending upon the ejection procedure, no more than 20% molten at ejection is a reasonable guideline.

Things to look for

- This result can be used to check whether the polymer has frozen off sufficiently before the part is ejected.
- Check the inverse result, the Percentage frozen layer result.

Temperature at surface, cold runner result

26

The Temperature at surface, cold runner result shows the cycle-averaged temperature of the cold runner surface in contact with the mold.

Using this result

Use this result to locate localized hot or cold spots on the model.

Things to look for

- The temperature of the mold should be as close as possible to the analysis target temperature.
- Check whether any hot spots are indicated, and whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels.

27 Temperature at surface, hot runner result

The Temperature at surface, hot runner result shows the temperature of the mold wall in contact with the hot runner, averaged over the cycle.

Using this result

Hot runners are usually well insulated from the mold. The Temperature at surface, hot runner result is the temperature of the mold wall in contact with the hot runner/insulation combination.

Things to look for

- Check for hot spots that cause cooling problems. If there is a problem, you may need to use a different hot runner or re-design the cooling circuit(s).

Temperature, circuit coolant (averaged) result

28

The **Temperature, circuit coolant (averaged)** result shows the average temperature of the coolant inside the cooling circuit, calculated using the finite element method (FEM).

Using this result

The Cool analysis log contains the change in coolant temperature from coolant-in to coolant-out. If the increase is unacceptable,(greater than 2-3°C), use the **Temperature, circuit coolant (averaged)** result to determine where the greatest increase in temperature occurs.

In parallel circuits, even though the final increase in coolant temperature from coolant-in to coolant-out is small, the coolant may have reached a high temperature in some sections of the cooling channels.

The following events occur when coolant flows through one channel:

- The temperature of the coolant increases.
- The high temperature coolant mixes with the low temperature coolant.
- The coolant leaves the circuit.

When this occurs, the end temperature is not the maximum coolant temperature; therefore, you should always look at the circuit coolant temperature result in parallel circuits.

Things to look for

When viewing the **Temperature, circuit coolant (averaged)** result, watch for the following.

- The inlet to outlet temperature rise should be no more than 2-3°C. Higher values may indicate a wider mold surface temperature range, which is of primary importance.
- Hot spots.

Temperature, circuit coolant (transient) result

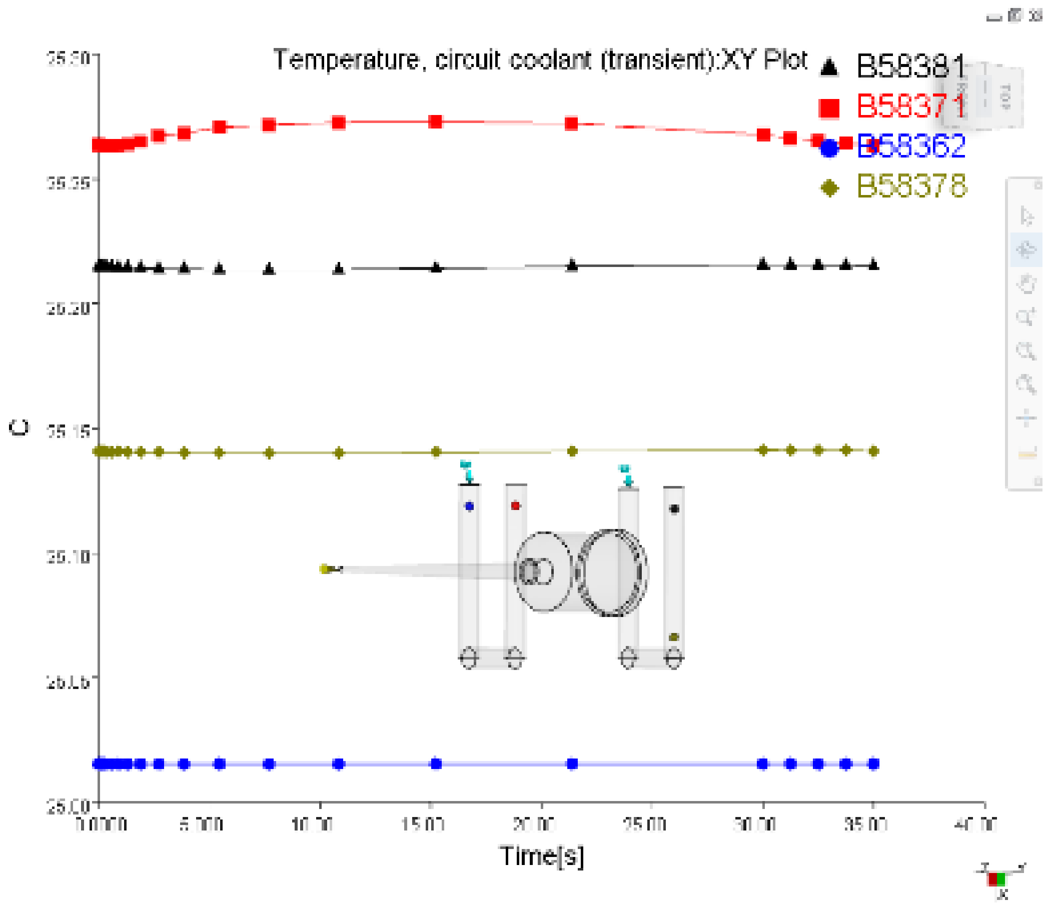
29

The **Temperature, circuit coolant (transient)** result shows how the temperature of the coolant in the cooling channels changes over the duration of the cycle.

Using this result

Use this result to determine whether the cooling channels are cooling effectively, and whether their placement will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

TIP: You can create an XY plot of the transient circuit coolant temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.



Things to look for

When viewing the **Temperature, circuit coolant (transient)** result, watch for the following.

- Localized hot or cold spots.
- The cooling pattern. Is it evenly distributed?

Temperature, circuit coolant (transient from start-up) result 30

The **Temperature, circuit coolant (transient from start-up)** result shows how the temperature of the coolant in the cooling channels changes during each cycle, until the mold temperature stabilizes.

Using this result

Use this result to determine whether the cooling channels are cooling effectively, and whether their placement will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

TIP: You can create an XY plot of the transient circuit coolant temperature during production start-up, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, circuit coolant (transient from start-up)** result, watch for the following.

- Localized hot or cold spots.
- The cooling pattern. Is it evenly distributed?

Temperature, core (averaged) result 31

The **Temperature, core (averaged)** result shows the temperature of the core across it's thickness, calculated at the end of the cooling time, using the Cool (FEM) solver.

The temperature of the mold is taken into consideration when calculating the temperature of the core, and is based on the average mold surface temperature *over the whole cycle* , including the clamp open time. The **Temperature, core (averaged)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the core. Using the cutting plane tools, you can also examine the temperatures within the core; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the core changes with time inside the solid model.

TIP: You can create an XY plot of the core (averaged) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, core (averaged)** result, watch for the following.

- The temperature of the core should cool to the specified mold temperature at the end of the cycle.

Temperature, core (transient) result

32

The **Temperature, core (transient)** result shows the temperature of the core across it's thickness, at every time iteration throughout the injection molding cycle.

The **Temperature, core (transient)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the core. Using the cutting plane tools, you can also examine the temperatures within the core; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the core changes with time inside the solid model.

TIP: You can create an XY plot of the core (transient) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, core (transient)** result, watch for the following.

- The temperature of the core should cool to the specified mold temperature at the end of the cycle.

33 Temperature, core (transient from start-up) result

The **Temperature, core (transient from start-up)** result shows the temperature of the core across it's thickness, at every time iteration and for all start-up cycles, until the mold temperature stabilizes.

The **Temperature, core (transient from start-up)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the core. Using the cutting plane tools, you can also examine the temperatures within the core; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the core changes with time inside the solid model.

TIP: You can create an XY plot of the core (averaged) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, core (averaged)** result, watch for the following.

- The temperature of the core should cool to the specified mold temperature at the end of the cycle.

Temperature difference, insert result 34

The Temperature difference, insert result shows the temperature difference between the insert and the mold on your model.

Using this result

The distribution of the temperature difference between the insert Temperature, insert (top) result, and mold Temperature, insert (bottom) result should be uniform.

A large difference in temperature between insert and mold may mean that heat cannot be extracted efficiently from the insert.

NOTE: If you specify a low conductance at the interface or on a parting plane, this will result in a large temperature difference.

Things to look for

When viewing the insert temperature difference, look at the following results to check for localized hot spots:

- Temperature, insert (top)
- Temperature, insert (bottom)

Temperature difference, part result 35

The Temperature difference, part result is the difference between the top and bottom temperatures.

It is top minus bottom; therefore, a negative number indicates the bottom temperature is hotter than the top temperature. This result is also only available for Midplane models as there is no bottom temperature result for Dual Domain.

Using this result

The difference between the top and bottom temperatures of the part should be within 5°C. The larger the temperature difference, the more likely the cooling will contribute to the part warping. This is known as differential cooling.

TIP: This result indicates the cooling effectiveness of the part in your design.

Things to look for

Use the results listed below to check for any hot spots in the part:

- Temperature, part (top)
- Temperature, part (bottom)

Temperature difference, parting plane result

36

The Temperature difference, parting plane result shows the difference of the averages in temperature between the top and bottom sides of the parting plane elements during the cycle.

Cycle time includes clamp open time.

Using this result

The distribution of the temperature difference between the top and bottom sides of a parting plane should be uniform or show only small variations to ensure even cooling and minimal warpage due to differential cooling effects. The smaller the difference, the more effective the cooling.

The temperature difference between the top and bottom sides of a parting plane should be small. Larger variations may indicate a poor cooling system design, and may contribute to part warpage. The difference between the top and bottom temperatures of the parting plane should be within 5°C.

Things to look for

Use the following results to check for hot spots:

- Temperature, parting plane (bottom) result.
- Temperature, parting plane (top) result.

Temperature, insert (bottom) result 37

The Temperature, insert (bottom) result shows the temperature of the mold surface in the area in contact with the insert in your cooling design.

NOTE: Results will not be displayed for the element(s) of the insert in contact with the plastic.

Using this result

An insert will only assist heat transfer if a cooling channel is located in or near the insert. Use this result to find localized hot or cold spots on the insert surfaces. A large difference in temperature between insert and mold may mean that heat cannot be extracted efficiently from the insert.

The difference between the temperature across the top or bottom face of any insert surface should not be greater than ±10°C (18°F).

NOTE: In some cases, you can have insert temperatures less than the coolant temperature. This is due to the Cool analysis solver tolerance. If you reduce the tolerance value for a Cool analysis in the Process Settings Wizard, and re-run the analysis, the result will be more accurate.

Things to look for

When viewing the insert bottom temperature, look at the following results to check for localized hot spots:

- Temperature, insert (top)
- Temperature difference, insert

Temperature, insert (top) result

38

The Temperature, insert (top) result shows the temperature on the top surface of any inserts that have been modeled in your cooling design.

Using this result

An insert will only assist heat transfer if a cooling channel is located in or near the insert. Use this result to find localized hot or cold spots on the insert surfaces. A large difference in temperature between insert and mold may mean that heat cannot be extracted efficiently from the insert.

The difference between the temperature across the insert and the mold surface should not be greater than ±10°C (18°F).

NOTE: In some cases, you can have insert temperatures less than the coolant temperature. This is due to the Cool analysis solver tolerance. If you reduce the tolerance value for a Cool analysis in the Process Settings Wizard, and re-run the analysis, the result will be more accurate.

Things to look for

When viewing the insert top temperature, look at the following results to check for localized hot spots:

- Temperature, insert (bottom)
- Temperature difference, insert

Temperature, internal mold result 39

The Temperature, internal mold result shows the cycle-average temperature of the mold for a 3D model.

This result is available only if you have performed the following steps:

- Defined a mold boundary.
- Enabled **Calculate internal mold temperature** in the Cool 3D solver parameters, and set a grid resolution.

This plot is not generated by default. Right-click on **Results** in the study tasks pane and select **New Plot** to plot the Temperature, internal mold result.

Using this result

Using the **Cutting Plane** tool, you can use this result to identify hot spots in the mold that exist because of inadequate cooling.

NOTE: Ensure that the mold block elements are not visible; otherwise you will not see the result.

You can use this result to help design the cooling system for maximum effectiveness.

Things to look for

- Hot spots in the mold indicate residual heat and may lead to uneven cooling and warpage.
- Cool spots in the mold may lead to uneven cooling and part failure.

Temperature, maximum, cold runner 40

The Temperature, maximum, cold runner result shows the maximum temperature across the cold runner temperature profile, calculated at the end of cooling time.

This profile is based on the average mold surface temperatures for the cycle (Temperature at surface, cold runner result).

Using this result

Use the Temperature, maximum, cold runner result plot to check that the polymer melt temperature is below the ejection temperature for the material at the end of cooling, so that the part can be ejected successfully.

NOTE: Solid plastic elements will normally take the longest to cool.

Things to look for

- Look for areas where the temperature is higher than the target temperature (that is, the ejection temperature).

Temperature, maximum, part result

41

The Temperature, maximum, part result displays the maximum temperature in the part, based on the cycle averaged mold surface temperatures (temperature, part (top), and temperature, part (bottom) results), calculated at the end of cooling time.

Using this result

Use the Temperature, maximum, part result plot to check that the polymer melt temperature is below the ejection temperature for the material at the end of cooling, so that the part can be ejected successfully.

Things to look for

- Look for areas where the temperature is higher than the ejection temperature.
- If your model has areas with temperatures higher than your ejection temperature, then create a plot of the temperature profile as an XY graph in the areas where high temperature occurs. Determine how much of the cross section is above the ejection temperature. There may be ejection or warpage problems when some of the cross section is above the ejection temperature.

Temperature, mold (bottom) result 42

The Temperature, mold (bottom) result shows the cycle averaged temperature on the mold side of the mold/part interface on the side of the part element that has been designated as the bottom.

The temperature throughout the mold is determined using heat inputs from the cavity (melt), runners and cartridge heaters and heat outputs to the cooling circuits and outer mold boundaries. The calculation takes into account the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**. The mold side of the part/mold interface will be slightly cooler than the part side of the interface.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cold spots, you may need to adjust the cooling channels, or coolant temperature.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5ºC for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage and an extended cycle time.

The Temperature, mold (bottom) result will typically be between 10ºC and 30ºC above the coolant inlet temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations. If an automatic Injection + Packing + Cooling time is used, a coolant temperature very close to the target temperature will significantly extend the predicted cycle time.

NOTE: If you use a cooling interface file for a Fill+Pack analysis, the mold temperature is defined as follows:

- For a Dual Domain model, the average of the top and bottom temperature is used as the mold temperature.
- For a Midplane model, the top temperature is used as the mold temperature.

The temperature of the mold should be as close as possible to the analysis target temperature.

Things to look for

- Use the following results to check for localized hot spots:
  - Temperature, mold (top)
  - Temperature, mold
- Try to acheive more uniform cooling

Temperature, mold (top) result 43

The Temperature, mold (top) result shows the cycle averaged temperature of the mold side of the mold/part interface on the side of the part element that is specified as top.

The temperature throughout the mold is determined using heat inputs from the cavity (melt), runners and cartridge heaters and heat outputs to the cooling circuits and outer mold boundaries. The calculation takes into account the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**. The mold side of the part/mold interface will be slightly cooler than the part side of the interface.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5ºC for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage and an extended cycle time.

The Temperature, mold (top) result will typically be between 10ºC and 30ºC above the coolant inlet temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations. If an automatic Injection + Packing + Cooling time is used, a coolant temperature very close to the target temperature will significantly extend the predicted cycle time.

NOTE: If you use a cooling interface file for a Fill+Pack analysis, the mold temperature is defined as follows:

- For a Dual Domain model, the average of the top and bottom temperature is used as the mold temperature.
- For a Midplane model, the top temperature is used as the mold temperature.

The temperature of the mold should be as close as possible to the analysis target temperature.

Things to look for

- Use the following results to check for localized hot spots:
  - Temperature, mold (bottom)
  - Temperature, mold
- Try to acheive more uniform cooling

Temperature, mold (averaged) result 44

The **Temperature, mold (averaged)** result shows the cycle averaged temperature of the entire mold, calculated using the finite element method (FEM). This result could be considered a sum of internal mold, the circuit metal and mold boundary results calculated using the boundary element method (BEM).

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cold spots, you may need to adjust the cooling channels, or coolant temperature.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5°C for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage and an extended cycle time.

The **Temperature, mold (averaged)** result will typically be between 10°C and 30°C above the coolant inlet temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations. If an automatic Injection + Packing + Cooling time is used, a coolant temperature very close to the target temperature will significantly extend the predicted cycle time.

Things to look for

When viewing the **Temperature, mold (averaged)** result, watch for the following:

- Localized hot spots.

Temperature, mold (transient) result 45

The **Temperature, mold (transient)** result shows the temperature of the mold as it changes over the duration of the cycle.

The temperature throughout the mold is determined using heat inputs from the cavity (melt), runners and cartridge heaters and heat outputs to the cooling circuits and outer mold boundaries. The calculation takes into account the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**. The mold side of the part/mold interface will be slightly cooler than the part side of the interface.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Use a cutting plane to investigate hot or cold spots inside the part.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5ºC for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage or an extended cycle time. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

The **Temperature, mold (transient)** result will typically be between 10ºC and 30ºC above the coolant inlet temperature. If an automatic Injection + Packing + Cooling time is used, a coolant temperature too close to the target temperature will significantly extend the predicted cycle time.

TIP: You can create an XY plot of the transient mold temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold (transient)** result, watch for the following.

- Localized hot spots.
- The cooling pattern. Is it evenly distributed?

Temperature, mold (transient from start-up) result

46

The **Temperature, mold (transient from start-up)** result shows the temperature of the mold as it changes during the injection cycle, from the initial start-up until the mold temperature stabilizes.

The temperature throughout the mold is determined using heat inputs from the cavity (melt), runners and cartridge heaters and heat outputs to the cooling circuits and outer mold boundaries. The calculation takes into account the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**. The mold side of the part/mold interface will be slightly cooler than the part side of the interface.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Use a cutting plane to investigate hot or cold spots inside the part.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5°C for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage or an extended cycle time. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

The **Temperature, mold (transient from start-up)** result will typically be between 10ºC and 30ºC above the coolant inlet temperature. If an automatic Injection + Packing + Cooling time is used, a coolant temperature too close to the target temperature will significantly extend the predicted cycle time.

TIP: You can create an XY plot of the transient mold temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold (transient from start-up)** result, watch for the following.

- Localized hot spots.
- The cooling pattern. Is it evenly distributed?

47 Temperature, mold boundary result

The Temperature, mold boundary result shows the outside surface temperature of the mold, averaged over the cycle.

Using this result

During the Cool analysis, it is assumed that the outside air temperature is 25°C. Therefore, the mold boundary temperature should be evenly distributed. If the mold boundary temperature is not even, then you may need to make the mold bigger or smaller. If the mold boundary result is showing hot regions, then you may need to add more cooling circuits to your design.

NOTE: The Mold Block Surface layer must be selected in the **Layers** pane in order to view this result or add this result to an Autodesk Moldflow Results file (*.mfr).

Things to look for

- Evenly distributed temperatures
- Hot spots—try to acheive more uniform cooling

Temperature, mold-cavity interface (averaged) result 48

The **Temperature, mold-cavity interface (averaged)** result shows the cycle averaged temperature of the mold, at the mold-cavity interface, calculated using the finite element method (FEM).

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cold spots, you may need to adjust the cooling channels, or coolant temperature.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5ºC for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage and an extended cycle time.

The **Temperature, mold-cavity interface (averaged)** result will typically be between 10ºC and 30ºC above the coolant inlet temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations. If an automatic Injection + Packing + Cooling time is used, a coolant temperature very close to the target temperature will significantly extend the predicted cycle time.

Things to look for

When viewing the **Temperature, mold-cavity interface (averaged)** result, watch for the following:

- Localized hot spots.

Temperature, mold-cavity interface (transient) result 49

The **Temperature, mold-cavity interface (transient)** result shows how the temperature at the interface between the mold and the cavity changes over the duration of the cycle.

Using this result

Use this result to monitor the temperature of the mold as it is affected by the temperature of the plastic in the cavity during the injection cycle. This result enables you to decide whether the cooling channels are cooling effectively, and whether their placement will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

TIP: You can create an XY plot of the transient mold-cavity interface temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-cavity interface (transient)** result, watch for the following.

- Localized hot or cold spots.
- The cooling pattern. Is it evenly distributed?

Temperature, mold-cavity interface (transient from start-up) result

50

The **Temperature, mold-cavity interface (transient from start-up)** result shows how the temperature at the interface between the mold and the cavity channels changes over the duration of the start-up cycles.

Using this result

Use this result to determine whether the cooling channels are cooling effectively, or whether their placement will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

The **Temperature, mold-cavity interface (transient from start-up)** result will typically be between 10ºC and 30ºC above the mold-cavity interface (transient from start-up) temperature, once it has stabilized. If an automatic Injection + Packing + Cooling time is used, a coolant temperature too close to the target temperature will significantly extend the predicted cycle time.

TIP: You can create an XY plot of the transient mold-cavity interface temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-cavity interface (transient from start-up)** result, watch for the following.

- Localized hot or cold spots.
- The cooling pattern. Is it evenly distributed?

Temperature, mold-circuit interface (averaged) result 51

The **Temperature, mold-circuit interface (averaged)** result is an elemental result averaged over the cycle, and shows the temperature of the metal cooling circuits, calculated using the finite element method (FEM).

Using this result

The temperature distribution should be evenly distributed on the cooling circuits. The temperature will increase where the circuit nears the part, and these hotter regions will also heat the coolant. The temperature should be no more than 5°C greater than the inlet temperature.

If the circuit temperature is too hot in these areas, consider the following resolutions:

- Increase the flow rate of the coolant.
- Make the cooling circuit larger and increase the flow rate of the coolant to maintain the Reynolds number.
- Add cooling channels in the area of the hot metal temperature.

Things to look for

When viewing the **Temperature, mold-circuit interface (averaged)** result, watch for the following:

- Mold hot spots.
- Circuit coolant temperature result.

Temperature, mold-circuit interface (transient) result 52

The **Temperature, mold-circuit interface (transient)** result shows how the temperature at the interface between the mold and the cooling channels changes over the duration of the cycle.

Using this result

Use this result to determine whether the cooling channels are cooling effectively, or whether their placement will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

The **Temperature, mold-circuit interface (transient)** result will typically be between 10ºC and 30ºC below the mold-cavity interface (transient) temperature. If an automatic Injection + Packing + Cooling time is used, a coolant temperature too close to the target temperature will significantly extend the predicted cycle time.

TIP: You can create an XY plot of the transient mold-circuit interface temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-circuit interface (transient)** result, watch for the following.

- Localized hot or cold spots.
- The cooling pattern. Is it evenly distributed?

Temperature, mold-circuit interface (transient from start-up) result

53

The **Temperature, mold-circuit interface (transient from start-up)** result shows how the temperature at the interface between the mold and the cooling channels changes during the start-up cycles, until the mold temperature stabilizes.

Using this result

Use this result to determine whether the cooling channels are cooling effectively, or whether their placement will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels, or coolant temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations.

The **Temperature, mold-circuit interface (transient from start-up)** result will typically be between 10ºC and 30ºC below the mold-cavity interface (transient from start-up) temperature. If an automatic Injection + Packing + Cooling time is used, a coolant temperature too close to the target temperature will significantly extend the predicted cycle time.

TIP: You can create an XY plot of the transient mold-circuit interface temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-circuit interface (transient from start-up)** result, watch for the following.

- Localized hot or cold spots.
- The cooling pattern. Is it evenly distributed?

Temperature, mold result 54

The Temperature, mold result shows the cycle averaged temperature of the mold side of the mold/part interface of the part element, during the cycle.

The temperature throughout the mold is determined using heat inputs from the cavity (melt), runners and cartridge heaters and heat outputs to the cooling circuits and outer mold boundaries. The calculation takes into account the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**. The mold side of the part/mold interface will be slightly cooler than the part side of the interface.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cold spots, you may need to adjust the cooling channels, or coolant temperature.

The minimum and maximum mold temperature should be within 10°C of the target temperature for amorphous materials and within 5ºC for semi-crystalline materials. This guideline may be difficult to achieve for most molds, but should be the target of the Cool analysis. The narrower the temperature variation over the mold face, the less likely the mold temperature variation will contribute to warpage and an extended cycle time.

The Temperature, mold result will typically be between 10ºC and 30ºC above the coolant inlet temperature. Cooling channel placement and the thermal conductivity of the mold will affect the temperature variations. If an automatic Injection + Packing + Cooling time is used, a coolant temperature very close to the target temperature will significantly extend the predicted cycle time.

Things to look for

- Use the following results to check for localized hot spots:
  - Temperature, mold (top)
  - Temperature, mold (bottom)
- Try to acheive more uniform cooling

Temperature, mold insert (averaged) result

55

The **Temperature, mold insert (averaged)** result shows the temperature of the mold insert across it's thickness, calculated at the end of the cooling time, using the Cool (FEM) solver.

The temperature of the mold is taken into consideration when calculating the temperature of the mold insert, and is based on the average mold surface temperature *over the entire cycle*, including the clamp open time. The **Temperature, mold insert (averaged)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the mold insert, or to determine whether a different mold insert material, with better heat conduction, should be used. Using the cutting plane tools, you can also examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the insert changes with time inside the solid model.

TIP: You can create an XY plot of the mold insert (averaged) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold insert (averaged)** result, watch for the following.

- The temperature of the mold insert should cool to the specified mold temperature at the end of the cycle.

Temperature, mold insert (transient) result

56

The **Temperature, mold insert (transient)** result shows the temperature of the mold insert across it's thickness, at every time iteration throughout the injection molding cycle.

The **Temperature, mold insert (transient)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the mold insert, or to determine whether a different mold insert material, with better heat conduction, should be used. Using the cutting plane tools, you can also examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the insert changes with time inside the solid model.

TIP: You can create an XY plot of the mold insert (transient) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold insert (transient)** result, watch for the following.

- The temperature of the mold insert should cool to the specified mold temperature at the end of the cycle.

Temperature, mold insert (transient from start-up) result 57

The **Temperature, mold insert (transient from start-up)** result shows the temperature of the mold insert across it's thickness, at every time iteration and for all start-up cycles, until the mold temperature stabilizes.

The **Temperature, mold insert (transient from start-up)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the mold insert, or to determine whether a different mold insert material, with better heat conduction, should be used. Using the cutting plane tools, you can also examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the insert changes with time inside the solid model.

TIP: You can create an XY plot of the mold insert (transient from start-up) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold insert (transient from start-up)** result, watch for the following.

- The temperature of the mold insert should cool to the specified mold temperature at the end of the cycle.

Temperature, mold-insert difference (averaged) result 58

The **Temperature, mold-insert difference (averaged)** result shows the temperature difference between the mold and the mold insert at their interface, calculated at the end of the cooling time using the Cool (FEM) solver.

The average mold surface temperature for the cycle, including the clamp open time, is used to calculate the temperature difference at the interface between the two mold plates. The **Temperature, mold-insert difference (averaged)** result is calculated using the finite element boundary method (FEM).

The temperature difference is determined by the external heat transfer coefficients (HTC), or the *interface conductance*, which are user-defined. A lower HTC value represents a greater resistance to heat transfer.

TIP: The External heat transfer coefficients are set in the **Mold insert (3D)** dialog. To access this dialog, select the mold insert elements, right-click and select **Properties** from the drop-down menu, then select **Mold insert (3D)** from the list.

Using this result

You can use this result to identify whether heat is being extracted sufficiently from the insert. Using the cutting plane tools, you can also examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature difference changes with time inside the solid model.

TIP: You can create an XY plot of the mold-insert temperature difference (averaged), on any given insert node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-insert difference (averaged)** result, watch for the following.

- A large difference in temperature between the mold and the insert may indicate an air gap between the two.

Temperature, mold-insert difference (transient) result 59

The **Temperature, mold-insert difference (transient)** result shows the temperature difference between the mold and the mold insert at their interface, at every time iteration throughout the injection molding cycle.

The **Temperature, mold-insert difference (transient)** result is calculated using the finite element boundary method (FEM).

The temperature difference is determined by the external heat transfer coefficients (HTC), or the *interface conductance*, which are user-defined. A lower HTC value represents a greater resistance to heat transfer.

TIP: The External heat transfer coefficients are set in the **Mold insert (3D)** dialog. To access this dialog, select the mold insert elements, right-click and select **Properties** from the drop-down menu, then select **Mold insert (3D)** from the list.

Using this result

You can use this result to identify whether heat is being extracted sufficiently from the insert. Using the cutting plane tools, you can also examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature difference changes with time inside the solid model.

TIP: You can create an XY plot of the mold-insert temperature difference (transient), on any given mold insert node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-insert difference (transient)** result, watch for the following.

- A large difference in temperature between the mold and the insert may indicate an air gap between the two.

Temperature, mold-insert difference (transient from start-up) result

60

The **Temperature, mold-insert difference (transient from start-up)** result shows the temperature difference between the mold and the mold insert at their interface, at every time iteration and for all start-up cycles, until the mold temperature stabilizes.

The **Temperature, mold-insert difference (transient from start-up)** result is calculated using the finite element boundary method (FEM).

The temperature difference is determined by the external heat transfer coefficients (HTC), or the *interface conductance*, which are user-defined. A lower HTC value represents a greater resistance to heat transfer.

TIP: The External heat transfer coefficients are set in the **Mold insert (3D)** dialog. To access this dialog, select the mold insert elements, right-click and select **Properties** from the drop-down menu, then select **Mold insert (3D)** from the list.

Using this result

You can use this result to identify whether heat is being extracted sufficiently from the insert. Using the cutting plane tools, you can also examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature difference changes with time inside the solid model.

TIP: You can create an XY plot of the mold-insert temperature difference (transient from start-up), on any given mold insert node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-insert difference (transient from start-up)** result, watch for the following.

- A large difference in temperature between the mold and the insert may indicate an air gap between the two.

Temperature, mold-mold difference (averaged) result 61

The **Temperature, mold-mold difference (averaged)** result shows the temperature difference at the interface between the two mold plates at the parting plane, calculated at the end of the cooling time using the Cool (FEM) solver.

The average mold surface temperature for the cycle, including the clamp open time, is used to calculate the temperature difference at the interface between the two mold plates. The **Temperature, mold-mold difference (averaged)** result is calculated using the finite element boundary method (FEM).

The temperature difference is determined by the external heat transfer coefficients (HTC), or the *interface conductance*, which are user-defined. A lower HTC value represents a greater resistance to heat transfer.

TIP: The External heat transfer coefficients are set in the **Mold block (3D)** dialog. To access this dialog, select the mold block elements, right-click and select **Properties** from the drop-down menu, then select **Mold block (3D)** from the list.

Using this result

You can use this result to analyze the design of the cooling system. The distribution of the temperature difference between the top and bottom sides of a parting plane should be uniform or show only small variations to ensure even cooling and minimal warpage due to differential cooling effects. The smaller the difference, the more effective the cooling.

Using the cutting plane tools, you can examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature difference changes with time inside the solid model.

TIP: You can create an XY plot of the mold-mold temperature difference (averaged), on any given mold node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-mold difference (averaged)** result, watch for the following.

- A large difference in temperature between the two mold plates may indicate an air gap between the two.

Temperature, mold-mold difference (transient) result 62

The **Temperature, mold-mold difference (transient)** result shows the temperature difference between the two mold plates at the parting plane, at every time iteration throughout the injection molding cycle.

The **Temperature, mold-mold difference (transient)** result is calculated using the finite element boundary method (FEM).

The temperature difference is determined by the external heat transfer coefficients (HTC), or the *interface conductance*, which are user-defined. A lower HTC value represents a greater resistance to heat transfer.

TIP: The External heat transfer coefficients are set in the **Mold block (3D)** dialog. To access this dialog, select the mold block elements, right-click and select **Properties** from the drop-down menu, then select **Mold block (3D)** from the list.

Using this result

You can use this result to analyze the design of the cooling system. The distribution of the temperature difference between the top and bottom sides of a parting plane should be uniform or show only small variations to ensure even cooling and minimal warpage due to differential cooling effects. The smaller the difference, the more effective the cooling.

Using the cutting plane tools, you can examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature difference changes with time inside the solid model.

TIP: You can create an XY plot of the mold-mold temperature difference (transient), on any given mold node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-mold difference (transient)** result, watch for the following.

- A large difference in temperature between the two mold plates may indicate an air gap between the two.

Temperature, mold-mold difference (transient from start-up) result 63

The **Temperature, mold-mold difference (transient from start-up)** result shows the temperature difference at the interface between the two mold plates at the parting plane, at every time iteration and for all start-up cycles, until the mold temperature stabilizes.

The **Temperature, mold-mold difference (transient from start-up)** result is calculated using the finite element boundary method (FEM).

The temperature difference is determined by the external heat transfer coefficients (HTC), or the *interface conductance*, which are user-defined. A lower HTC value represents a greater resistance to heat transfer.

TIP: The External heat transfer coefficients are set in the **Mold block (3D)** dialog. To access this dialog, select the mold block elements, right-click and select **Properties** from the drop-down menu, then select **Mold block (3D)** from the list.

Using this result

You can use this result to analyze the design of the cooling system. The distribution of the temperature difference between the top and bottom sides of a parting plane should be uniform or show only small variations to ensure even cooling and minimal warpage due to differential cooling effects. The smaller the difference, the more effective the cooling.

Using the cutting plane tools, you can examine the temperatures within the mold insert; there should be only a small variation in average temperature. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature difference changes with time inside the solid model.

TIP: You can create an XY plot of the mold-mold temperature difference (transient from start-up), on any given mold node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, mold-mold difference (transient from start-up)** result, watch for the following.

- A large difference in temperature between the two mold plates may indicate an air gap between the two.

Temperature, part result

64

The Temperature, part result shows the average temperature at the part boundary, which is at the part side of the part/mold interface, over the duration of the cycle.

This temperature is determined using the **Mold-melt Heat Transfer Coefficients (HTC) values** .

TIP: This is set in the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels.

The difference between the temperature across the top or bottom face of the part and the target mold temperature should not be greater than ±10°C.

The temperature variation over each mold face should be within 10°C. The Temperature, part (top) result should not be more than 10–20°C above the inlet temperature.

The wall temperature can be investigated by selecting **Results tab > Properties panel > Plot Properties** when the result is displayed, selecting the **Scaling** tab, and scaling the **Max** box to a smaller value.

For 3D models, use a cutting plane to investigate hot or cold spots inside the part.

NOTE: If you animate the result, it will show you how the temperature changed over the duration of the analysis inside the solid model.

Things to look for

When viewing the Temperature, part result, watch for the following.

- Regions that freeze off early. The gate should not freeze before the part.
- Hot and cold regions.
- The cooling pattern. Is it evenly distributed?

Temperature, part (bottom) result 65

The Temperature, part (bottom) result shows the average temperature of the part side of the part/mold interface, on the side of the part element that is designated as bottom.

This temperature is determined by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: This is set in the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cold spots, you may need to adjust the cooling channels, or coolant temperature.

The difference between the temperature across the top or bottom face of the part, and the target mold temperature, should not be greater than ±10°C.

The temperature variation over each mold face should be within 10°C. The Temperature, part (bottom) result should not be more than 5°C above the coolant inlet temperature.

NOTE: If you use a cooling interface file for a Fill+Pack analysis, the mold temperature is defined as follows:

- For a Dual Domain model, the average of the top and bottom temperature is used as the mold temperature.
- For a Midplane model, the top temperature is used as the mold temperature.

The temperature of the mold should be as close as possible to the analysis target temperature.

Things to look for

Use the following results to check for localized hot spots:

- Temperature, part (top)
- Temperature, part
- Temperature difference, part

Temperature, part (top) result 66

The Temperature, part (top) result shows the average temperature of the part side of the part/mold interface, on the side of the part element that is designated as top.

This temperature is determined by the **Mold-melt Heat Transfer Coefficients (HTC) values**.

TIP: This is set in the advanced options of the **Process Settings**.

A lower HTC value represents a greater resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels.

The difference between the temperature across the top or bottom face of the part, and the target mold temperature, should not be greater than ±10°C.

The temperature variation over each mold face should be within 10°C. The Temperature, part (top) result should not be more than 10–20°C above the inlet temperature.

NOTE: If you use a cooling interface file for a Fill+Pack analysis, the mold temperature is defined as follows:

- For a Dual Domain model, the average of the top and bottom temperature is used as the mold temperature.
- For a Midplane model, the top temperature is used as the mold temperature.

The temperature of the mold should be as close as possible to the analysis target temperature.

Things to look for

Use the following results to check for localized hot spots:

- Temperature, part (bottom)
- Temperature, part
- Temperature difference, part

Temperature, part (averaged) result 67

The **Temperature, part (averaged)** result shows the average temperature of the part across the part thickness, calculated at the end of the cooling time.

This profile is based on the average mold surface temperature for the cycle, which includes the clamp open time. The **Temperature, part (averaged)** result is calculated using the finite element boundary method (FEM).

Using this result

The average temperature should be about half way between the target mold temperature and the ejection temperature, for an optimized mold. There should be only a small variation in average temperature in the part. Areas of high average temperature may be thick regions of the part or areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, it will show you how the temperature changes over the duration of the analysis inside the solid model.

TIP: You can create an XY plot of the part (averaged) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, part (averaged)** result, watch for the following.

- Check that the average temperature is well below the ejection temperature for the material at the end of cooling, so that the part can be ejected successfully.

Temperature, part (transient) result 68

The **Temperature, part (transient)** result shows the temperature of the part as it changes over the duration of the cycle.

This temperature is determined using the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels. Use a cutting plane to investigate hot or cold spots inside the part.

The difference between the temperature across the top or bottom face of the part and the target mold temperature should not be greater than ±10°C.

The wall temperature can be studied by clicking on **Results** in the **Results** pane of the **Home** tab, selecting the **Set Scale** on the Scaling pane, and decreasing the value in the **Max** box.

NOTE: If you animate the result, it will show you how the temperature changed over the duration of the analysis inside the solid model.

TIP: You can create an XY plot of the transient part temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, part (transient)** result, watch for the following.

- Regions that freeze off early. The gate should not freeze before the part.
- Hot and cold regions.
- The cooling pattern. Is it evenly distributed?

Temperature, part (transient from start-up) result

69

The **Temperature, part (transient from start-up)** result shows the temperature of the part as it changes over an injection cycle, from the first start-up cycle until the mold temperature stabilizes.

This temperature is determined using the **Mold-melt Heat Transfer Coefficients (HTC) values**, which you can set on the **Mesh** tab of the **Solver parameters** dialog, in the **Advanced options** of the **Process Settings**.

TIP: The lower the HTC value, the greater the resistance to heat transfer between the polymer and the mold.

Using this result

Use this result to find localized hot or cold spots, and determine whether they will affect cycle time and part warpage. If there are hot or cool spots, you may need to adjust the cooling channels. Use a cutting plane to investigate hot or cold spots inside the part.

The difference between the temperature across the top or bottom face of the part and the target mold temperature should not be greater than ±10°C.

The wall temperature can be studied by clicking on **Results** in the **Results** pane of the **Home** tab, selecting the **Set Scale** on the Scaling pane, and decreasing the value in the **Max** box.

NOTE: If you animate the result, it will show you how the temperature changed over the duration of the analysis inside the solid model.

TIP: You can create an XY plot of the transient part temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, part (transient from start-up)** result, watch for the following.

- Regions that freeze off early. The gate should not freeze before the part.
- Hot and cold regions.
- The cooling pattern. Is it evenly distributed?

Temperature, part insert result 70

The Temperature, part insert result shows the temperature change over time of a part insert that uses tetrahedral elements.

Using this result

You can use this result to identify localized hot or cold spots on the surface of the part insert. Using the cutting plane tools, you can also examine the temperatures within the part insert.

Things to look for

- The temperature of the part insert should not be colder than the coldest inlet temperature or the initial temperature of the mold.
- If the initial part insert temperature you have specified is less than the melt temperature, ensure that part insert warms up adequately during the cycle.
- Conversely, if the initial part insert temperature you have specified is greater than the melt temperature, ensure that part insert cools down adequately during the cycle.

Temperature, part insert (averaged) result 71

The **Temperature, part insert (averaged)** result shows the temperature of the part insert across it's thickness, calculated at the end of the cooling time, using the Cool (FEM) solver.

The contribution to the result from the mold is based on the average mold surface temperature *for the cycle*, which includes the clamp open time. The **Temperature, part insert (averaged)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the part insert. Using the cutting plane tools, you can also examine the temperatures within the part insert. There should be only a small variation in average temperature in the part insert. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, it will show you how the temperature in the insert changes with time inside the solid model.

TIP: You can create an XY plot of the part insert (averaged) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, part insert (averaged)** result, watch for the following.

- The temperature of the part insert should not be colder than the coldest inlet temperature or the initial temperature of the mold.
- If the initial part insert temperature you have specified is less than the melt temperature, ensure that part insert warms up adequately during the cycle.
- Conversely, if the initial part insert temperature you have specified is greater than the melt temperature, ensure that part insert cools down adequately during the cycle.

Temperature, part insert (transient) result

72

The **Temperature, part insert (transient)** result shows the temperature of the part insert across it's thickness, at every time step through the injection molding cycle.

The **Temperature, part insert (transient)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the part insert. Using the cutting plane tools, you can also examine the temperatures within the part insert. There should be only a small variation in average temperature in the part insert. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the insert changes with time inside the solid model.

TIP: You can create an XY plot of the part insert (transient) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, part insert (transient)** result, watch for the following.

- The temperature of the part insert should not be colder than the coldest inlet temperature or the initial temperature of the mold.
- If the initial part insert temperature you have specified is less than the melt temperature, ensure that part insert warms up adequately during the cycle.
- Conversely, if the initial part insert temperature you have specified is greater than the melt temperature, ensure that part insert cools down adequately during the cycle.

Temperature, part insert (transient from start-up) result 73

The **Temperature, part insert (transient from start-up)** result shows the temperature of the part insert across it's thickness, at every time step through the cycle, for every cycle until the mold temperature stabilizes and reaches its optimum operating conditions.

The **Temperature, part insert (transient from start-up)** result is calculated using the finite element boundary method (FEM).

Using this result

You can use this result to identify localized hot or cold spots on the surface of the part insert. Using the cutting plane tools, you can also examine the temperatures within the part insert. There should be only a small variation in average temperature in the part insert. Areas of high average temperature may indicate areas that are poorly cooled. Consider adding cooling channels near these areas.

NOTE: If you animate the result, you can see how the temperature in the insert changes with time inside the solid model.

TIP: You can create an XY plot of the part insert (transient from start-up) temperature, on any given node to see how the temperature at that node varies with time. Click on **Results** in the **Results** pane of the **Home** tab, then click **(New Plot > Plot)** and scroll down to the result. Remember to change the **Plot type** to **XY plot**.

Things to look for

When viewing the **Temperature, part insert (transient from start-up)** result, watch for the following.

- The temperature of the part insert should not be colder than the coldest inlet temperature or the initial temperature of the mold.
- If the initial part insert temperature you have specified is less than the melt temperature, ensure that part insert warms up adequately during the cycle.
- Conversely, if the initial part insert temperature you have specified is greater than the melt temperature, ensure that part insert cools down adequately during the cycle.

Temperature, parting plane (bottom) result

74

The Temperature, parting plane (bottom) result shows the average temperature of the parting plane on the side of the parting plane element that is designated as bottom.

Using this result

Parting planes are used to define the interface conductance between two pieces of the mold that are composed of the same material. There should be a small variation in temperature across the bottom and top faces of the parting plane and between the top and bottom faces. The greater the difference, the more influence the interface conductance has on the cooling of the part, which may contribute to the part being poorly cooled.

NOTE: If you use a cooling interface file for a Fill+Pack analysis, the mold temperature is defined as follows:

- For a Dual Domain model, the average of the top and bottom temperature is used as the mold temperature.
- For a Midplane model, the top temperature is used as the mold temperature.

The temperature of the mold should be as close as possible to the analysis target temperature.

Things to look for

- Temperature, parting plane (top) result
- Temperature difference, parting plane
- Check the two results above for hot spots

Temperature, parting plane (top) result

75

The Temperature, parting plane (top) result shows the average temperature of the parting plane on the side of the parting plane element, that is designated as top.

Using this result

Parting planes are used to define the interface conductance between two pieces of the mold that are composed of the same material. There should be a small variation in temperature across the bottom and top faces of the parting plane and between the top and bottom faces. The greater the difference the more influence the interface conductance has on the cooling of the part, and may contribute to the part being poorly cooled.

Things to look for

- Temperature, parting plane (bottom) result
- Temperature difference, parting plane
- Check the two results above for hot spots

Temperature profile, cold runner result 76

The Temperature profile, cold runner result shows the temperature profile from the center of the runner to the surface.

Using this result

The Temperature profile, cold runner result can be created as an XY plot. The X-axis value of -1 represents the surface of the runner and 1.0 represents the center. The center of the runner will most likely be above the transition temperature because the runner cross section is generally much larger than the part cross section. As a result, the cycle time should be based primarily on temperature profile of the part rather than that of the runner.

Things to look for

- Check for elements that have a very high temperature, as this may limit the cycle time.

77 Temperature profile, hot runner result

The Temperature profile, hot runner result shows the temperature profile from the center of the hot runner to the surface.

Using this result

The Temperature profile, hot runner result can be created as either an animation plot or an XY plot, and shows the melt temperature of the polymer at ejection. The temperature should be uniform across the hot runner. When the result is created as an XY plot, the X-axis value of -1 represents the surface of the runner and 1.0 represents the center. The center of the runner will most likely be above the transition temperature because the cross section of the runner is generally much larger than that of the part. Because of this, the cycle time should be based on the temperature profile of the part rather than that of the runner.

Things to look for

- Check for elements that have a very high temperature, as this may limit the cycle time.

Temperature profile, part result

78

The Temperature profile, part result is generated at the end of a Cool analysis, and shows the temperature distribution from the top to the bottom of the part.

TIP: This result can be used in conjunction with the frozen layer fraction at end of fill results.

Using this result

Click **Results tab > Plots panel > New Plot**, and create the Temperature profile, part result as an **XY plot**.

After displaying the plot and clicking the cursor on the part, a curve is updated on the plot for the selected element.

At long cycle times, there will be little variation in the temperature through the thickness. The cycle time is optimized when the selected element is in the hottest region of the part, the maximum temperature on the curve is close to the ejection temperature, with the maximum temperature at a zero value on the X-axis.

The -1 and +1 X-axis locations will have similar Y-values near the target mold temperature. The X-axis displays the normalized thickness, where -1 represents the bottom and +1 represents the top of the part for a Midplane model. For a Dual Domain model, +1 represents the element selected and -1 the matched element on the other side of the part. The Y-axis represents the part temperature.

NOTE: Minimize the temperature difference between the top and bottom to minimize warpage. This can be checked by looking at the first and last points on each curve.

Things to look for

- For various areas on the model, check that the difference between the top and bottom of the part is small, that is, the value at -1 should be similar to the value at 1 on the X scale for each curve.

79 Temperature residual, exterior shell result

The Temperature residual, exterior shell result shows the absolute error for the temperature solution, in relation to the mold temperature convergence tolerance value.

This value is set on the **Advanced Options** page of the Process Settings Wizard—Cool Settings page.

NOTE: This result is only created if the convergence tolerance was not reached for at least one of the elements in the model.

Using this result

This result allows you to see which elements converged well and which elements had difficulty converging in the Cool analysis. The lower the temperature value (displayed in blue), the better the convergence for those elements. The higher the temperature value (displayed in red), the worse the convergence in those areas of the model.

A small number of elements with error values less than 1°C does not indicate a problem. A high number of elements with error values less than 1°C or a small number of elements with error values greater than 1°C indicates the analysis could not find a stable solution for those elements.

Things to look for

- Check the geometry in the problem area, as high aspect ratio elements can cause Cool analysis errors.
- Modeling problems, such as cooling channels being too close together, or elements being too close to each other can also cause problems with convergence in the Cool analysis. Check the model in the problem area to see if this is the cause.

NOTE: Decreasing the number of mold temperature iterations or slightly increasing the convergence tolerance can help the numerical method used in convergence to achieve the results. These alterations are recommended only as a last resort.

Temperature residual, inserts result

80

The Temperature residual, inserts result shows the absolute error for the temperature solution, in relation to the mold temperature convergence tolerance value.

This value is set on the **Advanced Options** page of the Process Settings Wizard—Cool Settings page.

NOTE: This result is only created if the convergence tolerance was not reached for at least one of the elements in the model.

Using this result

This result allows you to see which elements converged well and which elements had difficulty converging in the Cool analysis. The lower the temperature value (displayed in blue), the better the convergence for those elements. The higher the temperature value (displayed in red), the worse the convergence in those areas of the model.

A small number of elements with error values less than 1°C does not indicate a problem. A high number of elements with error values less than 1°C or a small number of elements with error values greater than 1°C indicates the software could not find a stable solution for those elements.

Things to look for

- Check the geometry in the problem area, as high aspect ratio elements can cause Cool analysis errors.
- Modeling problems, such as cooling channels being too close together, or elements being too close to each other can also cause problems with convergence in the Cool analysis. Check the model in the problem area to see if this is the cause.

NOTE: Decreasing the number of mold temperature iterations or slightly increasing the convergence tolerance can help the numerical method used in convergence to achieve the results. These alterations are recommended only as a last resort.

Temperature residual, part result 81

The Temperature residual, part result shows the absolute error for the temperature solution, in relation to the mold temperature convergence tolerance value.

The mold temperature convergance tolerance value is set on the **Advanced Options** page of the Process Settings Wizard—Cool Settings page.

NOTE: This result is only created if the convergence tolerance was not reached for at least one of the elements in the model.

Using this result

This result allows you to see which elements converged well and which elements had difficulty converging in the Cool analysis. The lower the temperature value (displayed in blue), the better the convergence for those elements. The higher the temperature value (displayed in red), the worse the convergence in those areas of the model.

A small number of elements with error values less than 1°C does not indicate a problem. A high number of elements with error values less than 1°C or a small number of elements with error values greater than 1°C indicates the software could not find a stable solution for those elements.

Things to look for

- Check the geometry in the problem area, as high aspect ratio elements can cause Cool analysis errors.
- Modeling problems, such as cooling channels being too close together, or elements being too close to each other can also cause problems with convergence in the Cool analysis. Check the model in the problem area to see if this is the cause.

NOTE: Decreasing the number of mold temperature iterations or slightly increasing the convergence tolerance can help the numerical method used in convergence to achieve the results. These alterations are recommended only as a last resort.

Time to reach ejection temperature, cold runner result

82

The Time to reach ejection temperature, cold runner result is generated from a Cool analysis, and shows the amount of time taken for all elements, including the cold runner, to freeze to ejection temperature.

At the start of the analysis (time zero), all elements, including the cold runner, are assumed to be filled with material at the melt temperature.

Using this result

Ideally, the part should freeze uniformly and as quickly as possible. Look at the time difference between most of the model freezing and the last element freezing in the cold runner. If this difference is large, consider re-designing the part, or increasing the cooling around the last area to freeze.

Most parts may be ejected with the runners 50% frozen and thick parts 80% frozen.

Thick plastic elements will normally take the longest to cool.

NOTE: If this result was not generated, then the cold runners were still not frozen at the completion of the Cool analysis.

Things to look for

- Check the **Time to reach ejection temperature, part** result to ensure that the runners did not freeze before the part

Time to reach ejection temperature, part result

83

The Time to reach ejection temperature, part result that is produced by a Cool analysis shows the time required to reach the ejection temperature, which is measured from the start of the cycle.

At the start of the measurement, the part is assumed to be filled with material at its melt temperature (Tmelt).

The time to reach ejection temperature is calculated for each element, based on the mold wall temperature. If the mold wall temperature at a specific element is above the ejection temperature (Teject), then a warning is posted in the Analysis Log and no result is written on those elements.

To avoid receiving a warning, the following steps can be taken.

1. Increase the cycle time, to obtain more time for cooling.
2. If you have already designed a cooling circuit, lower the temperature of the coolants.
3. Place a cooling circuit in the area where the elements are not freezing

Using this result

Ideally the part should freeze uniformly. Areas of the part that take longer to freeze may indicate hot spots, or thicker cross sections.

Look at the time difference between most of the model freezing and the last area freezing. If this difference is large, determine if the problem is caused by an increased wall thickness or a high mold temperature. If the thickness is high, consider redesigning the part. If the mold temperature is high, modify the cooling layout to eradicate the hot spots.

TIP: For 3D analysis technology, use a cutting plane to view how areas of the part freeze.

Things to look for

When viewing the Time to reach ejection temperature, part result, watch for the following:

- Uniform polymer freeze distribution.
- Check the Circuit Reynolds number result to ensure that the Reynolds number values for each circuit are high; low values indicate inefficient heat extraction. Increase the flow rate into the relevant circuit(s).
- Hot spots—try to achieve more uniform cooling.