AMI Co-injection Molding
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Co-injection analysis

Co-injection molding involves the injection of two different materials into the one mold.

Co-injection analysis

Setting up a Co-injection analysis

The following table summarizes the setup tasks required to prepare a Co-injection analysis of a non fiber-filled, or fiber-filled thermoplastic material.

<table>
<thead>
<tr>
<th>Setup task</th>
<th>Analysis technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molding processes</td>
<td></td>
</tr>
<tr>
<td>Meshing the model</td>
<td></td>
</tr>
<tr>
<td>Checking the mesh before analysis</td>
<td></td>
</tr>
<tr>
<td>Analysis sequence</td>
<td></td>
</tr>
<tr>
<td>Co-injection material on page 12 (core and skin materials)</td>
<td></td>
</tr>
<tr>
<td>Injection locations</td>
<td></td>
</tr>
<tr>
<td>Process settings</td>
<td></td>
</tr>
<tr>
<td>Co-injection controllers on page 13</td>
<td></td>
</tr>
</tbody>
</table>

Optional setup tasks

<table>
<thead>
<tr>
<th>Setup task</th>
<th>Supported for analysis technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity/pressure switch-over point</td>
<td></td>
</tr>
<tr>
<td>Occurrence numbers</td>
<td></td>
</tr>
<tr>
<td>Valve gates</td>
<td></td>
</tr>
</tbody>
</table>
Co-injection analysis

Use these dialogs to specify settings for a Co-injection analysis.

Process Settings Wizard dialog—Controller A Settings

This page of the Process Settings Wizard is used to specify the following for the Co-injection analysis sequence:

- Process settings specific to Controller A, and
- Certain process settings shared by Controllers A and B.

To access this dialog, ensure that you have selected the Co-injection Molding process and an analysis sequence that includes Fill+Pack, then click (Home tab > Molding Process Setup panel > Process Settings).

NOTE: Some of the items listed below may not be available on the current dialog. This is dependent on the mesh type, molding process and analysis sequence selected.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mold surface temperature</td>
<td>The temperature of the mold at the plastic-metal interface, where the plastic touches the mold.</td>
</tr>
<tr>
<td>Melt temperature</td>
<td>The temperature of the molten plastic, or melt, as it starts to flow into the cavity.</td>
</tr>
<tr>
<td>Filling control</td>
<td>Specifies the method by which the filling phase of the analysis is controlled.</td>
</tr>
<tr>
<td>Velocity/pressure switch-over</td>
<td>The criteria by which the molding machine will switch from velocity control to pressure control.</td>
</tr>
<tr>
<td>Pack/holding control</td>
<td>Specifies the method by which the pressure phase of the molding process is controlled.</td>
</tr>
<tr>
<td>Cooling time</td>
<td>Specify a cooling time, or have it calculated automatically during the Fill+Pack analysis.</td>
</tr>
<tr>
<td>Switch to the other controller by</td>
<td>Specifies when to switch from Controller A to Controller B, or from Controller B back to Controller A.</td>
</tr>
<tr>
<td>Controller A settings...</td>
<td>Click this button to display the advanced options for Controller A of the Co-injection process.</td>
</tr>
<tr>
<td>Fiber orientation analysis if fiber material</td>
<td>Enables a Fiber orientation analysis if the material includes fiber.</td>
</tr>
</tbody>
</table>
Process Settings Wizard dialog—Controller B Settings

This dialog is used to specify process settings for Controller B in the Co-injection analysis:

To access this dialog, ensure that you have selected the Co-injection Molding process and an analysis sequence that includes Fill+Pack, click (Home tab > Molding Process Setup panel > Process Settings), then click Next to navigate to the Controller B Settings page of the Wizard.

NOTE: Some of the items listed below may not be available on the current dialog. This is dependent on the mesh type, molding process and analysis sequence selected.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melt temperature</td>
<td>The temperature of the molten plastic, or melt, as it starts to flow into the cavity.</td>
</tr>
<tr>
<td>Filling control</td>
<td>Specifies the method by which the filling phase of the analysis is controlled.</td>
</tr>
<tr>
<td>Velocity/pressure switch-over</td>
<td>The criteria by which the molding machine will switch from velocity control to pressure control.</td>
</tr>
<tr>
<td>Switch to the other controller by</td>
<td>Specifies when to switch from Controller A to Controller B, or from Controller B back to Controller A.</td>
</tr>
<tr>
<td>Controller B settings...</td>
<td>Click this button to display the advanced options for Controller B of the Co-injection process.</td>
</tr>
</tbody>
</table>

Controller A Settings dialog

This dialog is used to specify the Controller A related advanced options for the Co-injection analysis sequence.

To access this dialog, ensure that you have selected the Co-injection Molding process and an analysis sequence that includes Fill+Pack, click (Home tab > Molding Process Setup panel > Process Settings), then click Controller A Settings.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molding material</td>
<td>Select and edit the material to analyze.</td>
</tr>
<tr>
<td>Process controller</td>
<td>Allows you to select and edit a process controller to control the injection molding process during the analysis. You can control the filling phase, velocity/pressure switch-over point, pack/holding phase, mold temperature and mold-open time.</td>
</tr>
</tbody>
</table>
Select and edit an injection molding machine to simulate your molding machine during the analysis. You can configure the injection unit, hydraulic unit, and clamping unit.

Mold material
Allows you to select and edit the mold material to be used during the analysis. You can specify the density, specific heat, and thermal conductivity of the mold material.

Solver parameters
Allows you to select and edit the solver parameters to be used during the analysis.

**Controller B Settings dialog**

This dialog is used to specify the Controller B related advanced options for the Co-injection analysis sequence.

To access this dialog, ensure that you have selected the Co-injection Molding process and an analysis sequence that includes Fill+Pack, click (Home tab > Molding Process Setup panel > Process Settings), click Next to navigate to the Controller B Settings page of the Wizard, then click Controller B settings.

<table>
<thead>
<tr>
<th>Material B</th>
<th>Allows you to select and/or edit the material used by Controller B in the analysis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection molding machine B</td>
<td>Allows you to select and/or edit the injection molding machine used to inject polymer B in the Co-injection process.</td>
</tr>
</tbody>
</table>
Co-injection molding overview

Co-injection molding involves injection of two dissimilar materials. Because of this, co-injection has some special advantages, as well as some potential molding problems. The Co-injection analysis helps you overcome the potential problems and leverage the advantages, by helping to optimize process control strategies and enhance part quality.

Co-Injection analysis simulates the sequential injection of skin and core plastic materials. Sequential co-injection processes have two barrels and one nozzle in an injection molding machine.

(a) The skin plastic is injected into the mold first. (b) The core plastic then is injected. (c) finally, the skin plastic is injected again, to purge the core material from the sprue.

![Co-injection process](image)

Figure 1: Co-injection process

The skin plastic is the material that is expected to be deposited on the cavity wall over the entire surface of the part. The core plastic displaces the skin plastic at the hot core, pushing it to fill the rest of the cavity. The end product is a sandwich-like structure, with the core plastic in the middle and the skin plastic on the surfaces of the part.

Co-injection molding takes advantage of a characteristic of injection molding called fountain flow. As the cavity is filled, the plastic at the melt front moves from the center line of the stream to the cavity walls. Because the wall temperature is below the transition temperature (freeze temperature) of the melt, the material that touches the walls cools rapidly and freezes in place. This provides insulating layers on each wall, through which new melt makes its way to the melt front.

Advantages and applications

The advantages of this process are:

- The combination of two material properties into one part.
- The maximization of the overall performance/cost ratio.
Examples of co-injection applications include:

- The use of plastic regrind as the core material, while maintaining surface finish quality by using virgin plastic as the skin material.
- The use of a core material that is thermally more stable, to increase the thermal resistance of a part.
- The use of a high melt-flow index plastic as the core material, to reduce the overall clamp force.
Co-injection molding analysis types and analysis technologies

The following table shows the available analysis technologies for a Co-injection molding analysis type.

**Table 1: Co-injection Molding process and analysis types**

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Analysis Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill+Pack</td>
<td></td>
</tr>
<tr>
<td>Fiber Fill+Pack</td>
<td></td>
</tr>
<tr>
<td>Cool</td>
<td></td>
</tr>
<tr>
<td>Warp</td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td></td>
</tr>
</tbody>
</table>
Because Co-injection molding involves the injection of two dissimilar materials, there are some potential molding problems that may need to be overcome.

The biggest challenges in Co-injection molding are:

- To determine the optimal ratio of skin material to core material.
- To determine the optimal time to switch from injection of skin material to injection of core material.

The theoretical maximum amount of core plastic in a part is about sixty-seven percent by volume. However, it is very difficult to accomplish this in an actual application, with complex part geometry. In practice, about thirty percent core plastic by volume can be achieved.

With an improper mold design or an insufficient amount of skin plastic, the core plastic may eventually deplete all the skin plastic injected ahead of it, and appear on the part surface. This undesirable “core surfacing” typically occurs at areas that fill last (where plastic has the longest flow length).

![Skin Polymer, Core Polymer](image)

**Figure 2: Correct flow (above), Core Surfacing (below)**

**Using Co-injection to overcome potential molding problems**

Co-injection analysis traces the spatial distribution of the skin and core plastics throughout the cavity during the filling process. The analysis accounts for the differences in material...
properties and in processing temperatures of the skin and core plastics, as well as the mass, heat, and momentum interactions between them. Co-injection provides information that designers and engineers use to qualitatively predict part performance, improve mold designs, and optimize process controls. In particular, it is an efficient tool for determining the best combination of skin and core plastics, and the most appropriate switch-over time.
Hot runners can be included in the part design when running a Co-injection molding analysis. The advantage of using hot runners is that the Co-injection molding analysis is more accurate due to the calculation of pressure drop in the hot runners.

The hot runners are occupied by one material during molding, therefore, you need to specify which material (A or B) is injected from a particular injection location.

**Modeling**

Each hot runner will have a material assigned to it (A/B, or skin/core material). The hot runner that is carrying material A and material B will meet at a cold runner or a part element.
The sequence of steps required for modeling a hot runner for a Co-injection molding analysis is listed below:

Include the hot runner (gate/sprue) in the design.
One hot runner system is for material A (skin), and the other hot runner system is for material B (core). The two systems will meet at a cold runner or a part element, depending on how your part is modeled.
Use Set Co-injection Material in the Analysis menu to assign material A or B to each injection location.

NOTE: You do not need to use a valve gate in the last hot runner (or gate) element to open and close the gate when switching the material. This is done automatically during the analysis.

How it works
The Co-injection molding analysis automatically determines the last element in the hot runner (that is connected to the cold runner or the part). It attaches the gate valve property to those elements and closes or opens the valve as the material switches from A (skin) to B (core) or B to A.
The analysis log generated during the analysis will show the valve gates opening or closing as the material switches.

**Co-injection material**

Specify which material (A or B) is injected from a particular injection location for hot runners.

**Selecting co-injection materials**

The Co-injection molding analysis can incorporate hot runners. Because the hot runners are occupied by one material during molding, you need to specify which material (A or B) is injected from a particular injection location.

**NOTE:** This is used only when you want to include hot runners in a Co-injection molding analysis, and when there are two injection locations with each location injecting different materials.

1. Ensure that you have modeled your part, including the hot runners.
2. Ensure that you have set the injection locations.
3. Click **Boundary Conditions tab > Feed System panel > Set Controller.**
   The **Set Material to inject (A/B)** dialog appears and the cursor changes to cross-hairs.
4. Click **New**, select **A** in the **Material to inject (A/B)** drop-down list, enter a name for the property and click **OK**.
5. Click the cross-hairs on the hot runner, hot sprue or hot gate element where material A is to be injected.
6. Repeat steps 4-5 to create a **Material to inject** property for material B, and assign that property to required location in the model.
7. Right-click the mouse and select **Finish Set Co-Injection Material**.

**Co-injection material**

Use this dialog to specify which material is injected at the selected injection location for a Co-injection molding analysis.

**Material to inject (A/B) dialog**

The **Material to inject (A/B)** dialog is used to specify whether material A or material B is injected at the selected injection location for a Co-injection molding analysis.

The collection of property values defined on the dialog are saved to a property set with the description shown in the **Name** box.
Co-injection controllers

Standard injection molding uses one process controller. In contrast, Co-injection molding uses two controllers; Controller A controls Material A (usually the skin material) and Controller B controls Material B (usually the core material).

In Co-injection, you can specify these switches by setting **Switch to other controller by percent volume filled**.

Co-injection controllers

You can specify the switch-over point from Controller A (skin material) to Controller B (core material).

**Editing the co-injection controller switch-over point**

For Co-injection molding, you can specify when to switch from Controller A to Controller B. Controller A controls the injection of Material A (skin material) and Controller B controls the injection of Material B (core material).

In Co-injection, material A is injected, then material B is injected, and finally, material A is injected again. Therefore, you need to specify the switch from Controller A to B and the switch from Controller B back to A.

1. Click **Home tab > Molding Process Setup panel > Process Settings**, or double-click the Process Settings icon in the **Study Tasks** pane.
2. On the Controller A Settings page, enter a percentage value in the **Switch to the other controller by** box, and click **Next**.
3. On the Controller B Settings page, enter a percentage value in the **Switch to the other controller by** box.
   - The default value is 80%.
4. Click **Finish**.

Co-injection controllers

Use this dialog to specify co-injection control related settings.
Co-injection Controller dialog

The Co-injection Controller dialog is used to specify Co-injection control related settings for a Co-injection molding analysis.

The collection of property values defined on the dialog are saved to a property set with the description shown in the Name box.