

## UNIT 1: Overview of the Simulation Process

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Solidification modeling refers to the process of simulating, on a computer, what happens when a casting is poured into a mold and the metal cools and solidifies. By simulating this process, we hope to predict potential defects in the casting and redesign the process to eliminate the defects, before making actual castings.

SOLIDCast is unique in that it contains built-in tools to help you create an effective rigging system, not just test a given gating and riser design. The gating and riser design wizards take you step-by-step through the process, providing an effective and repeatable design path. Once the rigging system has been developed, you can verify the design by using comprehensive fluid flow analysis from FLOWCast and combined thermal and volumetric analysis from SOLIDCast to insure that you are creating a sound casting. Once the design is verified, you can optionally fine tune the results using OPTICast, to automatically insure the most efficient design, highest yield and best properties.

What are the basic steps in performing casting process design?

### 1. Customer Specifications and Data

This includes such things as the part geometry, in CAD or drawing format, casting alloy and other process details.

### 2. Initial Design Concepts

The first step is to run a simulation on the part without rigging. This is called 'freezing naked'. The idea is to determine the 'natural' progression of solidification, based on the part geometry and process. SOLIDCast then feeds this information into the Riser Design and Gating Design Wizards, in order to determine feeding zones, riser sizes and locations, as well as to determine appropriate sized gating components designed to fill the casting in an appropriate time and manner.

### 3. Design Verification

The gating and risering are added to the model, and FLOWCast and SOLIDCast are used to verify the filling and solidification of the part. Adjustments and process changes can be investigated at this point.

### 4. Design Optimization

Once the rigging system has been verified, you may optionally want to fine tune, or optimize, the system using OPTICast. OPTICast allows you to set up a desired outcome, such as the highest casting yield, subject to various constraints, such as amount of macro or microporosity in the casting. OPTICast can automatically change the model and run simulations until it finds the optimum conditions.

What are the basic steps in performing a simulation?

1. Create a 3D Model of the Casting(and rigging)

We need to be able to model the shape of the casting, gating and risers. There are several methods in SOLIDCast by which this can be accomplished:

- a. Import all geometry from a CAD system as STL file or files
- b. Import casting geometry from CAD and create gating and risering in SOLIDCast
- c. Create the entire casting and rigging geometry within SOLIDCast

In SOLIDCast we can create casting and rigging geometry using the following methods:

- a. Create basic geometric shapes (rectangular blocks, solid or hollow cylinders, spheres)
- b. Create a 2D shape and revolve about a center line to create a Solid of Revolution
- c. Create a 2D shape and extrude to form a Solid of Extrusion

Where do we get the 2D shapes used in b and c above?

- a. We can create 2D geometry in SOLIDCast by free-hand drawing using the mouse
- b. We can import 2D DXF files from another CAD system

2. Select Materials and Initial Conditions

We need first of all to select the Casting Alloy out of which we are making the casting. SOLIDCast contains a database of well over 200 casting alloys, and you can add to it at any time.

Second, we need to select any materials that will be used in the mold. This may include such things as:

- a. Molding sand
- b. Core sands
- c. Chills
- d. Sleeves
- e. Investment shell material
- f. Permanent mold die materials
- g. Cooling channels
- h. Hot topping
- i. Insulating blankets

Third, we need to specify the rate at which heat is exchanged across surfaces. For most sand and shell processes, this involves specifying Heat Transfer Coefficients at external surfaces. For investment processes, we may need to perform a View Factor Calculation to take into account radiation heat exchange between various portions of the shell. For permanent mold processes, we need to specify Internal Heat Transfer Coefficients to take into account mold coatings. Calculation of these values is included in the software.

We also need to specify the Ambient Temperature and, if we are going to simulate the filling of the mold cavity, the filling time.

### 3. Mesh the Model

Meshing the model refers to breaking the model into many small elements so the Heat Transfer Calculations can be performed on the casting and mold.

SOLIDCast uses the Finite Difference Method (FDM) of calculation. This means that the mesh is rectangular, made up of a series of cube-shaped blocks called nodes. You can specify the node size, or the number of nodes to be used in the mesh. Once you have specified the meshing parameters, meshing is automatic.

In SOLIDCast, the creation of the mold around the casting *can* be done as an automatic operation when the mesh is generated, either as a rectangular box, or as a constant-thickness shell. (This is not strictly necessary: The mold can be created as part of the model, in which case you can bypass automatic mold creation.)

### 4. Run the Simulation

This is an automatic function in SOLIDCast. You can start a simulation running, then use the computer to perform other operations while the simulation is running in the background. You can run multiple simulations on the same machine, if you have enough memory and a multi-core processor.

### 5. Analyze the Results

Once the simulation is finished, you can analyze and plot results in several ways:

- a. Iso-Surface Plots show 3D surfaces inside a transparent casting. This allows you to plot the location of molten metal at a given time, or the area of the casting that has a specific temperature.
- b. Cut-Plane Plots show data inside the casting on a 2D plane that can be moved through the casting model.
- c. CastPic plots show three-dimensional images, in color, of the results of the simulation.

There are also five different animation methods, which allow you to create Windows-Standard WMV movie clips, which can be rerun on any computer that has the Windows Media Player.

Using these tools, you can analyze the simulation results to predict whether there will be porosity (shrinkage) problems in the casting, or whether the casting is likely to be sound with a given rigging design. If the casting appears to be unsound, then the process design can be altered and a new design can be evaluated. You may want to make changes in such things as:

- a. Riser size
- b. Riser shape
- c. Number of risers
- d. Riser placement
- e. Gate location
- f. Fill rate
- g. Casting shape
- h. Pouring temperature
- i. Mold or shell preheat temperature
- j. Chills
- k. Sleeves
- l. Mold material

Etc....

Making a change in one or more of the above will mean a new simulation run and evaluation of the effects of the change by plotting the simulation results again.

### The Goals:

Improve your success rate on the first casting poured.

Eliminate production problems quickly.

Reduce scrap.

Improve yield.

Lower costs.

Improve quality.

Improve your foundry's profitability.