HOW TO MAXIMIZE SIMULATION PAYBACK USING PROCESS OPTIMIZATION

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ARTICLE TAKEAWAYS:
- Casting simulation is more efficient than shop-floor trial-and-error
- Optimization can maximize simulation paybacks
- For high production, melt cost savings can exceed $100,000.

Casting process simulation has been used by many foundries to design the process for production of castings before castings are made or before equipment is built or altered. Computer modeling can evaluate process designs in much less time, and at much less cost, than building equipment and producing sample castings.

In effect, we have replaced the traditional trial-and-error on the foundry floor with trial-and-error on the computer. The advantage is that the time and cost have been reduced. However, we are still dependent upon the foundry engineer to interpret simulation results and decide what changes are required for the next design iteration. And, once an acceptable result has been achieved, we still do not know if the result is optimum. For example, is this the smallest riser size that would produce a sound casting, or could we have gone smaller?

To advance beyond the trial and-error stage, OPTICast™ was developed to apply optimization methods to simulation, so that the design of a given casting with its rigging could be automatically modified to produce an optimum condition, thereby maximizing simulation payback.

Simulation is extremely useful in answering the question, “Will this process setup give me a sound casting?” What is not answered is “Can I get a sound casting more efficiently?” That is where optimization comes in.

Optimization requires the identification of three basic parameters:

1. DESIGN VARIABLES

These are features of a design that can change while the system searches for an optimum condition. Design variables may be geometric features such as the diameter and height of a riser or a riser/sleeve combination. They may also be process specifications such as the pouring temperature. Each variable has a minimum, maximum and nominal value so that the optimization system knows what “envelope” it can operate in. Multiple design variables are allowed in a single optimization.

2. CONSTRAINTS

Constraints set the range of data that is allowed. Values in the range are good, and values outside the range are bad. Constraints may be specified as a minimum condition, where the result value must be at or above the given constraint value, or as a maximum condition where the result value must be at or below the given constraint value. One or more constraints may be specified for each optimization run. An example constraint would be a maximum allowable porosity level.

3. OBJECTIVE FUNCTION

The objective function specifies what is trying to be achieved with a given process design. The objective function tells the optimization system what process result is to be used to judge whether you have achieved an optimum condition. The user selects an objective function and specifies whether the value of that function is to be minimized or maximized. For example, you might select predicted shrinkage porosity as an objective function, in which case you would want to minimize its value. On the other hand, you might select material yield (the ratio of casting weight to poured weight) as an objective function and try to maximize its value.

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FIGURE 1:
Steel piling hammer casting model

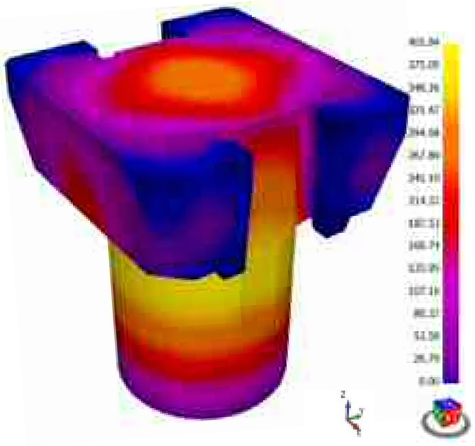


FIGURE 2:
Unrigged simulation results

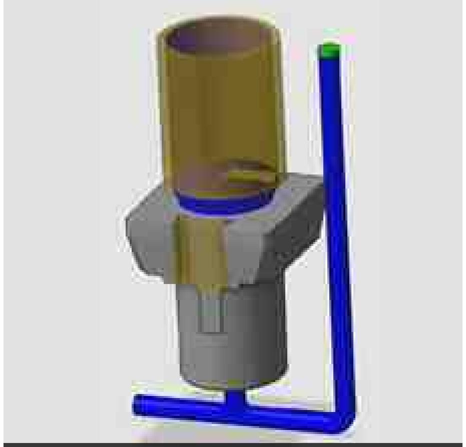


FIGURE 3:
Rigged model, based on Gating and Riser Design Wizards

Only one objective function can be specified for each optimization run.

In this case study the variables will be the height and diameter of the top riser. The constraint will be that we expect the casting to be shrinkage-free. This is expressed as the Material Density Factor (MDF) throughout the casting having a value of 1.0. The objective function is to maximize the casting yield. **Figure 1** shows the unrigged casting model, including Chromite facing sand.

The casting has a flat base dimension of approximately 30in (762mm) and weighs 2200lb (1000kg). The casting alloy is BS 3100-A5 and the mold material is alkaline phenolic bonded silica sand. **Figure 2** shows the results of the unrigged simulation.

Figure 3 shows the rigged model. Gating and risering component sizes, along with the pouring time, are based on calculations in the Gating and Riser Design Wizards. The riser size is 23in (585mm) in diameter by 28in (710mm) high.

Full simulation results shown in **Figure 4** demonstrate that the Gating and Riser Design Wizards did an excellent job in producing a rigging method that produces a sound casting. A great starting point. Applying optimization to this design allows us to fine tune this result to maximize the process yield while maintaining good casting quality.

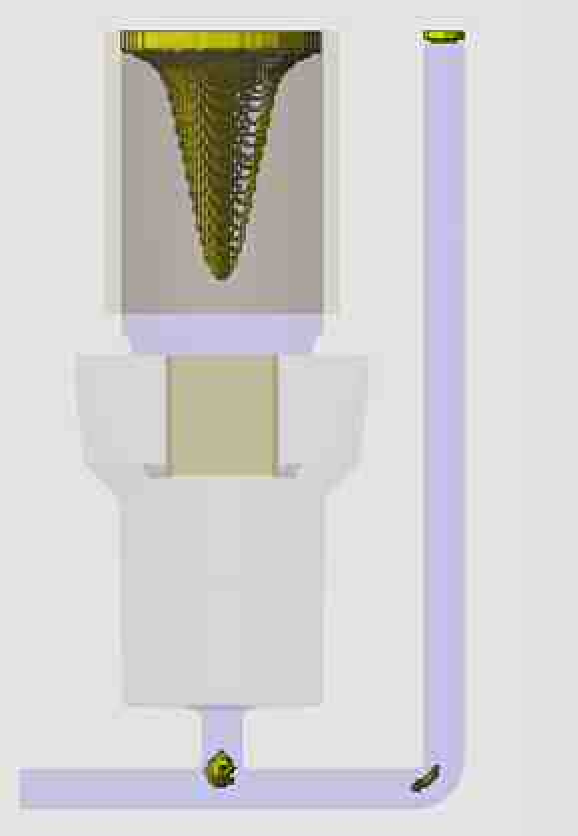


FIGURE 4:
Full simulation results verify a shrink-free casting

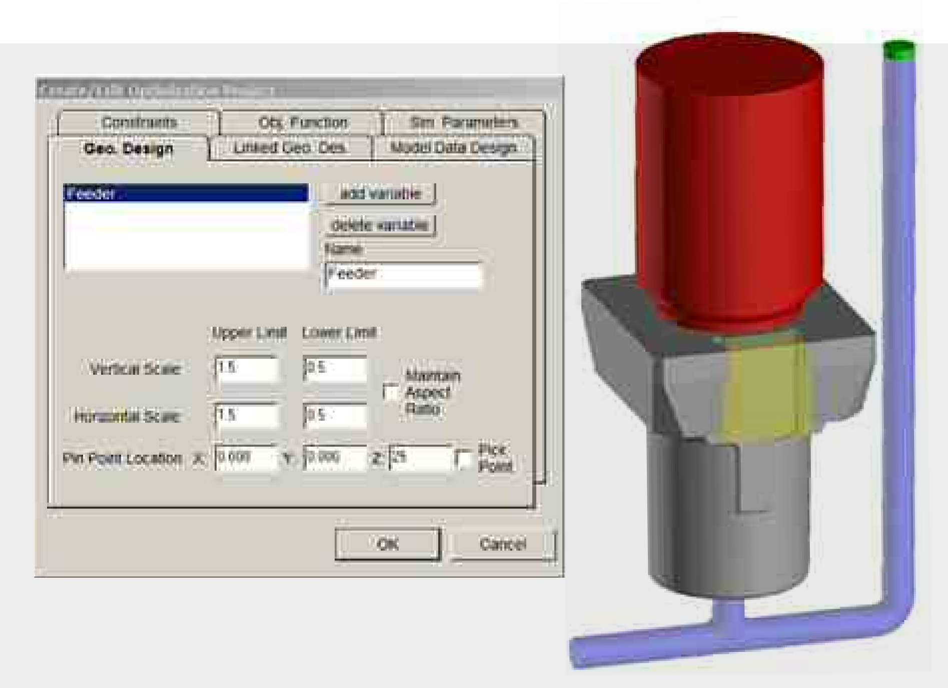
Figure 5 shows the setup of the optimization run. The variables will be riser height and diameter. This includes riser metal, sleeve, and riser contact, which will vary as a group.

When selecting variables, you can give minimum and maximum limits to the variable range, and specify a 'Pin Point', that locks a feature in place. In this example, the pin point is at the center of the riser contact where it touches the casting face.

The constraint for this run is to have a shrink-free casting. This is expressed as maintaining a Material Density Factor (MDF) of 1.0 throughout the casting.

The objective function for the optimization is to maximize process yield.

Once setup is complete, the optimization is launched, and the process becomes fully automatic. In this example, twenty-five simulations were run to achieve the optimized results, which provided a 12% increase in process yield. The riser size was reduced to 21in (535mm) diameter by 17in (430mm) height. A visual comparison between the start and end model, along with the final shrinkage prediction, is shown in **Figure 6**.



Feeder

Name: Feeder

	Upper Limit	Lower Limit
Vertical Scale	1.5	0.5
Horizontal Scale	1.5	0.5

☐ Maintain Aspect Ratio

Pin Point Location X: 0.000 Y: 0.000 Z: 25 ☐ Pick Point

FIGURE 5:
Optimization setup

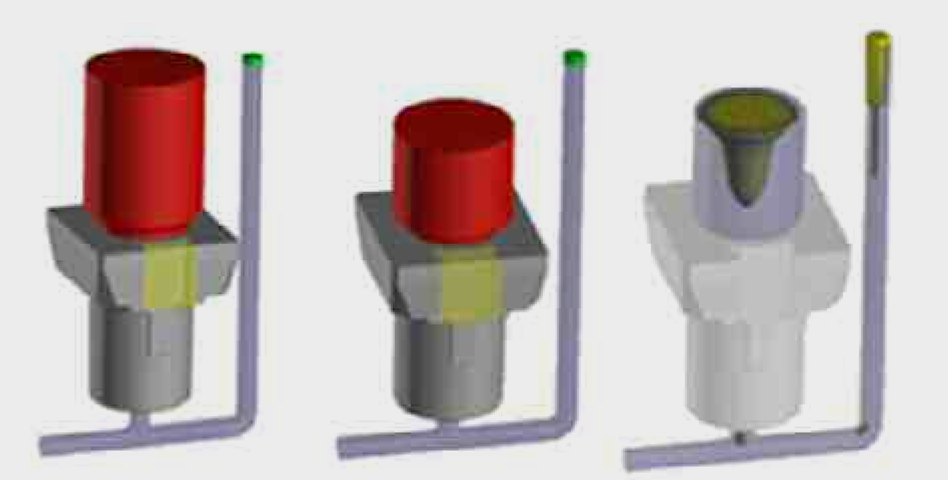


FIGURE 6:
Part yield was improved by 12% while maintaining casting soundness

Casting simulation software has gradually evolved from a problem detection or verification tool to an integrated part of the design method process. Simulation is no longer used simply to check a rigging system, but to be the driving force for the design of the system itself. Even complex geometries can be successfully rigged in a brief period using such tools.

The use of simulation results directly in the rigging process produces a more accurate result than manual techniques and does it in a much shorter time. This integrated approach cuts overall costs and reduces lead times.

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