

SIMULATION SETUPS FOR VARIOUS MOLDING PROCESSES



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ARTICLE TAKEAWAYS:

- Different molding processes require different setups for accurate simulation
- Sand casting is the simplest setup, followed by investment casting and permanent mold
- Setups can be reused to reduce operator time and increase consistency in simulation

When simulating various molding processes, it's important to account for the specific features of each process to make sure the overall simulation result is as accurate as possible. Calculations should also be efficient to provide results quickly.

Heat transfer calculations deal with heat flow through materials and the barriers to heat flow between materials. **Figure 1** shows these relations.

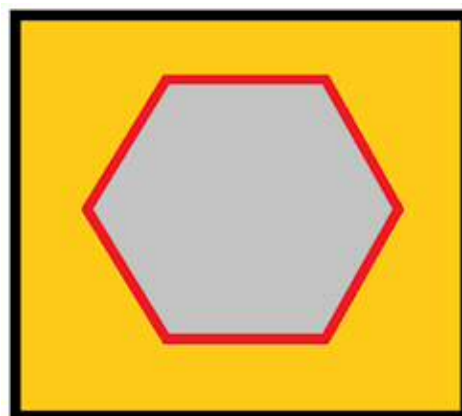
Consider an aluminum casting poured into a sand mold. Heat flows through the casting based on its thermal properties. The heat flows from the casting into the mold based on the properties

of the internal interface (or gap) that forms between the casting and the mold. Heat continues to flow through the mold until it reaches the outside edge of the mold, where it finally goes out into the air on the foundry floor.

If the mold material is insulating, like with sand or investment casting, you can usually ignore internal interfaces because their contribution to the overall result is negligible. Internal interfaces are very important in permanent mold casting where die coatings are frequently used to control heat transfer. Heat transfer coefficients (HTCs) are used to measure the resistance to heat flow across these interfaces.

As mold temperatures go up, it's important to deal with heat flow from the mold surfaces out into the foundry air. Radiation heat flow is significant as temperatures rise, like the hot shells used in investment casting.

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External Interface
Mold Material
Internal Interface
Casting Material

Figure 1: Heat flow is affected by material properties and interface properties.

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Here's how to adjust setups for each of the three main casting processes.

1. Sand Casting

Sand casting is the easiest setup, since the sand mold is insulating and the external mold faces are generally cool. This allows us to neglect internal interfaces and use low cooling conditions into the foundry air. The basic setup is shown in **Figure 2**.

External cooling is represented by a low external heat transfer coefficient of 1.5, and the use of internal HTC's is turned off.

2. Investment Casting

Setup for investment casting is more complex than sand casting because the investment shell is normally preheated to a high temperature. The ceramic shell is insulating (like sand), so we can ignore Internal HTC's. The high shell temperature requires a larger external HTC, along with radiation view factor calculations, which adjust the external HTC based on what each area of the shell sees in terms of other hot or cold areas on the shell. The setup details are shown in **Figures 3 and 4**.

3. Permanent Mold Casting

Permanent mold casting has the most complex setup. Since a metal die is conductive (like the metal that's poured into it), die coatings significantly affect heat transfer. This is taken into account with a table of HTC's, which measure the resistance to heat flow at any surface between two materials, such as casting/die, die/air, and gating/die. Insulating sprays on the gating/risering can easily be handled using HTC's. You can also configure the system to lower the HTC on a casting surface when it solidifies. This is used to simulate the air gap that forms as the

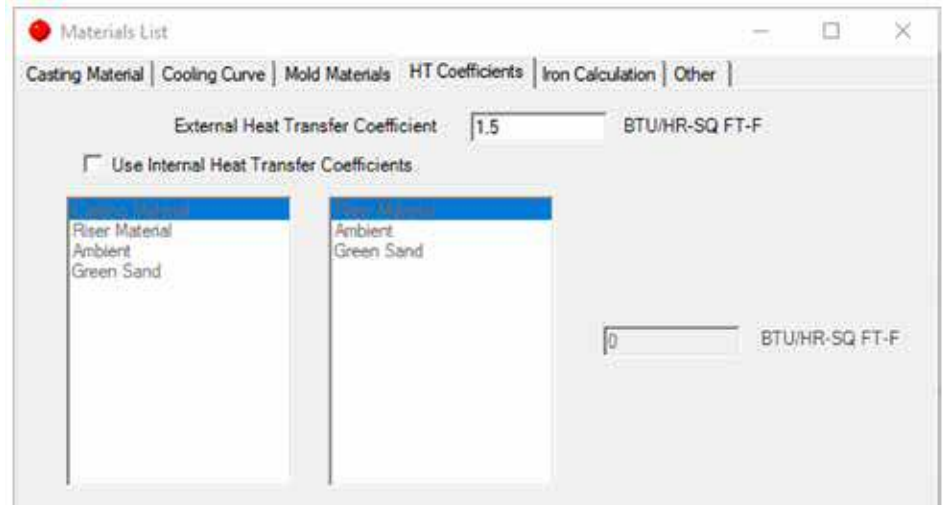


Figure 2. Setup Considerations for Sand Casting.

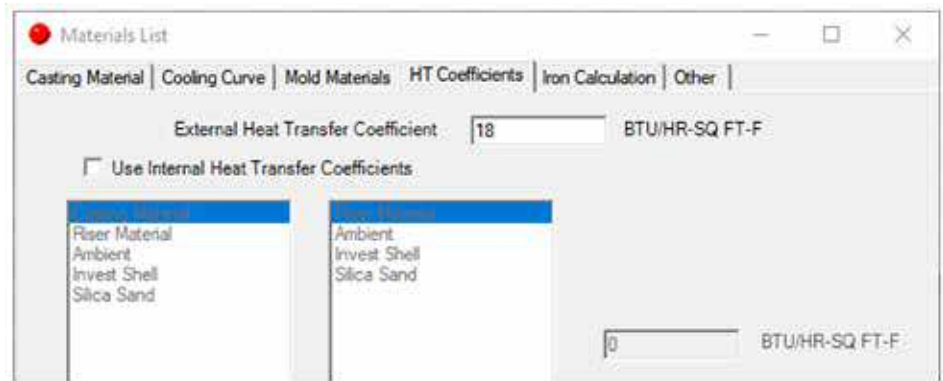


Figure 3. Setup Considerations for Investment Casting.

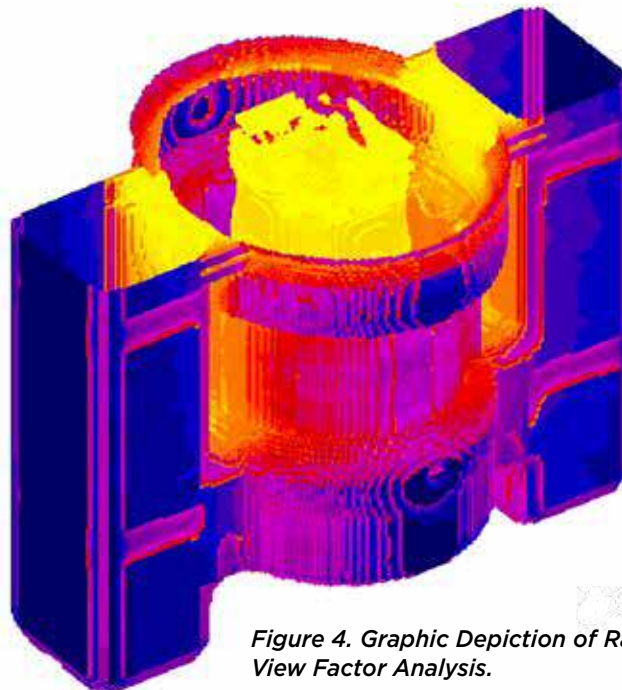


Figure 4. Graphic Depiction of Radiation View Factor Analysis.

Figure 5. Simulation Setup Using Coarse and Fine Meshes.

casting contracts and tries to pull away from the mold. HTC and radiation view factor calculations can also be used to predict cooling on the outside of the die in the foundry environment.

Other Considerations

Another major setup consideration is how to handle die cycling. Most dies are preheated before casting starts, but it still takes a number of cycles for the die temperatures to heat up to the operating conditions. In simulation, the number of warm-up cycles can be reduced by starting the die at a hotter temperature than normal and let the die cool slightly to the operating temperature.

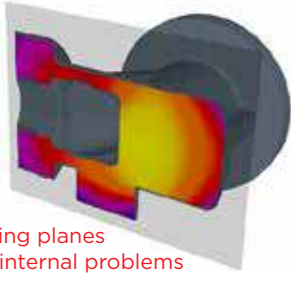
For example, you may heat a die to 300°F in the foundry, but the overall operating temperature may be in the 600-700°F range. If you start the die at 800°F in a simulation, it may take five cycles to cool to the operating temperature instead of 15 cycles if the die had to warm up from 300°F.

You can also speed up the warm-up section of the simulation by creating two meshes: one coarse and one fine. The coarse mesh is used for the warm-up phase, where the detailed progression of solidification is not important. With fewer nodes making up the mesh, the simulation can progress

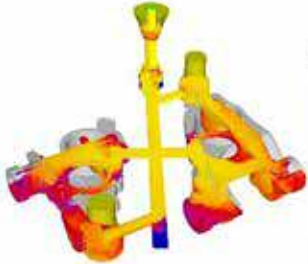
quite rapidly. If you use an 8:1 fine/coarse ratio, the warm-up phase of the simulation can run up to ten times faster. You can even use simplified filling analysis to speed this up even more. Once the die is at an operating condition, the temperature distribution from the coarse mesh is mapped into a fine mesh, and detailed and accurate CFD filling analysis and solidification can be calculated for maximum accuracy with minimum time spent. An example of the setup can be seen in **Figure 5**.



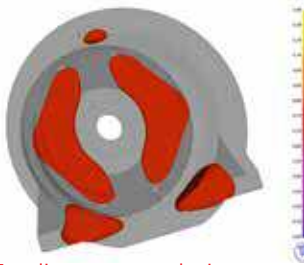
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