Dr. Die Cast

Question of the month goes here?

Casting simulation programs have been in use for more than 30 years. In the hands of a skilled engineer, they are a powerful tool, but just running one simulation is not a magic bullet.

As I mentioned in a previous article on CAD software, the ability to create a 3D mesh was an essential step toward solid modeling and simulation software. Initially, the computer hardware was a bottleneck in that "Workstations" or mainframes were the only computers powerful enough to run the software. PC's have increased in power while prices have dropped so that a seat of simulation software is much more affordable than ever.

A few of the developers follow:

- Flow 3D FLOW-3D CAST | State-of-the-art Metal Casting Simulation (flow3d.com)
- MagmaSoft was founded in Aachen, Germany in 1988. Start page MAGMA North America (magmasoft.com)
- EKK was founded in 1991. EKK, Inc. | Company Overview (ekkinc.com)
- ProCAST-ESI ProCAST (esi.com.au)
- NADCA's Castview Visualization Software (diecasting.org)
- And others…

There are loyal fans of each of the brands that will argue persuasively to defend their favorite software, especially while sharing their favorite brew at a NADCA event.

Initially simulation programs predicted solidification patterns. Followed by fluid flow and distortion. Sadly, many people stop short of the full potential by only performing a flow simulation. As will be outlined below, a solidification simulation can often be as important as the flow simulation.

In the 1990's we invited several die casting simulation program representatives to speak at our local NADCA meetings. During one of the Q & A sessions I asked "what are the qualifications of the ideal simulation operator?" The response was a surprise. He said, "give me your best process engineer. We will teach him the software but he will recognize a defect when he sees it." (and how to correct it, my comment added).

His answer supports my experience since. I have reviewed countless simulations both good and bad. Often after viewing the simulation, I comment that "I hope this was the "first pass" and that there is a revision that addresses the problem", only to learn that in fact, no one "saw" the problem and addressed it and they built the die with the problem, the problem that was clear on the first (and in many cases, the only) iteration.

That takes us to the point. Whether the defect is shrinkage porosity, a knit line or trapped gas, most simulation programs will display it when viewed correctly.

Identification and corrective actions:

Shrinkage/sinks: While everyone builds the cavities and cores to a dimensional shrink factor, it seems that many ignore the volumetric factor of shrinkage. A heavy isolated wall section will have a shrink void unless addressed by extraordinary temperature control or casting pressure measures. These include but are not limited to, accelerating the solidification with "High Thermal Coefficient" die materials such as Anviloy or special die steels. "Jet Cooling" is another technique to accelerate cooling.

Squeeze pins can be installed to displace the shrinkage during solidification.

Squeeze casting uses "gates" that are nearly as thick as the casting in order to maintain casting pressure during solidification. While effective in controlling shrink, the down side is a longer cycle time than normal high pressure die casting.

Delaying solidification in the gate entry also yields results. This can be accomplished using hot oil circuits or cartridge heaters near the gate. A slower heat transfer die material could be simulated to see the differences.

Flow lines and trapped gas:

Flow can often entrap gas when the metal seals off vents and overflows early. In one extreme case the metal flowed all the way to the far side of the casting while only touching the cover side. This sealed off the vents, then it returned touching

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only the ejector side. The result was a metal sandwich with trapped gas in the center. Since it was a painted casting, during the heated, drying process it blistered. The simulation plan view looked fine. However, the cause of this defect was only clearly visible in the simulation when looking at in cross section.

Another defect that can result from flow lines are physical failures. When two streams of metal do not adequately blend it can create a cold joint. Two streams of dissimilar temperature metal are not as homogenous as when it left the furnace. It must blend in order to reach full strength in the finished casting.

Blocked overflows, vents and recirculation:

Most castings have more overflows than they need. A lot of them are added in self-defense, i.e., just in case they're needed. Using the simulation program to identify where the last feature to fill is a good start. I have seen overflows, get filled early in the filling cycle and then start bleeding back, recirculating cold, partly solidified metal into the casting.

Vents are a necessary feature but they only work if they are allowed to remove air, especially the last high-pressure air in cavity. If the vents fill early due to location, then they need to be relocated. Vent thicknesses should shut-off before reaching the outside of the die.

Overflows should be located such that they are the last to fill. An overflow that is filled in first 10 to 20% of cavity fill is dead weight.

Multi-cavity timing:

Multi-cavity tools increase productivity but they are often plagued by miss-matched cavity filling and casting quality. Other issues resulting from late filling cavities are gate wash-out and/or solder. The gate velocity that fills the last cavity can be 2 to 10 times the intended speed. The solution is to optimize the timing using flow simulation so that all the cavities fill at the same rate at the same time.