Casting Buyers Need to Understand Porosity Technologies to Prevent Defects

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Executive summary:
The growth of the transportation industry has increased casting production throughout North American foundries. This rise in production and the need for faster deliveries has led to an increase in casting defects – especially porosity defects after machining.

Read how a recent foundry defect was discovered by the casting buyer and how this problem was resolved.

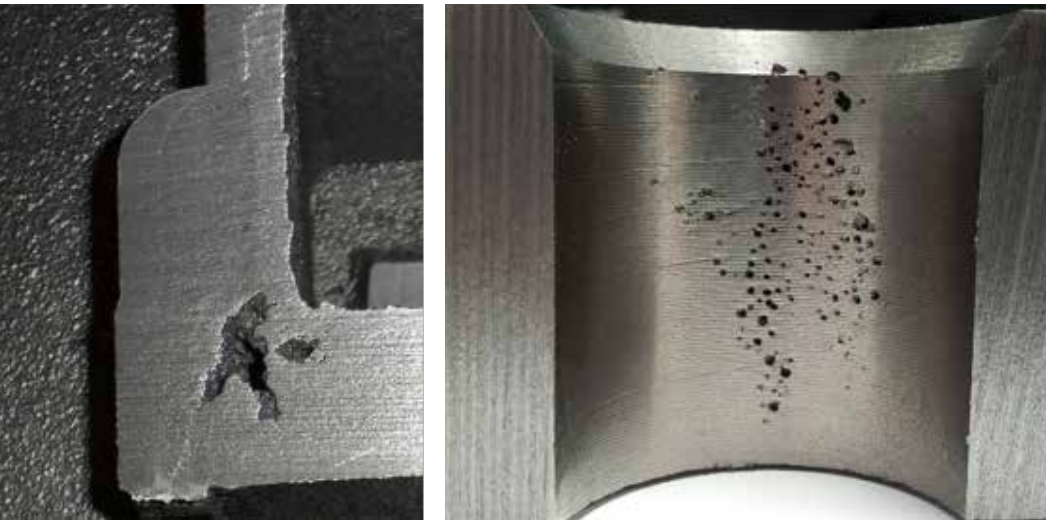


Figure 1: Shows two different ductile iron castings molded in sand with defects discovered after machining by an transportation sector OEM. The automotive OEM wondered, "What if I am buying more defective castings, that I'm not even aware of..."?

- A red flag was raised after casting defects were discovered after machining
- The OEM suffered delays due to an unexpected high reject rate at the foundry
- Casting defects and delays are expensive for both the foundry and casting buyer
- The OEM wanted to keep the job with that foundry
- The OEM did not have foundry expertise in-house to understand and challenge the foundry process specifically for the castings ordered
- The foundry was pressed by growth in orders and difficulties with labor retention
- The foundry needed to establish new process controls to keep quality high and attract young labor with technologies
- An audit on the foundry process was conducted by impartial foundry expert

  The measures on melt and mold design properties required for the specific castings were conducted by thermal analysis and casting process simulation, respectively. Sometimes the problem is in the mold design, sometimes it's in the melt or mold properties, especially for sand molding.
- It is important for both the casting buyer and the foundry to use metallurgical services to ensure quality.

How casting buyers can work with foundries to prevent porosity defects

Casting buyers and OEMs typically work with several foundries to source aluminum, steel and ductile iron castings not only for transportation industry but also for several sectors. Moreover, OEMs often use foundries to convert their welded assemblies to castings. Casting buyers often seek a one-stop, cost-effective, problem-free, and long-term relationship with foundries, as keeping everything with one foundry under one roof usually yields higher quality. Right?

Defects from Porosities

Quality variations with castings are frustrating, especially when you don't understand the root cause. It's a loss of time and money when you discover porosities during machining or worse, in service. The time to setup and run the CNC machine can be worth more than the casting itself, which still needs to be rejected. The foundry usually replaces the casting, however, this still is a time consuming problem and the question remains, how to correct porosity problems?

Understanding the root cause and how the foundry is addressing it is important for everyone to understand in order to properly meet your objectives and future needs.

In this particular case study, it was critical for everyone to understand the importance of thermal analysis and casting process simulation. In other cases, sand properties are often the culprit, which is another area for OEMs to understand.

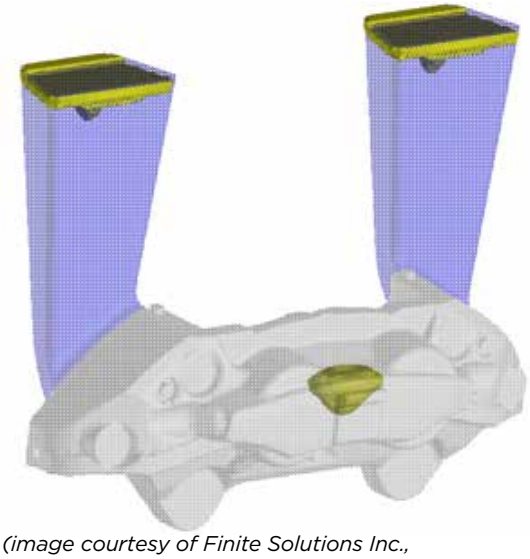


Figure 2: It took less than 5 minutes to simulate the porosity defect tendency (yellow region) in a tilt pour permanent mold A356 brake caliper casting design. The foundry knew it needed to work on an improved filling and solidification design to avoid defects. Then, what about the melt properties?

(image courtesy of Finite Solutions Inc., www.finitesolutions.com)

Casting buyers usually don't have the expertise in-house to understand porosity tendencies and need to trust their foundry, or decide based on the lowest cost. OEMs often don't have the measuring instruments to measure the process quality on the spot during the audit or introduction visit in order to compare two or more foundries. Plus, you don't know what to look for when you visit the foundry; everything will look fine but is it really?

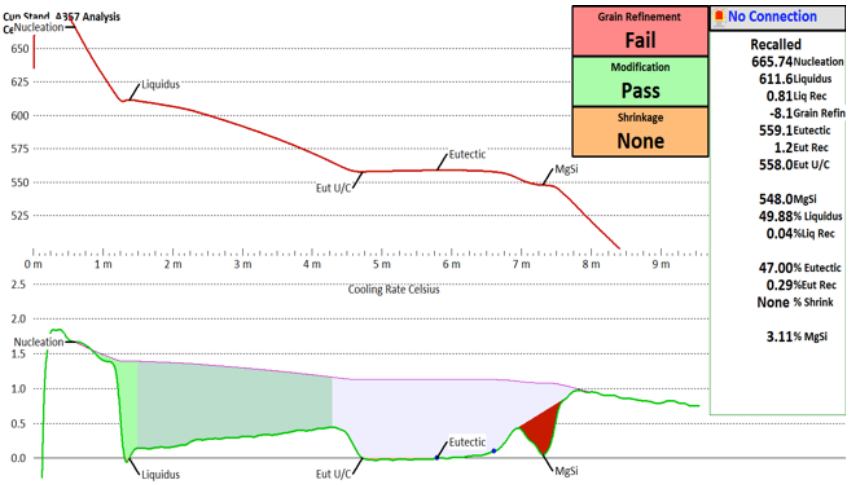
Our suggestion is for all OEMs to maintain a team of experts to guide them in these quality processes – to be proactive versus reactive. Your team can include internal engineers as well as outside consultants that can be pulled in on especially difficult projects.

Often problems arise because of lack of proactive engineering and process control, or it's too late and expensive corrective actions needs to be rushed. Cost-effective proactive actions are a must for win-win, long-term relationship between the foundry and OEM. Casting cost is only one variable in selecting the right foundry. Invest in this effort before ordering your next casting.

Controlling Melt Variation

Figure 3: Shows a foundry is serious about controlling their melt quality variation by using thermal analysis. Is this always a necessity for all foundries–No. Should the OEM care to understand why such technologies are not needed at that particular foundry–Yes.

Also shows thermal analysis of a given aluminum A357 melt sample which failed the grain refinement test. The melt needs to be grain refined before molds can be filled with molten A357.



(image courtesy MeltLab™ Systems, www.meltlab.com) **Continued** on page 16

How to challenge your foundry?
Here are three effective ways to challenge the foundry you're working with or seeking to work with:

1. Request to see the casting simulation results on the mold design to see how the liquid metal you buy fills the mold and solidifies to avoid porosity defects.
2. Request to see the thermal analysis measurements on the melt quality that will fill your molds, to review how consistent the melt quality is to avoid defects.
3. Ask an impartial foundry process engineer to work with you, the machining shop and the foundry as a team for long-term follow-up and success. Audits once a year don't work; invest in a closer relationship.
4. For sand molding, require data regarding sand properties and the controls that are in place.

Predictive Simulation

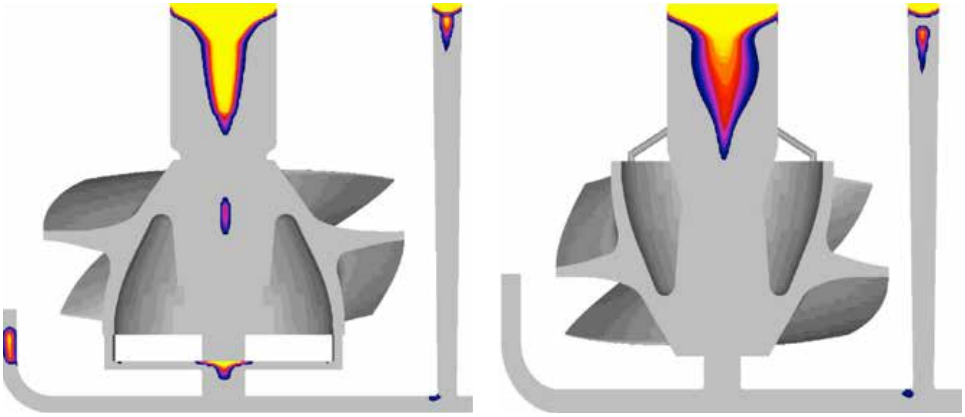


Figure 4: Cut plane showing porosity defects as predicted by simulation in the cast steel impeller for mold design #1; no porosity predicted on the improved mold design #2 to produce the same impeller with success.
(image courtesy of Finite Solutions Inc. www.finitesolutions.com)

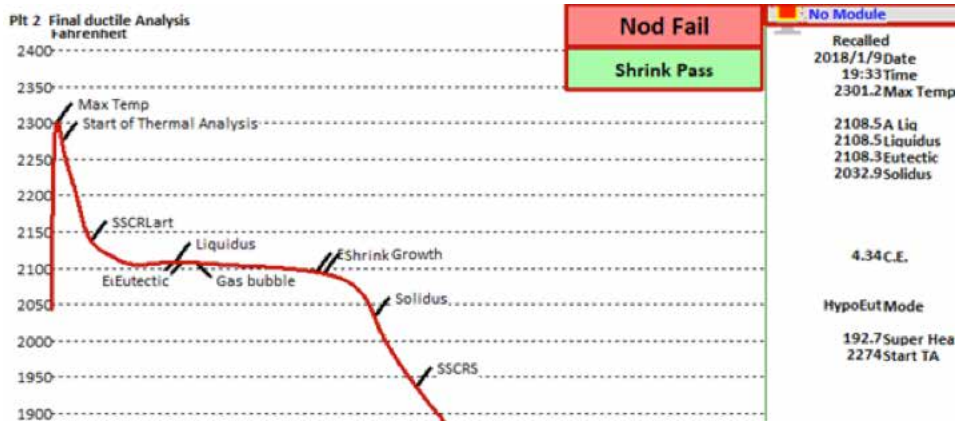


Figure 5: Ductile iron 80k thermal analysis sample with bad nodularity and gas bubble as the sample solidifies, while shrinkage porosity test passed.
(image courtesy of MeltLab™ Systems, www.meltlab.com)

How to collaborate successfully
Casting buyers and machine shops need to talk the same language that the foundry uses, or frustration awaits. While you can rely on the foundry to be your experts – challenging their team with your expert team will bring you the most value.

Sometimes the foundry needs a little push from the OEM to adopt a new technology. For example, OEMs need to see newer technologies that can prevent these defects such as casting simulation and thermal analysis to support their in-house experts. You as an OEM will end up with more consistent castings delivered more quickly by participating in the process and being up to date on current technologies.

Foundries do their best to be current in the latest technologies, however as castings become more complex, the dynamics change. Your particular project may be that situation where a collaborative environment yields the highest results for all of you.

Figure 5: shows a thermal analysis sample taken from a final ductile iron melt. That's what the foundry was pouring into the molds. As predicted, castings from that melt exhibited casting defects especially due to low nodularity and gas. The mold design was improved to reduce turbulence, however, the thermal analysis results indicated the metallurgical properties of the molten metal were not right.

In this particular case study, the analysis was conducted and problem solved because the OEM took the lead and hired an expert to bring this resources at a critical time.

The OEM has this consultant as part of their internal team, exactly for this purpose.

In conclusion, stop working in silos; start working as a team with the machine shop, foundry, and your own team of experts. You'll save time, prevent defects, and overall save money. Therefore, before you order any castings, challenge the foundry first by asking to review the predictive simulation and thermal analysis processes they have in place to prevent these porosity defects.

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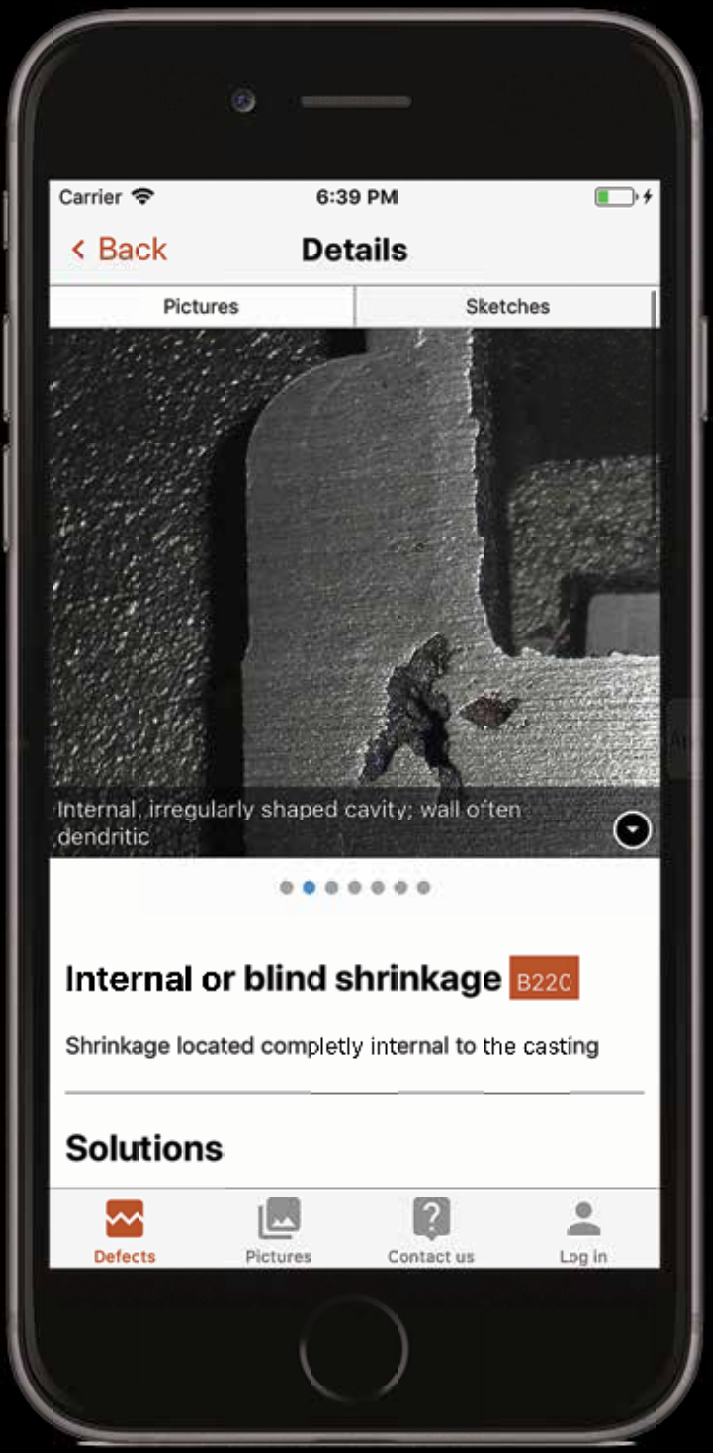
Casting Defect

A casting defect diagnosis tool by
Foundry Solutions & Metallurgical Services Inc.



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