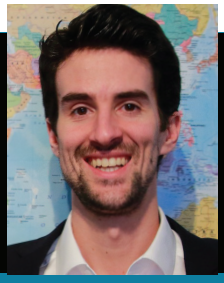
How to use Thermal Analysis (TA) in Aluminum Foundries



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ARTICLE TAKEAWAYS:

- Thermal Analysis data helps to find the root cause of casting defects
- Thermal Analysis is important to validate the melt treatment and record/correct melt variations
- Qualify new ingots based on metallurgy to avoid problems, not just chemistry

Most aluminum foundries know how to use the reduced pressure tester to control hydrogen and oxide removal from the melt. The spectrometer is to control chemistry variations. On the other hand, thermal analysis of the melt has been regarded as not repeatable; not worth implementing versus value added or simply not shop-floor ready.

Furthermore, the previous systems were only for grain refinement and eutectic modification control with limited precision. The important secondary phases and fraction solid curve were not available and the calibration of the system was expensive.

SFTA launched an innovative thermal analysis system a year ago, using a variation of the Newtonian principle and higher order derivatives. The accuracy and precision are much better compared to previous algorithms relying on time and temperature. As the liquid metal solidifies, it transforms into different solid phases that release or absorb heat. With each sample, important variations in phase formation are detected for Mg2Si, Al2Cu, iron intermetallics, late eutectics, etc. The fraction solid curve is plotted for more accurate casting simulation inputs.

Today with Industry 4.0, all the operator has to do is take a sample to generate all the data on solidification properties. The complete analysis is automated and the data is recorded on the server. Only a portion of the results is displayed to the operator or the supervisor and it's customizable (Figure 1). Melt

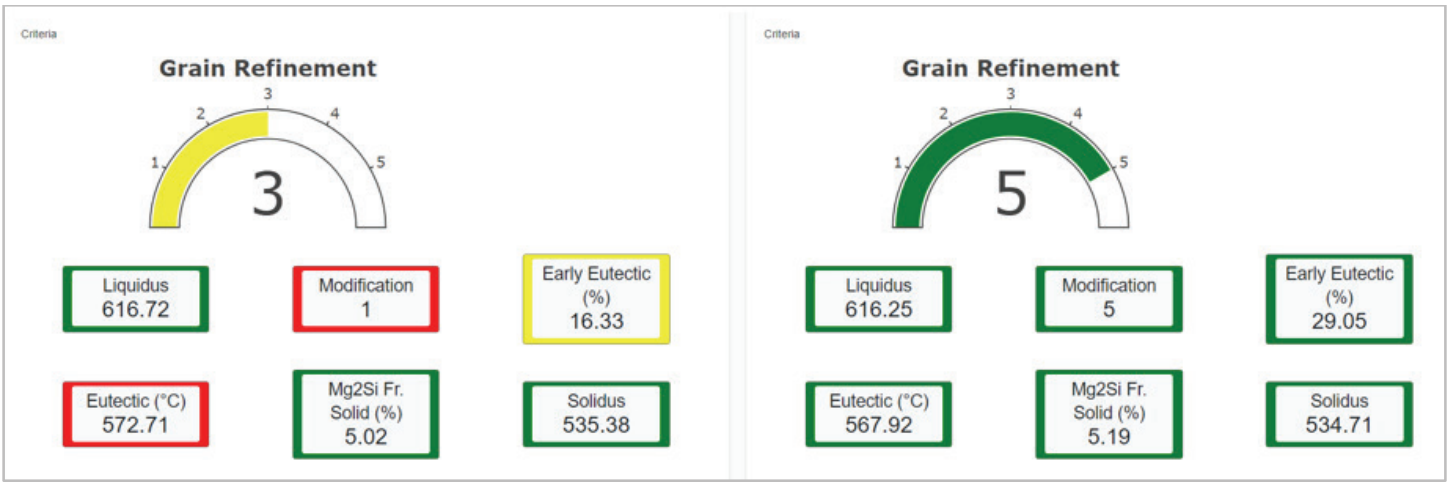

Figure 1. Thermal Analysis software interface displaying A356 data before (left) and after (right) grain refinement and strontium additions.

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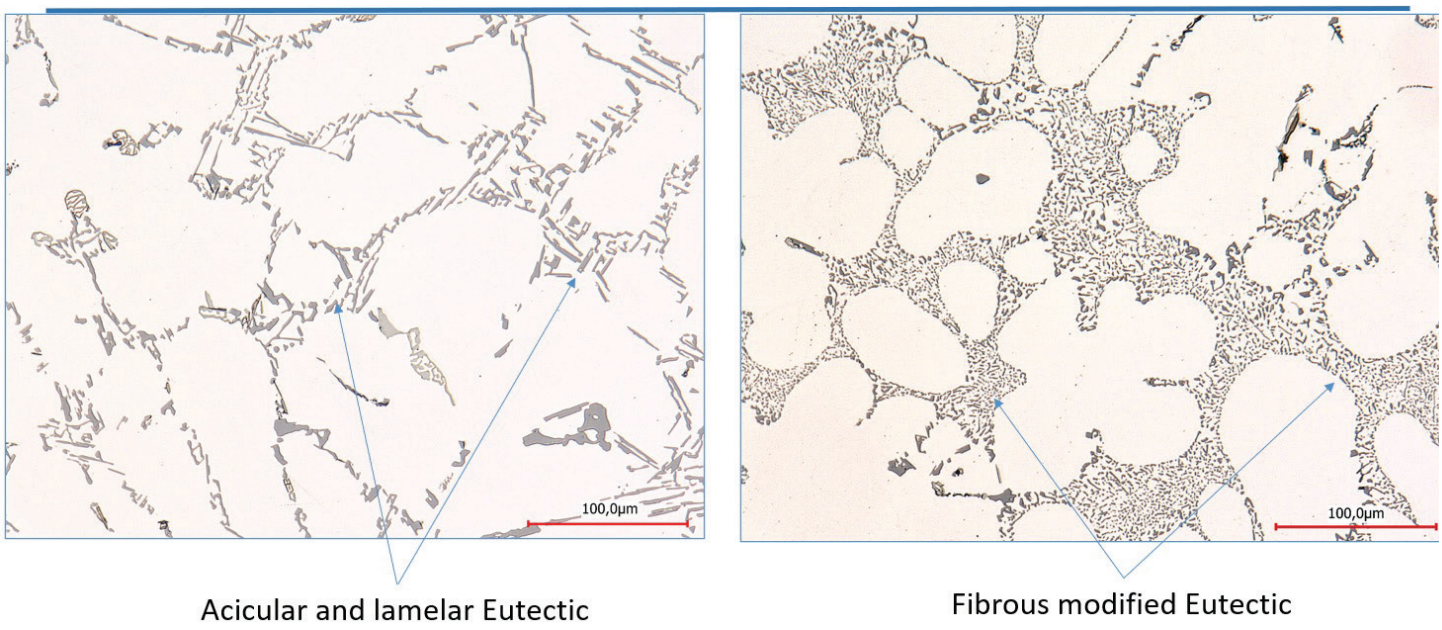

Figure 2. A356 metallography before (left) and after (right) grain refinement and strontium additions.

quality indicators specific to the foundry are programmed and optimized in the software as data is generated. Non-conformities are corrected before suffering a scrap episode.

PRACTICAL EXAMPLE

A foundry concluded they had strontium-related porosity issues in aluminum-silicon alloys. They also decided to stop buying strontium-containing ingots. They used thermal analysis to realize they could only add 120-140ppm of strontium compared to the 180-240ppm of strontium in the new ingots they were buying. Now, they generate less strontium oxides known to nucleate porosities. It's more cost-effective and accurate to spot check the melt by thermal analysis than metallography (figure 2). While the foundry first wanted to use thermal analysis for eutectic modification, they also generated the data to control grain refinement, secondary phases, etc.

CONCLUSION

From the 2014 literature review by Djurdjevic with Nemak: *''Thermal analysis is used to evaluate the following processing and materials parameters: grain size, dendrite coherency temperature, dendrite arm spacing, level of Al-Si eutectic modification, solid fraction as well as the characteristic temperatures of various metallurgical reactions between liquidus and solidus temperatures.''*

From Geoffrey Sigworth's talk at CastExpo 2016: *''In secondary alloys P (Sb or Bi) can 'poison' modification, so thermal analysis is required for Quality Control; In Cu-containing alloys over modification (Sr + Ca) can cause undesirable 'blocky' Al2Cu phase to form. Thermal analysis can prevent this; Thermal analysis helps to track down 'problems' (e.g., sudden out breaks of shrinkage porosity).''*

Since our introduction of this innovative thermal analysis system, there are now many case studies documenting the ability to better validate melt treatment (and variations) to determine the root cause of casting defects, which has resulted in a reduction of defects and scarp, and increased the production of higher quality parts.

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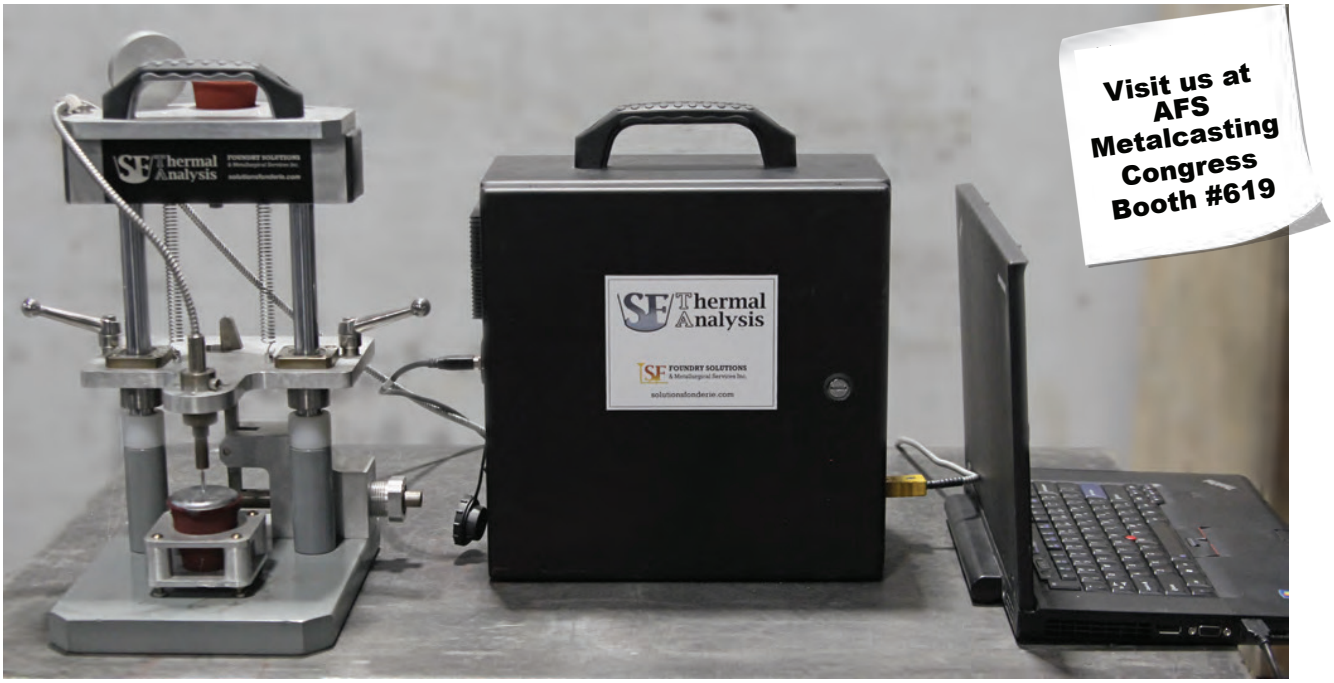
SF Thermal Analysis

NEW TECHNOLOGY



- Measure your solidification properties
- Eutectic modification, grain refinement
- Evaluate the intermetallics Mg_2Si, Al_2Cu
- Adjust your melt treatment based on data
- Diagnostic tool for casting defects
- Inexpensive calibration by the user

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