Making Better Aluminum through Thermal Analysis

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***Introduction**: Metal is much more than its component elements. The structure and physical properties are controlled by minor factors that can produce a great consistent casting, or a disaster resulting in loss of a customer. Understanding and controlling the microstructure is critical for producing modern castings.*

Background: Aluminum generally falls into two groups where the principle alloy is either silicon (300 and related series) or copper (200 and related series). Boron, titanium and strontium or phosphorus are used to control how the first series develops, while phosphorus is the key addition to the second. Each alloy needs to produce smaller and tighter grain structure to produce the best possible physical properties.

In addition, aluminum is subject to gas and shrinkage defects. The gas comes from moisture/humidity and shrinkage is a natural effect of solidification, though it can be made better or worse by casting design, under/over degassing, dirty metal, and difficulties in feeding due to over modification.

In short, it can be difficult to make good castings if you aren't paying attention to the process and don't have good process controls in place.

Grain Refinement can be measured either by taking a micro of the metal or by thermal analysis. We call the first method a postmortem analysis since it is too late to help the casting. Thermal analysis can be taken of the molten metal before pouring to make sure there is enough grain refinement in the metal. Since the most common grain refinement material can cost up to $5 per pound delivered, there are also cost savings in not over grain refining the metal. In addition, the grain refinement fades with time and will deteriorate in 30 to 60 minutes.

Modification by strontium is used in the 300 series and related alloys to produce a fibrous silicon structure. Strontium is neutralized by phosphorus so the two should not be used together. Also, the Strontium fades with time and will need freshening. Many foundries use only spectrometer analysis to check on the level of this element, but that tells you nothing about age or effectiveness. Volume 2 of Bäckerud's "Solidification Characteristics of Aluminum Alloys" shows some pictures of the shape of modification aging. MeltLab has researched this and developed a measurable aging parameter as well as measuring the energy of the modification arrest as suggested by Geoffrey Sigsworth. These two values help a foundry control and stabilize their modification.

Degassing and micro-shrinkage is an expensive and time-consuming process, and over degassing can lead to shrinkage. Aluminum castings will have a certain amount of porosity that needs to be balanced between gas and micro-shrink to avoid macro-shrink. Only high-pressure casting gets totally away from this problem. Thermal analysis allows us to measure the balance between gas and micro-porosity so we can have a little of each and not too much of either. The trick is that both cause tiny heat absorbing events that MeltLab, with its extremely high precision, can measure and evaluate. Moisture in the air and wet charge materials increases the gas content while recycled material adds to the micro-shrinkage in the casting. Thermal analysis lets you know where you are at.

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