CERAMIC MATERIAL SELECTION IN MOLTEN ALUMINUM APPLICATIONS:

BLASCH PRECISION CERAMICS

PHILIP GEERS
Molten Metal Market Manager
BLASCH PRECISION CERAMICS

ARTICLE TAKEAWAYS:

1. General terminology for properties of ceramics
2. Ceramic materials used in aluminum casting and properties

The modern Aluminum caster finds an increasing amount of options when looking at refractory products in the cast shop. Many casters are running multiple alloys at different times, or the same time in different parts of the shop. Even given just one alloy, there also are variables of treatment and process steps required in casting, in which just one type of refractory will not be sufficient. Given this, it is good to review the types of refractories available, the properties that they have and some of the differences and applications that each one could be used in.

Before we discuss these materials and applications, let's review the general terminology for the properties of ceramics:

Coefficient of Thermal Expansion (CTE): Thermal expansion is the tendency of material to change in shape, area, and volume in response to a change in temperature. As far as refractory use is concerned, ceramic materials expand when heated, but this expansion occurs at different rates for different materials. When designing parts that fit together, or parts that nest together (a ceramic sleeve inside of a metal tube, for example), the user must know what the different expansion rates are for each material, so that when in operation at maximum temperature, there are not any conflicting mechanical interferences or tolerance issues between parts.

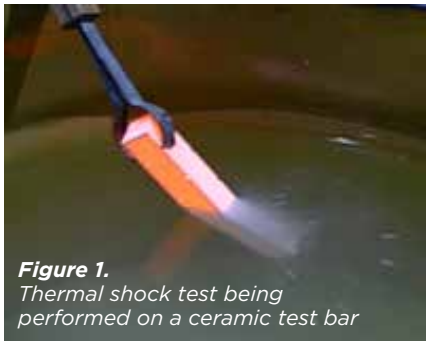

Figure 1.
Thermal shock test being performed on a ceramic test bar

Thermal Conductivity: Thermal conductivity is the property of a material to conduct heat. For nearly all casting house applications with molten metal, understanding this property is critical to success of the ceramic components used. Heat transfer occurs at a lower rate across ceramic materials of low thermal conductivity than across ceramic materials of high thermal conductivity. Because of this, ceramic materials with high thermal conductivity are used in heat sink or heat transfer applications and ceramic materials of low thermal conductivity are used as thermal insulation. Ceramics generally fall into two categories: insulating (low thermally conductive ceramics) or conductive (high thermally conductive ceramics). As you can imagine, ceramics used for resistant heaters need to be thermally conductive to be effective in their use. Materials such as silicon carbides fall into the thermally conductive category. In addition, ceramics used for insulation or long-term metal holding need to be in the low thermally conductive category to be effective, and a ceramic like fused silica is a good insulating ceramic.

Figure 2.
Ceramic materials being MOR strength tested

Flexural Strength/Modulus of Rupture (MOR): Flexural strength is a material property defined as the maximum stress in a material just before it yields (breaks) in a flexure test. As ceramics really do not bend like a metal would, this property test is the determining factor as to how strong a ceramic material is. Ceramic strength is something that must always be considered in use. While many ceramics are quite strong under compression, compared to metals, they are very brittle and cannot survive being twisted or bent in application. When mechanical strength is needed (ladles or stopper rods, for example), choosing a ceramic that has the highest flexural strength will help extend life in the application. Occasionally, when other property requirements necessitate the use of a weaker than desired material, care must be taken in the design of the part and load on the part to reduce possible failure.

Corrosion Resistance/Wettability:
Ceramic materials that are used for direct contact with molten metal must be able to withstand the constant effects of metal corrosion and penetration. While some materials can take short term exposure, if extended exposure times (weeks, months) are required, the material must be tested and proven for use in the requested metal alloy, and at the required temperature. Remember that the addition of fluxes into your alloys can greatly change the chemical composition and reactivity of the metal. Also, metal can increase reactivity with increased temperature and this must be taken into consideration when the proper ceramics are selected.

Figure 3. *Corrosion test displaying non-wetting property of Blasch Nitron™*

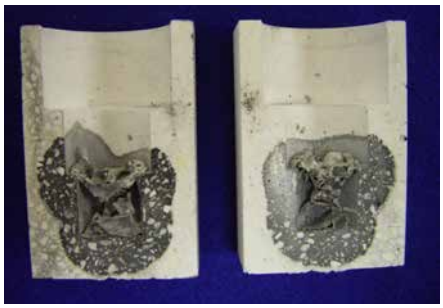

Figure 4. *Corrosion test displaying negative results when using material not suited for application*

Below is a table with several common ceramic materials used in aluminum casting applications and their general properties.

Blasch Product	Description	Part Cost	Eng/ Setup Cost	Tolerances	Shape Capability	Porosity	Thermal Shock Resistance	Chemical /Corrosion Resistance
Oxytron	Oxide Bonded SiC	Low	Medium	+/- 1/2%	High	15%	High	High
Nitron	Nitride Bonded SiC	Medium	Medium	+/- 1/2%	High	15%	Medium	High
Altech	Aluminum Titanate	High	Low	Machined	High	Dense	High	High
	Fused Silica	Low	Low	+/- 1%	High	5%	High	Med

As you look to improve your casting process and want to improve the life of your ceramic products, leverage your relationship with your refractory provider and share as much information you can regarding your process. Process changes in temperature, thermal cycles, and alloy types will all affect your choice of ceramic. Utilize the knowledge of your refractory supplier to provide you with the best options for improvement. With new ceramic materials being formulated all the time, it is good practice to check in often to see what new products might benefit your casting facility.

Contact:
PHILIP GEERS
pgeers@blaschceramics.com