SHOULD YOU BE USING FIBER IN YOUR SLURRIES?

By Kermit Buntock, Buntrock Industries

Originally published in INCAST *Magazine*

Is your shell room running out of capacity? Instead of investing in more robots and drying conveyors, perhaps it's time to consider fiber-enhanced slurries. Many investment casters who have used fiber-enhanced slurries have been successful in reducing the number of dip coats and thereby increasing shell room throughput.

One of the most exciting developments for the investment casting industry is the use of organic fiber. Dan Duffey and Richard Shaw (the inventor of the "Shaw Process") were issued a U.K. Patent and three U.S. Patents covering the use of organic fibers for use in investment casting slurries. Originally, Buntrock Industries, Inc. licensed this technology, but has since purchased the three U.S. patents. The major advantages of incorporating the fiber into an investment casting slurry are:

1) Thicker shell build for each coat. This frequently means that the shell can be constructed with less dips.
2) More uniform shell build around corners and sharp radii. The University of Birmingham in cooperation with Rolls Royce developed a special edge test for evaluating the MOR strength around the trailing edge of airfoil shapes. The fibers tend to wrap themselves around sharp corners of the assembly and reinforce the "weakest points of shell construction." For Rolls, this edge breaking test was much more predictive of shell cracking than the standard three-point break MOR test.
3) The fibers prevent crack propagation.
4) Due to the above reasons, shell molds are less likely to crack and this has been verified by D.O.E. tests at a number of foundries.
5) Since the fibers are organic, they burn out during the furnacing cycle. The hollow channels from the vacated fibers significantly increase permeability and improve knock-out. Caustic leaching is also improved, as the chemical solution now has paths within the shell to penetrate and remove shell material.

Much of the current work has centered around a special organic fiber with about a 1.5mm length (both the length and diameter of the fiber are important).

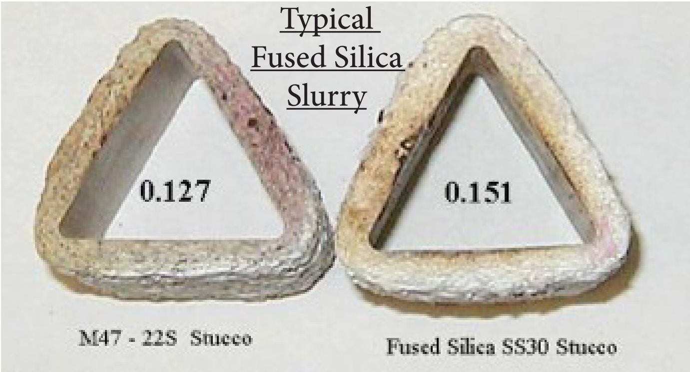
Some investment casters have nicknamed this product "Black Beauty"

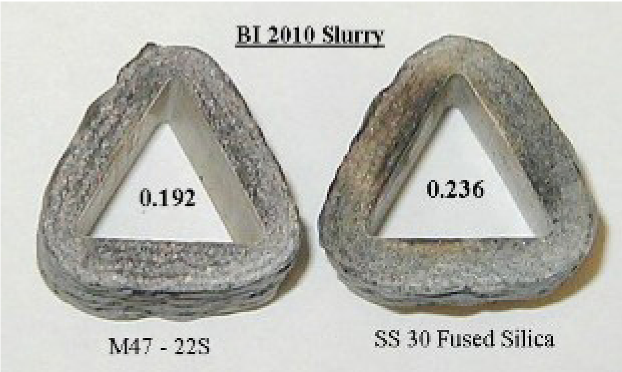
Although other types of fibers and lengths are possible, this particular one seems to work well for back-up slurries and is the most common one in use.

In order to achieve better economics, Buntrock has developed other additives which enhance slurry rheology and increase the shell build per coat. An excellent candidate is Carb-O-Sil refractory. This product was developed by Wesbond and its use with fibers is covered in Buntrock Industries' U.S. Patent 6814131; this patent also protects the art of blending fiber and refractory materials to form a convenient pre-blend. Additional U.S. patents have been issued (U.S. 6991022 and 7,004,230) to further protect this technology.

Carb-O-Sil is a low-cost silica/carbon refractory sand (about 100 mesh) with a uniform rounded, and porous structure. As such it serves to help disperse the fibers uniformly in the slurry while improving the shell build per coat.

After burn-out, part of the Carb-O-Sil remains behind as a silica skeleton. If burn-out is not complete, some of the carbon is left behind and serves as an oxygen scavenger





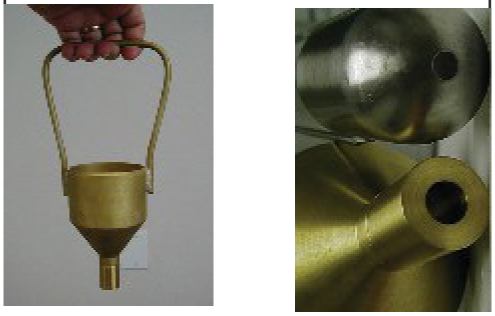
to help prevent chrome pitting in difficult alloys such as common carbon steels, 400 series stainless, 17-4, etc.

Some investment casters have nick-named this product “Black Beauty”, since it turns the slurry a jet black. Shells are black when first dipped, then turn gray upon drying. Since fiber length, fiber loading, additive concentration, and refractory particle distribution all impact shell building, a number of pre-blended refractory and fiber products have been developed which optimize slurry rheology, draining, and shell coverage.

To further optimize the system, several new colloidal silica sols (TMM-30, TMM-35, and Shellbond 321) have been developed for use in the fiber-enhanced slurries. These sols are unique in that they offer significantly higher green strengths and more resistance to soften-ing upon being heated (flash fire units) or being steamed (autoclave units).

One of the unusual attributes of the selected organic fibers is that although they reduce shell cracking, they actually lower the green strength as measured by the standard three-point break test. With two labs involved in R&D and technical service, researchers have broken lots of ceramic test strips. In general, with a fused silica system using standard small particle sol, researchers will achieve dry green strengths of 450psi to 550psi. When the special organic fiber is added, this measurement falls to 350psi to 450psi. However, with the use of the special sols, the dry green strengths jump to 450 psi to 650 psi range. Broadening out the refractory blend may yield another 100psi or so for this test. Alumina silicate systems usually test out about 20% lower than fused silica.

Specially designed flow cup with a larger cup with a larger hole



Another even more interesting phe-nomenon is to evaluate the ceramic test bars wet after steaming or soaking in 200ºF water. This test was designed to simulate autoclave conditions, so as not to be tricked by just the dry three-point break test.

A shell bonded with a normal colloidal silica sol will lose about 30-40% of its strength with this test. When tested hot and wet, many polymer-enhanced systems will lose green strength of 50% or more. Shells bonded with the special sols may lose only about 10-25% strength in this test.

Perhaps a comment about viscosity measurement is also appropriate. The fibers in a broad distribution slurry tend to wrap themselves around the holes of a Zahn cup and may make reading the results more variable. With a #4 Zahn cup, the hole usually plugs over; the #5 Zahn has a larger hole but the end point is not sharp. Consistent viscosities can easily be measured by using a specially designed flow cup which has a larger cup with a larger hole. Designated as a BI #5 cup, it is available from Buntrock and essentially duplicates the reading from a #5 Zahn cup, but with more accurate and consistent measurements.

The use of fiber in investment casting slurries is perhaps one of the most significant developments in shell chemistry in the last several decades. A great deal of work has already gone into formulating special products to optimize this technology. Since development work is ongoing, future improvements are also anticipated.

LEARN MORE AT
WWW.BUNTROCKINDUSTRIES.COM