

► Working with a specialist can help manufacturers find the right raw material ingredients and set the correct furnace parameters to produce a successful fused product.

# Custom Fusion & Milling

**R**efractories manufacturers in search of special fused minerals often seek a specialist with the skills and equipment to test out new fused mineral products and concepts. Many manufacturers don't have the know-how or the furnaces to run their experiments and don't want to invest in costly capital equipment for just a few product trials with uncertain outcomes. The R&D specialists at these companies usually have a general idea of the kind of product they want to make, but don't have the expertise in electric-arc fusion know-how to test their concept.

## Expert Assistance

Working with a specialist can help refractories companies find the right raw material ingredients and set the correct furnace parameters to produce a successful fused product. Scaled-down large electric-arc furnace technology accommodates the need for small-scale furnace runs. In addition, small-scale pilot fusion and milling plants can service the needs of companies

looking for small quantities (5 to 100 lbs) of custom-fused minerals.

A trial-size furnace can produce as little as just a few pounds so as not to waste precious raw materials until the desired product has been achieved. Depending on the result, the composition of raw materials can be altered, adding more of one ingredient and less of the other until the sample matches the product concept. From there, the process can be scaled up to make as little as 10 or 100 lbs, or as much as 300+ tons, depending on how much product the customer needs for testing.

Based on the application for the new product, the new fused material from the furnace needs to be reduced to a variety of different sizes. Some manufacturers require coarse particle sizes while other processes require the fused mineral to be in a fine powder form. Milling equipment has been engineered to reduce the furnaced product to a size that is appropriate for a variety of final applications. Small-scale crushing, milling and magnetic separation have

been custom built to handle small quantities of different types of fused products. In some cases, special surface treatments can be applied to the final product to enhance particular product properties.



Analyzing grains for size and particle shape.

Custom fusions can be done with nearly any combination of oxide materials, as well as some carbides. Custom-fused products have been created for a variety of applications, including refractories, thermal sprays, aerospace, space research, technical ceramics, and abrasives. Fused products vary from standard aluminas and zirconias to more exotic minerals like rare earths (see Examples

# CUSTOM FUSION & MILLING

## Examples of Fused Materials

Alumina (Fused Alumina)  
Alumina-Zirconia (80-20% / 60-40%)  
Alumina-Zirconia-Magnesia (57-10-32%)  
Alumina-Zirconia-Titania (72-26-2%)  
Alumina-Chrome Oxide ( $\text{Cr}_2\text{O}_3$  varied by 0.3-99%)  
Alumina-Nickel Oxide (56-44%)  
Alumina-Titania-Yttria (94-3-3%)  
Aluminum-Titania (98-2% / 87-13% / 60-40%)  
Alumina-Silica-Zirconia-Titania (70-20-5-2%)  
Alumina-Magnesia-Silica (14-35-51%, Cordierite)  
Calcium Stabilized Zirconia (4% Lime)  
Calcium-Silica (64-34%, Larnite)  
Calcium-Yttria-Manganese Oxide (26-25-49%)  
Calcium Oxide (Fused Lime)  
Cerium Oxide (Fused Ceria)  
Erbium Oxide (Fused Erbium)  
FerroSilicon FeSi (84-15%)

Lanthanum Oxide (Fused Lanthanum Oxide)  
Lime-Magnesia-Alumina-Silica (37-7-12-48%)  
Magnesia-Chrome Oxide (20-80%)  
Magnesia-Chrome Oxide (40-60%)  
Magnesia-Alumina (87-13%)  
Magnesia-Alumina-Zirconia (82-13-5%)  
Magnesia-Chrome-Alumina-Iron Oxide (64-19-6-11%)  
Magnesia-Chrome-Alumina-Iron Oxide (53-37-4-6%)  
Magnesia-Silica (55-45%, Forsterite)  
Praseodymium Oxide (Fused Praseodymium Oxide)  
 $\text{TiO}_2$  (Fused Titania)  
Yttria (Fused Yttria)  
Zirconium-Dysprosium Oxide  
Zirconium-Dysprosium-Indium Oxide  
Zirconium Diboride ( $\text{ZrB}_2$ )  
Zirconia-Ytterbium Oxide  
Zirconia-Yttria (91-9% / 93-7%)

of Fused Materials sidebar). Custom fusion runs provide the flexibility to vary the percentage of each raw material input as needed and make the necessary adjustments throughout the fusion process.

### Scaling Up

In some cases, the concept product is made and tested but does not perform as expected. In others, the product meets or exceeds research expectations and the manufacturer can begin looking for ways to scale up the production. Having access to a variety of furnace sizes is key to the success of the scaled-up product.

It would be difficult to successfully reproduce a product by going directly from 10 lbs to 300 tons without a lot of trial and error, not to mention the use of costly raw materials. The gradual scaling up of the furnaces allows for precise control, ensuring that the same 10-lb results can be achieved with 1 ton of product. Experience in operating electric-arc furnaces and familiarity with the minerals involved are essential to achieving good results through the scale-up process.

### Laboratory Testing

An on-site, fully equipped analytical laboratory also facilitates the custom fusion process. Once a product has been made, it can go directly to the laboratory to be fully tested for chemical and physical characteristics. The laboratory should be equipped with X-ray fluorescence and X-ray diffraction equipment that can perform chemical or elemental analysis, as well as phase analysis and crystal structure analysis.

Other important laboratory tests include particle size analysis, bulk density testing, specific gravity, magnetics, friability and other types of analysis. On-site laboratory testing provides immediate results and adds flexibility to the fusion process because ingredients and furnace parameters can be adjusted on the fly to avoid costly mistakes.

### Fusing a Partnership

Small-scale custom fusion runs require a vision for a new or



X-ray fluorescence analysis.

improved product, but little else on the part of the refractories manufacturer. The collaboration between a custom fusion team and an R&D group matches up the skills required to test out a new fused product and eliminates the need for costly capital investment.

When looking for a custom fusion specialist, manufacturers should ensure that all fusions for individual customers are done solely for that customer and the data is not shared with anyone else. Custom formulations and applications should be kept in strict confidence. The specialist's aim should be to offer a valuable service to product development and R&D teams by providing the furnaces and the know-how to fuse a new product or improve an old one. 🌐

*For more information regarding customized fusion options, contact Washington Mills, 1801 Buffalo Ave., Niagara Falls, NY 14302; (716) 278-6600; e-mail [info@washingtonmills.com](mailto:info@washingtonmills.com); or visit the website at [www.washingtonmills.com](http://www.washingtonmills.com).*