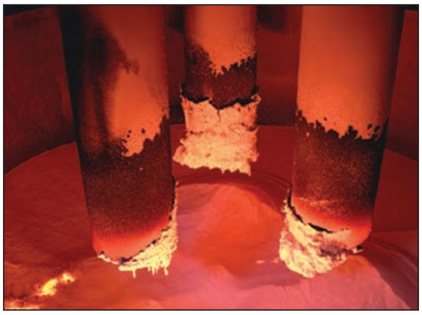
Understanding the Benefits of Electric Arc Furnace Technology

Minerals processed via electric arc furnace technology provide optimal purity, porosity and crystal size to meet the increasingly stringent needs of a range of industries.



Whether a finishing process uses sandpaper or a grinding wheel, pressure blasting or thermal spraying, abrasive and ceramic grains and powders play an integral role in the appearance and performance of thousands of products that are used every day all over the world. These minerals, which are also used to produce ceramic parts and kiln furniture, among other refractory products, undergo a meticulous production process in order to meet the increasingly stringent requirements of various end-use applications. A vital aspect of that process is the electric arc furnace, which helps ensure the minerals' optimal purity, porosity, and crystal size.

The Fusion Process

Simply put, an electric arc furnace is a vessel that uses electricity to melt minerals or other materials. The process begins when the dry minerals are weighed and mixed together, then evenly distributed throughout the furnace via feed chutes. Power is supplied to the furnace by a transformer and graphite electrodes. The electrodes are lowered into the furnace, touching the materials, and an electric arc is formed between the electrodes. The arc then melts the materials, resulting in a liquid bath.

Virtually any oxide material can be processed in an electric arc furnace.

Temperatures in an electric arc furnace can be quite high, around 1,800-2,500°C, depending on the melting point of the materials being fused. To avoid burn-through, the steel vessel is equipped with a water cooling system that chills the liquid material up against the shell and causes the formation of what is called a skull. The skull acts as a protective barrier between the molten liquid and the steel shell.

Once the optimal chemistry is achieved in the melted material, it is poured into a mold and moved to a cooling area for 24 hours. The solidified ingot then goes through various size reduction and powder processing steps to achieve the material's desired finished properties.

Virtually any oxide material can be processed in an electric arc furnace. Because the materials are melted and actually reach the liquid state, the end result is a near-perfect fusion. Let's take a look at mullite as an example. To produce mullite, alumina and silica are put in the electric arc furnace and the electrodes produce the arc, heating the two minerals and melting them together. After being poured from the furnace, the mixture cools within the mold as an aluminum silicate compound to form the mullite structure. The end product is a near 100% conversion of alumina and silica into mullite.

The Fusion Advantage

Fused minerals see multiple benefits compared to those produced through other processes, such as sintering. Before a sintering process can even begin, the materials need to be sized very carefully in order to ensure the desired reaction. The electric arc furnace does not require such precisely sized materials, therefore saving both time and energy—and the resulting costs.

A sintered material has more porosity than a fused mineral, due to the lower temperatures involved in the sintering process. Since materials in the fusion process are in their liquid state, porosity is reduced dramatically. In fact, the bulk specific gravity of a fused mineral is very close to its theoretical specific gravity, which is not the case with a sintered material.

Purity is another benefit of the electric arc furnace technology. As mentioned previously, the fusion process results in a virtual 100% conversion of the minerals. If we look back at our example of mullite, the same alumina and silica processed through sintering would not be able to achieve the electric arc furnace's 100% mullite end product. In addition, a small percentage of unreacted alumina and silica could remain following sintering, creating waste and process inefficiencies.

Minerals can also be purified during the electric arc fusion process. While the initial minerals are in their liquid state, other materials can be added in order to increase purity or change chemistry. Bauxite, for example, is high in alumina but contains naturally occurring contaminants like silica, iron oxide and titania. Bauxite is melted in an electric arc furnace in the presence of carbon, which reduces the iron oxide down to an iron metal, and, since it has a higher specific gravity than the alumina, it settles to the bottom of the furnace. Silica and some of the titania in the bauxite are also reduced, increasing the alumina content from 80-85% in the raw material and up to 95-96% in the fused product. Sintering simply can't facilitate these types of adjustments. Another potential problem in sintering is contamination from the furnace lining.

Electric arc furnace technology's other main benefit lies in crystal size, which can have a significant impact on the finished product—particularly in grinding materials. When the liquid material is poured into a mold, depending on the mold design, fairly large crystals can result. Large crystals of alumina in a grinding material would prove to be quite aggressive, since the cutting particles are larger. On the other hand, large crystals in a grinding material with a fairly coarse grit (e.g., 24 or 30 grit) would be difficult to achieve via sintering, which typically results in fairly small crystal sizes.

Minerals can also be purified during the electric arc fusion process.

Some finished compositions might require the inclusion of 4-5 different oxide minerals, which is difficult to achieve through sintering. Blending those oxides and then adding them to the electric arc furnace to melt them together results in a completely fused final material.

Other formulations might benefit from the low thermal conductivity provided by alumina "bubbles," which can serve as an ideal insulating material in some applications. These bubbles can be easily produced in an electric arc furnace by melting the alumina and pouring it through an air stream in such a way that hollow spheres are formed. This process is not possible with sintering.

After the Melt

The cooled ingot of fused material can be 4-12 tons in mass, depending on the size of the furnace and mold. From there, it has to be broken down and ground to the right size. The process begins when the ingot is dumped onto a steel floor. An electromagnet is used to pick up a steel ball and drop it repeatedly onto the ingot, breaking it into smaller pieces.

When these pieces are small enough, they are sent through a series of crushers and screens that eventually separate out coarse sizes, mid-sizes, and fine sizes. High-intensity rare earth magnets are used to remove any crushing iron that was added during the size reduction process. Materials that don't meet specifications can be sent through the process again, eliminating scrap.

Quality control and assurance from start to finish is key to ensuring that the finished materials meet customers' expectations. Raw materials are evaluated before they are sent to the electric arc furnace, as is the fused material when it is poured out of the furnace and again in the cooled state. Chemical and physical tests are performed, depending on the material(s), to determine factors such as purity, particle size and density. Visual inspections for color are performed as well.

Custom Fusions

Companies can take advantage of opportunities to explore new, custom material formulations. A test furnace is used for initial tests to determine if the material in question is a feasible prospect for fusion. If the material melts and pours well, the process can be strategically scaled up and evaluated.

During the scale-up process, the size of the furnace increases from a smaller test furnace to a larger experimental furnace that melts the same material. The feasibility at that size is evaluated, including the required power input, chemistries, etc. If those results are satisfactory, a larger run (e.g., 50-200 tons) will be performed in a production furnace. Again, all of the same tests are conducted to ensure that the finished material meets the required specifications—with no surprises.

Fusing a Winning Partnership

Fused minerals produced in an electric arc furnace offer multiple benefits, including low porosity, high purity, and larger crystal sizes, compared to sintering and other processes. Partnering with a company experienced in electric arc furnace technology can provide not only a stable supply of high-quality material for today's needs, but the opportunity to explore and produce new material formulations for expanded success in the future.

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