LANCASTER PRODUCTS

Refractory Applications

BACKGROUND

Refractories are important to high-temperature manufacturing. They are critical to industries such as glass, ceramic, and metallurgy by thermally insulating equipment, thereby protecting personnel and equipment, and saving fuel.

Alumina (neutral) and magnesite (chemically basic) represent two common ingredients used in the production of refractories. Their use depends on the chemical environment for which the refractory serves. In general, refractories are used for temperatures in excess of 2000 F, such as the melting of glass and of metal, and the curing of ceramic wares. Depending on the method of installation, refractories come in monolithic form (unshaped) that are applied on-site, such as molded forms or bricks for the lining of kilns and tanks.

IMPORTANCE OF MIXING IN REFRACTORY MANUFACTURING

Typical processing steps include the mixing of raw materials followed by bagging in the case of monolithics. Shaping, drying, and curing are additional steps for preformed articles. Regardless of either monolithic or performed, the refractory manufacturing process involves a mixing step which is critical to the quality and cost of the final product. Mixing is critical because raw materials can be vastly different in physical characteristics, such as particle size (from powdery to 1/4" granular) and bulk density (35 pcf for graphite to 100+ pcf for minerals).

Incomplete or deficient mixing can lead to premature failure, shortening the service life of the refractory. Only a decade or two ago, a typical glass tank needed relining every 8-10 years. The efforts and downtime are extensive for such an exercise. Many glass producers now go through a cold shut down every 15-20+ years, reaping substantial savings. Such advances are attributed to formulation and other improvements, including mixing, in the manufacture of refractories.

For refractory castables, the mixing cycle first goes through a dry mixing phase where all solid raw materials are homogenized. The dry mixing phase may be followed by water addition and an ensuing wet mixing phase. To facilitate mixing, it is best to go through dry mixing of powdery and granular ingredients before adding liquids.
This is because inter-particle attraction is generally lower with dry materials making it easier for them to mingle.

HIGH INTENSITY MIXING

Modern best practice suggests mixing be accomplished at the highest practical intensity to maximize production rate. High intensity means using high mixing tool speeds during both dry and wet mixing – provided wear, ventilation and other issues are acceptable.

One of the advantages of high-intensity mixing includes shorter mixing time. In general, mixing time is roughly proportional to the inverse of tool speed squared. That is, the same degree of mix quality can be achieved in ¼ of the time if tool speed is doubled. A typical batch cycle for castables should be approximately 4 minutes, including material charge and batch discharge time with minimal residue after discharge.

General statements like the above always imply variations. High intensity and fast mixing go hand in hand for mixes with Newtonian flow behaviors. For non-Newtonian mixes, particularly those water-based slurries having high solids content and exhibiting dilatant (shear thickening) characteristics, there usually is a range of intensities the mix can tolerate. In those cases, mixing tool speed(s) must be determined through experimentation to optimize the batch cycle time. Specifically, highest tool speed can be used for dry mixing and part or all of the water addition phase. Tool speed can then be adjusted lower depending on specific rheological characteristics of the mix for wet mixing.

Variable Mixing Intensity with Lancaster K-Series Mixer can input custom-designed levels of mixing intensities, varying at will through the use of VFD control. The intensity range typically covers one order of magnitude, or roughly 1-10, to as much as 1-100. This wide range of intensity is more than adequate to handle any refractory applications for very short cycle times. Compared with other types of mixers, the flexibility to vary the mixing intensity input represents one of the advantages a counter-current, rotating pan mixer has over other types of mixers which have limited latitude in intensity adjustment.