ThermoDyne

DynaGuard Ladle Liner

DynaGuard High Temperature Microporous Insulation

Application Data

Industry: Cement and Lime Producers

Description: DuraGuard Flexible Panels Used As Insulation In Rotary Kilns

Background: Producers of lime and Portland cement operate rotary kilns as part of their manufacturing process. These rotary kilns are large horizontal cylinders, slightly elevated at the charge end to permit gravity to propel their product through kiln, which rotates slowly to tumble the product inside the kiln. Operating continuously at very high temperatures, these rotary kilns are lined with dense refractory blocks to protect the steel casing (shell) of the kiln from the high heat.

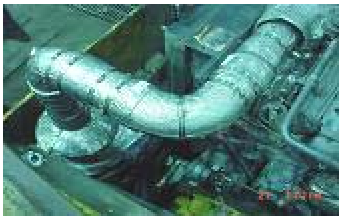
Problems: The refractory blocks that line rotary kilns must be of sufficient density to withstand the mechanical abuse inflicted by the constant tumbling of the product as it moves through the kiln. This high density refractory, while effective in resisting wear, has two negative affects. First, dense refractories exhibit **high thermal conductivity** resulting in elevated shell temperatures as the refractory is worn down over time, as well as high energy consumption, a problem that greatly affects costs as fuel prices continue to escalate. Elevated temperatures outside the kiln also have a negative effect on the mechanical drive components (called "tyres") and the safety of personnel working in the area. The second problem associated with dense refractory is its tendency to exhibit **thermal shock**. High density refractories will spall or severely crack when exposed to any drastic changes in temperature or a relatively high thermal gradient from the cold face of the block to the hot face. In cases where the refractory is exposed to severe changes in temperature, such as when a summer rainstorm quickly reduces the shell temperature, total failure of the refractory lining is possible, and would result in having to shut the kiln down for relining. Even minor spalling of the refractory hot face will result in reduced lining life. Refractory repairs and relines are expensive in terms of labor and materials required to perform the repair or reline, and also in terms of lost production time.

Insulating Between The Refractory And The Steel Shell: The solution to reducing the negative effects of high density refractories-high thermal conductivity and propensity to thermal shock-can be achieved by simply insulating between the refractory and the steel shell. While this sounds simple, there are important considerations in the selection of the proper insulation for this application. These considerations are outlined below:

- **<u>Temperature resistance of the insulation</u>:** The insulation must be able to survive at the temperatures to which it is exposed, in this case the temperatures seen behind the dense refractory blocks. This temperature in this area is different in different zones of the kiln, and in each zone the temperatures will increase as the thickness of the refractory lining is decreased over time by wear caused by constant exposure to the tumbling product inside the kiln.
- **<u>Thermal conductivity of the insulation</u>:** Simply put, the lower the thermal conductivity of the insulation, the better it will reduce heat loss and the greater the benefit of employing it. Thermal conductivity is influenced by three mechanisms; conductance, convection and radiation. The best insulation will reduce the effects of all three mechanisms at the application temperature. In addition to lowering heat loss through the refractory lining, an insulation that is low in thermal conductivity will reduce the thermal gradient (the difference in the hot face temperature minus the cold face temperature) of the refractory lining, resulting in a more uniform temperature distribution, which, in turn, reduces the refractory's propensity to thermal shock.
- **<u>Mechanical resistance of the insulation</u>:** For any insulation to survive between the dense refractory block and the steel shell it will require properties that will withstand both the weight of the refractory and the movement of the individual blocks, and rings of blocks, caused by the constant rotation of the kiln. If the insulation is too soft, it will compress to the point where it is too inefficient to provide sufficient benefit. If it cannot withstand the constant movement of the refractory blocks, a phenomenon sometimes referred to as "dancing" of the blocks, or the shifting of a complete ring of blocks, however slight, it will disintegrate into powder over time and create a gap behind the refractory that will endanger the integrity of the entire lining.

<u>Thickness of the insulation</u>: The most prevalent refractory used in rotary kilns is dense block. Any insulation placed behind the refractory will have the effect of increasing the thickness of the overall lining and, thus, result in a smaller inside diameter of the kiln. For this reason it is best to minimize the thickness of the insulation. Some operators of rotary kilns have employed an insulating brick behind the refractory block to reduce heat loss, but these brick are high in thermal conductivity and thick, compared to other insulations, and require substantially more labor to install. The best choices are insulating products that are relatively thin (1/8" to 1/2"), thermally efficient, and easily installed. In some areas of the rotary kiln castable refractories are used, which are applied wet and held in place with alloy anchors. A thicker insulation may be used behind this type of refractory because the overall lining thickness can be controlled by simply applying less of the castable refractory to accommodate the insulation thickness. Care must be taken, however, to protect the insulation from exposure to water by covering it with a flexible polyethylene sheet before the wet castable refractory is applied. The installer should also use alloy anchors that will accommodate the insulation. These anchors are readily available.

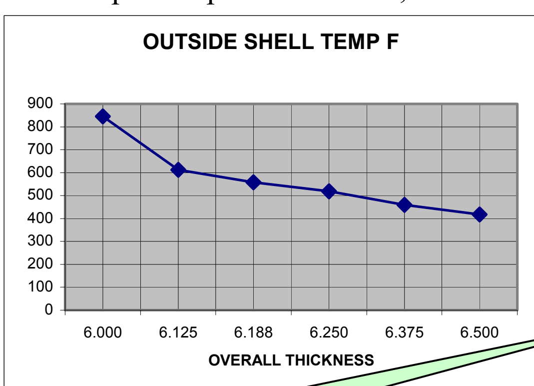
<u>Insulation Choices</u>: The criteria for selecting the optimal insulation for rotary kilns is outlined above. The following types of insulating products have been considered, and the benefits and drawbacks are discussed:

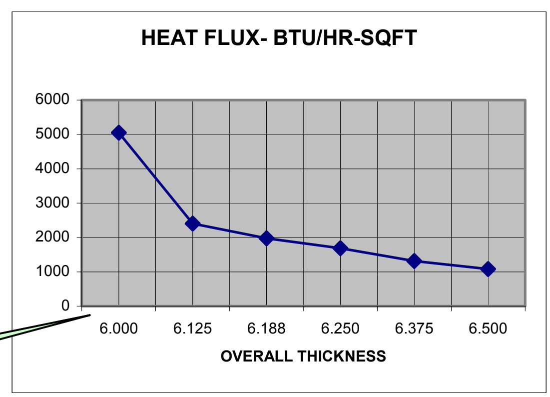


- **Insulating brick:** Requires substantial labor to install (bricks must be "keyed" in place). Thickness of 2.5" must be accommodated. Relatively high conductivity.
- **Ceramic fiber blankets:** Ceramic fiber blankets of ¼" to ½" thickness can provide lower thermal conductivity than insulating brick, and contain no organic binders that will burn out, but do not contain sufficient density to withstand the weight of the refractory lining or the mechanical wear that will occur in application.
- **Ceramic fiber papers:** Ceramic paper is thin and has low thermal conductivity, but contains organic binders that will burn out after exposure to heat, leaving the paper without the necessary mechanical strength necessary for survival.
- **Microporous insulation:** Clearly the best choice for this application. Composed of a blend of silica powders and fibers, and special opacifiers, within a microporous structure, encased in a fiberglass fabric, and stitched. These products provide superior thermal stability, high compressive strength and very low thermal conductivity, resulting in the minimization of all three modes of heat transfer.

Benefits Of Insulating Rotary Kilns With Microporous Insulation:

- Since microporous insulation minimizes the effects of all three modes of heat transfer (conduction, convection and radiation), it exhibits the lowest thermal conductivity of all high temperature insulations. This results in **reduced heat loss** through the lining and **reduced energy consumption**.
- Reducing the heat loss through the lining results in a **reduced kiln shell temperature** and **reduced heat on drive mechanisms ("tyres")**.
- Insulating behind the refractory block will **decrease the thermal gradient of the refractory**, making the refractory less prone to thermal shock and, therefore, resulting in **prolonged lining life**.
- Microporous panels are **easy to install** in 36" x 72" panels, requiring only an air-set refractory mortar or contact adhesive to secure them to the inside of the kiln.
- Microporous panels are **thin**, with standard thicknesses of 1/8" to 1/2".





With only 1/8" or more of our ladle liner material there is a dramatic drop in heat loss.

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Heat calculations based on 2300F hot face and 85F ambient with 6" of 175pcf brick @75% alumina. (Calculations based on ASTM C-680). The additional thickness from the 6" is made up of our DynaGuard Ladle Liner.