NEXT-GENERATION INSULATING PRODUCTS CUT ENERGY CONSUMPTION

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Near-record energy prices are driving many companies to consider changing over to more thermally efficient insulating and refractory materials to reduce heat loss and cut energy consumption. But they should look at all the options before upgrading.

Predicted higher worldwide demand for oil through 2020 combined with higher near-term oil prices and reduced oil output in the Middle East arc driving energy-intensive industries that use high-temperature processing equipment to review the efficiency of refractory and insulating systems in these units. Thermal-processing equipment still is often lined with dense castables or conventional firebrick, which have poor insulating qualities. Many of these heavy linings offer long life and good resistance to chemical attack, but they also function as heat sinks, absorbing thermal energy to heat the lining itself. Moreover, they have a high thermal conductivity, which leads to excessive heat loss through the lining. Therefore, there is increased interest in upgrading furnace linings in the ferrous and nonferrous metals industries to products tbat deliver better energy efficiency in thermal processing equipment such as continuous heat treating furnaces (figure 1), steel reheat furnaces (slab and roller hearth) and rotary forge furnaces. Many energy-saving options are available.

INSULATING FIREBRICK

Lightweight insulating firebrick (IFB) offers good thermal efficiency, low heat loss and structural properties that minimize the need for a supporting steel structure. Insulating firebrick has been around for a long time, but lately has been overlooked by users, many of who changed over from dense firebrick and castables directly to ceramic fiber modules.

A range of IFB grades are available for use at temperatures to 3,200°F (1760°C). Low-temperature grades, rated for use to 2,000, 2,300 and 2,500°F (1090, 1260 and 1370°C), have densities ranging from 30 to 42 Ib/ft3 (480 to 670 kglm3). Thermal conductivities ranging from 1.6 to

2.0 Btu in/ft2°F (0.23 to 0.29 W/m·K) at a temperature of 2,000°F (109 5°C) make these materials approximately three to six times more thermally efficient than similar temperature-rated dense castables and firebrick (figure 2). High-temperature grades, rated for use at 2,600, 2,800 and 3,000°F (1430,1540 and 1650°C), have densities ranging from 50 to SO Ib/ft3 (800 to 1280 kg/m3) and thermal conductivities ranging from

2.4 to 3.8 Btu in/ft2°F (0.35 to

0.55 W/m·K). They are four to eight times more thermally efficient than dense castables and firebrick in the same temperature range.

Both low-and high-temperature IFB have the durability to withstand high-velocity process gases. This makes them a good choice to line ductwork in stacks, furnaces with stirring fans and belts and for use in other applications in which resistance to gas velocity is an issue, such as combustion hot-air piping and combustion chambers.

IFB also withstand chemical attack and have an excellent resistance to alkalis, which makes them ideal for use in environments containing cleaners, lubricants, washes and metal oxides. They also have excellent hot load resistance and perform well in designs having mechanical requirements.

INSULATING CASTABLES

Lightweight castables, which can be based on many different raw material constituents, offer virtual1y the same thermal and structural properties as IFB, as shown in Table I. They offer good resistance to chemical attack, withstand gas velocity and offer structural support, yet provide several alternative means of instal1ation. For example, while IFB are bonded together with refractory mortar, insulating castables can be conventionally cast, pumped, gunned or poured into molds to form precast shapes. Lightweight castables can be used alone or in tandem with IFB to create systems that combine brick with castable shapes for door jambs, arches, crowns, spanner tiles and other areas.

CERAMIC FIBRE MODULES

Lightweight fiber modules offer even lower thermal conductivity and higher energy efficiency than IFB or castables. They are available in a variety of ceramic fiber compositions, attachment anchoring systems and construction designs for lining industrial furnaces. Lighter than IFB, module densities range from 8 to 15 Ib/ft3 (128 to 240 kg/1ll3). Thermal conductivity ranges from 2.25 to 2.75 Btu inlft2°F (0.32 to 0.4 W/m·K) at a temperature of 2,000°F (1095°FC).

Ceramic fiber modules offer greater thermal efficiency than IFB and insulating castables (see Table I) and are easier to install. However, they are not structural1y supporting and are somewhat more vulnerable to chemical attack and high gas velocity; the module surface can react with corrosive chemicals causing fiber deterioration. Ceramic fiber modules are ideal for use in thermal processing equipment such as heat treating furnaces (figure 3) and forging reheat furnaces operating in a temperature range of 1,650 to 2,350°F (900 to 1290°C). Also, many companies are replacing IFB with modules to line continuous coating lines because the lightweight, thermal1y efficient modules cut energy costs. For example, Nucor Steel recently relined a vertical continuous galvanizing line at its Berkeley, SC facility using Thermal Ceramics Pyro-Bloc ceramic fiber modules.

Traditional alumina-silica zirconia composition fiber modules can withstand operating temperatures to 2,450°F (1340°C). The addition of chromia in the benign trivalent state in Thermal Ceramics Pyro-Bloc Chrome modules raises the maximum continuous-use temperature to 2,500°F (1370°C). Densities of these materials range from 10 to 15 Ib/ft3 (160 to 240 kg/m3). The chrome containing modules have lower thermal shrinkage at higher ten peratures than other alumina~ silica based modules, making them a cost-effective alternative to very expensive mullite or high alumina fibers in many applications, including high-temperature furnaces in the ferrous and nonferrous foundry industries.

MODULAR VENEERING

Veneering, a process developed during the early 1980s energy crisis to reduce heat loss in thermal processing, is again seeing increased interest. The biggest applications include reheat furnaces, such as walking-beam and forging reheat furnaces. It is an easy, relatively inexpensive way to gain some of the benefits of a fiber lining without tearing out the existing refractory lining. Ceramic fiber veneering modules two or three inches thick are mortared directly onto the existing furnace lining (figure 4).

High-temperature modules, such as Thermal Ceramics Unifelt, can be applied to a variety of surfaces include refractory castables, monolithic plastics, high temperature [FB and ceramic fiber modules. Attached using a high temperature air-setting mortar, the modules can be sprayed with a coating compound to protect against chemical attack and shrinkage cracks. Veneering is a good choice when the existing lining is still in good shape or when users want to prevent thermal shock in units that are repeatedly cycled due to production fluctuations. Figure 5 illustrates annual cost savings possible for different veneered lining combinations and operating conditions. Given today's high fuel cost and cyclic operation of furnaces, payback for the lining upgrade usually is less than 18 months.

NON-CERAMIC FIBER BLANKETS AND MODULES

Non-ceramic fiber products are a good choice for use in nonferrous applications such as melting-and holding furnace doors and roofs; carbon bake furnace corners, heat treating and homogenizing furnace linings; and as backup furnace insulation. The materials also can be used in troughs, gaskets, ladles, and other areas, as they are non-wetting to molten aluminum.

Superwool 607 and 607 Max amorphous wool products, including blankets, modules, boards and flexible paper, are made of a patented calciasilica-magnesia chemistry. Compared with traditional high temperature insulation, Thermal Ceramics Superwool products are formulated to have low biopersistence; that is, they have a reduced capability to persist in the body. Superwool 607 blanket, the first bio-soluble fibrous insulating material on the market, contains no organic binders that cause outgassing or undergo changes from atmospheric conditions during the life cycle of the material. In addition, its low thermal conductivity (similar to that of traditional ceramic fiber insulation) reduces energy consumption. Maximum continuous-use temperatures of Superwool 607 and 607 Max are 1830 and 2200°F (1000 and 1200°C), respectively. Both materials have very low shrinkage at their temperature use limit (<2%).

"NO-SHOT" BLANKETS

High-temperature, particulate-free blankets and modules make ideal linings in furnace and ductwork equipment used for processing aluminum can stock. They provide good thermal efficiency and do not contaminate the materials being processed.

Kao-mat 2000 SL, Thermal Ceramics no-shot silica blanket specifically treated during manufacture to reduce residual shrinkage and to maintain high strength and dimensional stability in service, has a density of 11 Ib/ft3 (176 kg/m3) and is rated for use at temperatures to 2000°F (1095°C).

MICROPOROUS INSULATION

Microporous silica material, available in a variety of board and stitched panel forms, is the most thermally efficient insulation on the market today, having a thermal conductivity less than that of still air. The thin, lightweight products are a highly effective backup to IFB, castables and ceramic fiber (figure 6). Because of their low density, microporous insulation materials, such as Thermal Ceramics BTU-Block, are particularly useful in areas in which thickness or weight is an issue. Just 0.25 to 0.5 in. (6 to 13 mm) thick microporous silica material used as a cold face lining will result in a significant reduction in heat loss. For example, I-in. (25 mm) thick BTU-Block delivers the same thermal efficiency as three to four inches of standard ceramic fiber blanket or board.
Microporous silica insulation offers high compression strength, low shrinkage at high temperatures and good resistance to vibration. It can serve as a good back-up insulation in ladles for handling molten metal and in furnace areas where thickness is limited.