MAINTENANCE FOR ENERGY EFFICIENCY

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Maintenance of your furnace lining/significant energy savings. In more efficient lining materials can often be recouped within a year or two.

Despite efforts by all major industries to “go green,” energy consumption in North America remains at record high levels. Manufacturing costs, especially in energy-intensive processes requiring furnaces and kilns, have been negatively impacted by these rising fuel costs. Improving energy efficiency is key to staying competitive in today’s global economy, and now is the time for evaluating the performance of your furnaces and kilns. Key to the energy efficiency of your furnaces and kilns is the job the refractory insulation lining is doing. It is an unfortunate fact that although refractory insulation provides many heat-saving benefits, it needs to be maintained and repaired during service. Rather than haphazardly replacing materials, it is better to first conduct a thorough evaluation of the furnace lining condition.

ANALYSIS

The analysis of the existing furnace is critical to determining which steps to take in lining maintenance. In addition to observing the general integrity of the furnace lining, using engineering services like heat-flow calculations, infrared cameras and energy analysis allows for the discovery of insulation inefficiencies and inadequacies that are essential in establishing maintenance protocol. Infrared cameras provide the ability to survey the furnace lining while the unit is operating to determine the location and severity of furnace hot spots. The infrared camera captures the thermographic data needed to assess the thermal efficiency of the existing insulation lining and, thus, evaluate the integrity of the current ceramic/ refractory furnace lining. The collected data from the infrared- camera survey and the needs of the customer are then analyzed to determine if a ceramic fiber/refractory lining is in need of repair or replacement. As an example (Figs. 1-3), a survey was completed on a furnace that didn’t have significant visible signs of lining degradation. The survey indicated that degradation of the lining was resulting in high shell temperatures – average 253°F (123°C) – and, thus, high heat/energy loss. From this data, it was determined that the lining would be replaced. Heat-fl ow calculation software will estimate the thermal characteristics and behavior of proposed and existing furnace refractory systems. This software uses internationally recognized engineering standards to estimate heat loss, heat storage and casing temperature values based on several operational parameters, taking into consideration the effects of radiant, convective and conductive heat transfer. Technical service departments at refractory and insulation companies use the software to calculate and visually illustrate potential economic savings by upgrading or changing refractory systems to include more efficient furnace-lining materials.

The operational parameters needed to run heat-loss calculations are the following:

- Geometric casing condition (i.e. wall, roof, floor, vertical cylinder, horizontal cylinder, diameter, etc.)
- Ambient temperature
- Ambient air velocity
- Casing emissivity
- Furnace operating temperature
- Atmosphere (i.e. air, nitrogen, hydrogen, endothermic, exothermic, etc.)
- Furnace gas flow

Using these parameters, calculations can be run to determine proposed furnace lining materials, lining thickness, appropriate anchoring materials, estimated casing temperatures, heat losses (flux) and heat storages of a refractory system. These are of particular importance to furnace builders and end users because it provides insighton system efficiency and optimization.

When coupled with infrared thermographic scanning techniques, heat-loss calculations can be used to infer the performance and behavior of existing refractory systems and compare them with proposed systems to show their possible economic benefit. For example, a forge shop has a furnace currently lined with 9 inches (229mm) of 3000°F (1649°C) rated general- duty dense monolithic with 3 inches (76mm) of board insulation for backup. The furnace is direct fired with natural gas burners, and the thermocouple setpoint is 2350°F (1288°C). Actual infrared thermos graphic scans show average casing temperatures in excess of 320°F (160°C) while the initial heat-loss calculations estimate the furnace casing temperature should be around 260°F (127°C). This indicates there has either been some degradation in the lining's performance or the thermocouple may be reading the operating temperature incorrectly. Here, the heat-loss calculation software coupled with infrared scanning is used as a diagnostic tool to determine lining and furnace operation characteristics (Fig. 6).

Another advantage of heat-flow calculations is that multiple upgrade options can be evaluated based upon economics of the customer's needs. For example, a furnace manufacturer is proposing two refractory options to their customer. Option 1 is 9 inches (228mm) of medium duty firebrick with a heat loss of 500 BTU/ft^2/hr (1577 w/m2). Option 2 is 9 inches (228mm) of ceramic-fiber module, alumina-silica, 12 lb/ft^3 (192m/kg3) with a heat loss of 200 BTU/ft^2/hr (630 w/m2). The heat-loss values are determined using heat-loss calculation software with the same operational parameters for both options. Assuming natural gas costs approximately $8.00 per 1,000 ft^3 and an operation time of 6,000 hours per year, the potential savings in fuel costs from heat loss alone with option 2 are about $21.50 per ft^2. In most cases, the extra cost of more efficient lining materials can be recouped within a year or two.

REPAIR OR REPLACEMENT

Determining whether to repair or replace a furnace lining is ultimately up to the customer. The engineer evaluating the furnace offers their experience and the acquired data from the analysis of the existing furnace to aid in the decision to repair or replace. Based on the collected data, the engineer will recommend several options from either a hot-spot repair to a complete tear down and installation of a new furnace lining.

Hot-spot repairs can be quick or can take up to a week to complete. A fast, economical hot-spot repair made with a mastic product can often be completed while the furnace is in operation. Mastic products range in temperatures from 2000°F to 2400°F (1093-1316°C) and are available in both refractory ceramic fiber and biosoluble fiber. Small holes are drilled into the furnace outer shell in the targeted placement area and the material is pumped into place. In an example of a hot blast stove in a blast furnace, pumping of a mastic repair product lowered the cold-face temperature of the hot spot from 500-575°F (250-300°C) to 160-210°F (70-100°C).

Other hot-spot repair solutions involve shutting the furnace down until completely cooled and spraying a mastic coating on the fiber lining surface to seal it. This works especially well with fiber module systems that have opened up gaps over time.

In some cases, the maintenance needed for furnaces is more than a hot-spot repair, and a complete furnace lining replacement is required. The choices for lining replacement are vast and can be overwhelming.

By having an experienced engineer with knowledge of ceramic and refractory products, the decision to completely overhaul your furnace is made easier.

Furnace-lining replacement materials are both high-temperature fiber and hard refractory-based. High-temperature fibers are available in both refractory ceramic fiber and bio soluble insulation in various forms including blankets, modules, vacuum form boards and shapes for use up to 2600°F (1426°C).

Also available for furnace-lining materials are refractory products that include many grades and types of insulating firebrick (IFB) (Fig. 5) and refractory monolithics. These refractory materials offer excellent structural and physical properties in furnace-lining applications. They have evolved over the years from efficient standard grades into a technologically advanced high-performance products.

These IFB and refractory monolithic grades now offer enhanced properties resulting in thermal conductivity values one-third to one-half less than that of the standard product offerings.

Alternative materials that are not in the typical high-temperature insulating fiber line-up are microporous silica and refractory textile products (Fig. 4). With a thermal conductivity less than still air, microporous silica insulation materials are the most thermally efficient high-temperature insulation on the market. They are available in thin, lightweight panels and boards and serve as an excellent backup insulation to IFB, firebrick or refractory monolithics. Refractory textile products work well as a gasket or a seal, and they range in use temperature from 1000- 2500°F (538-1371°C) (Fig. 7).

CONCLUSION

Energy costs will continue to rise, and furnace maintenance in heat-intensive industries is crucial to keeping fuel expenses under control. Routine engineering audits of the furnace lining and energy analysis determine the condition of the existing equipment. Maintaining the lining in your furnace and making the recommended and necessary changes enables you and your business to reduce energy waste and improve operating efficiencies and process consistency.