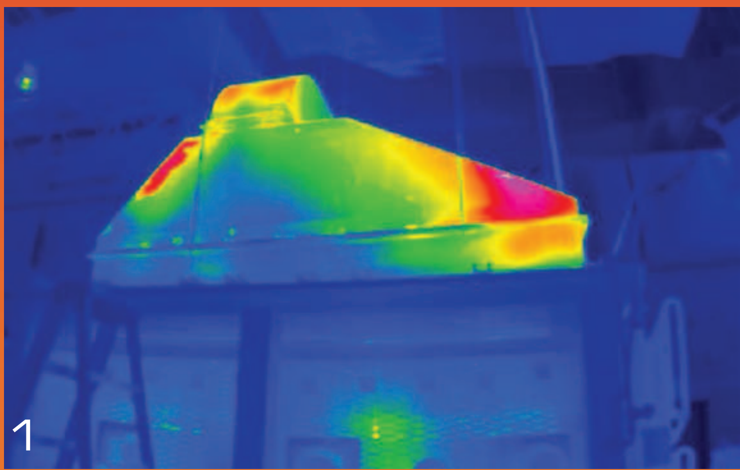
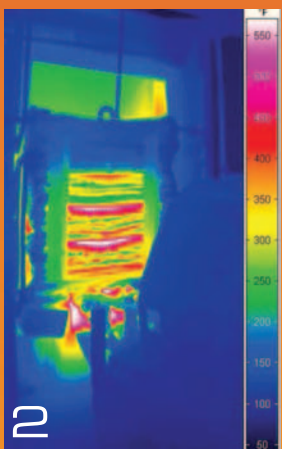
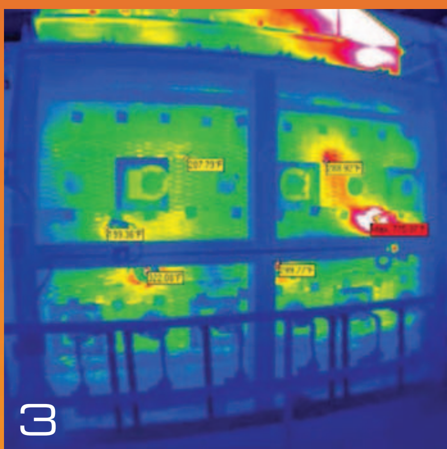
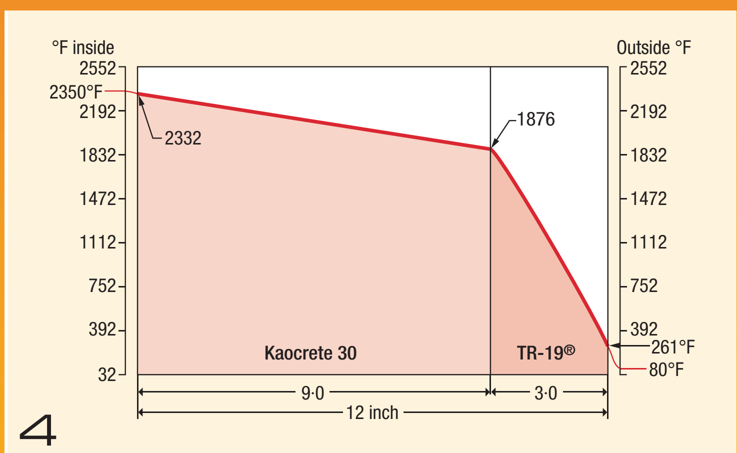
Hot stuff

Proper maintenance and repair of furnace linings and insulation can result in significant energy savings, with the cost of new materials often being recouped within 12–24 months. Thomas Rebernak and Steve Chernak explain









Despite efforts by major industries to go green, energy consumption remains stubbornly high. And, with soaring fuel prices, that translates to excessive manufacturing costs, especially for energy-intensive processes. So with energy efficiency key to staying competitive, the message is that it's time to check the performance of your furnaces and kilns.

Among the keys to achieving energy efficiency here is the job being done by the refractory lining – and, just as with most other aspects of plant, the insulation needs to be maintained and sometimes repaired during service. However, what matters is how that is done: rather than simply replacing materials, according to gut feel, plant engineers are advised first to carefully evaluate the furnace lining condition in some detail and hence determining which steps are required for maintenance. And that means applying engineering methods, such as heat-flow analysis and infrared thermography.

In situ survey

Infrared cameras enable plant engineers to survey the furnace lining while the unit is operating to determine both the location and severity of hot spots – and so gain a good understanding of the integrity of the current ceramic/refractory lining. By way of example, Figures 1 to 3 show results from a survey of a furnace that showed no visible signs of lining degradation. It indicates that hidden degradation is resulting in high shell temperatures – average 123°C – and, thus, heat/energy loss.

Meanwhile, heat-flow software is good for estimating the thermal characteristics of existing and proposed furnace refractory systems. Most software uses engineering standards to forecast heat loss, heat storage and casing temperature values, taking into consideration radiant, convective and conductive heat transfer.

Parameters needed to run heat-loss calculations include: geometric casing condition (wall, roof, floor, vertical cylinder, horizontal cylinder, diameter etc); ambient temperature; ambient air velocity; casing emissivity; furnace operating temperature; atmosphere (air, nitrogen, hydrogen etc); and furnace gas flow.

Running the software then firms up on existing conditions and best replacement furnace lining

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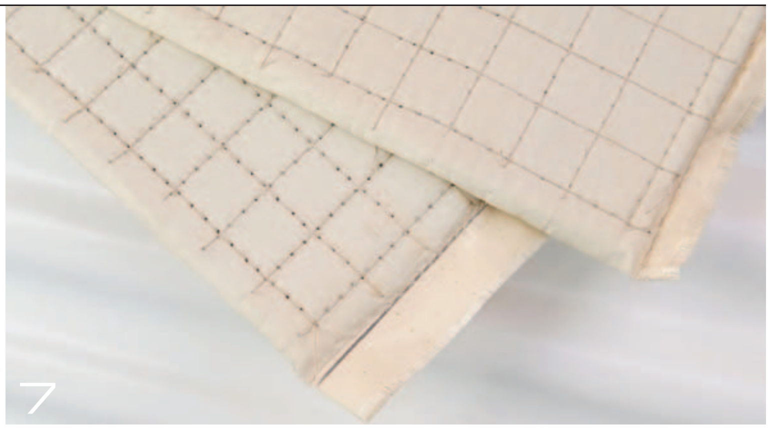

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materials, thicknesses, anchoring materials and casing temperatures, as well as heat losses (flux) and refractory heat storage – everything plant engineers need to know to make an informed decision. When coupled with infrared scanning data, heat-loss calculations can be used to infer the performance and behaviour of existing refractory systems and compare them with the proposals.

For example, Figure 4 shows data from a forge shop with a furnace lined with 9in (229mm) of 1,649°C rated general-duty dense monolithic, with 3in (76mm) of board insulation. The furnace is direct fired with natural gas burners and the thermocouple setpoint is 1,288°C. Infrared thermographic scans show average casing temperatures in excess of 160°C, while heat-loss calculations suggest it should be 127°C. This indicates either that there has been degradation in lining performance or that the thermocouple is failing.

So much for their use as a diagnostic tool; multiple upgrade options can also be evaluated using the technique. For example, a furnace manufacturer may propose two refractory options for plant furnace. Option one might be 9in (228mm) medium duty firebrick, with a heat loss of 500btu/ft^2/hr (1,577w/m^2). Option two could be 9in (228mm) of ceramic-fibre module, alumina-silica, 12lb/ft^3 (192m/kg^3), with a heat loss of 200btu/ft^2/hr (630w/m^2). Assuming natural gas costs \$8 per 1,000 ft^3 and an operation time of 6,000 hours per year, savings in fuel costs from heat loss alone with option two are likely to be about \$21.50 per ft^2.

Repair or replacement

Such illustrations help plant engineers to determine whether to effect a hot-spot repair or go for a complete tear down, followed by installation of a new furnace lining. Neither is an automatic choice and there are variations in the treatment detail. For example, hot-spot repairs can be quick or may take up to a week to complete.

Fast, economical hot-spot repair made with a mastic product can often be carried out while the furnace is still running. Mastic products range from 1,093–1,316°C and are available as both refractory ceramic fibre and biosoluble fibre types. In each case, small holes are drilled into the furnace outer shell in the target area and the material pumped into place. And it works. On one hot blast stove for a blast furnace, pumping a mastic repair product lowered the cold-face temperature of the hot spot from 250–300°C to 70–100°C.

Meanwhile, other hot-spot repairs involve shutting the furnace down, waiting until cooled and then spraying a mastic coating on the fibre lining surface to seal it. This works well with fibre module systems that have opened up gaps over time.

In some cases, however, the maintenance needed for furnaces is more than a hot-spot repair can handle and a complete furnace lining replacement is the only option. Then the choices for lining replacement are vast and expert assistance is recommended. Furnace-lining materials are both high-temperature fibre and hard refractory-based. High-temperature fibres are available in both refractory ceramic fibre and biosoluble insulation in various forms, including blankets, modules, vacuum form boards and shapes for use up to 1,426°C.

Also available are refractory products that include many grades and types of insulating firebrick (IFB) and refractory monolithics. These materials offer excellent structural and physical properties, and have evolved from standard grades into advanced, high-performance products. Indeed, IFB and refractory monolithic grades now offer enhanced properties resulting in thermal conductivity values one-third to one-half those of the standard offerings.

Incidentally, IFBs also offer a combination of insulating properties and load bearing capacity. They are particularly suited to applications above 1,000°C, because their thermal conductivity is as low as fibre based products (in some cases lower), but with structural integrity capable of handling erosive and abrasive environments.

Alternative materials not in the typical high-temperature insulating fibre line-up are microporous silica and refractory textile products. With a thermal conductivity less than still air, microporous silica insulation materials represent the most thermally efficient high-temperature insulation materials 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 gaskets or seals and can be used in temperature ranging from 538°C to 1,371°C. PE

Figure 1: infrared camera survey of furnace flue
Figure 2: furnace door
Figure 3: furnace sidewall, showing temperature
Figure 4: diagnostic tool for revealing lining performance
Figure 5: Insulating firebrick (IFB)
Figure 6: refractory blanket material
Figure 7: microporous textile material

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