TAKING THE HEAT

Stephen Chernack, Thermal Ceramics, Inc., USA, reviews several innovative solutions that can reduce heat loss and cut energy consumption in petrochemical and refinery fired heaters.

Recent spikes in fuel prices have not only affected individual consumers, but have also raised the costs of operating petrochemical plants. Although prices are now stabilising, both the European Union and the US government predict that increased consumption and geopolitical instability may cause future price increases and possible energy shortages. Against this backdrop, many petrochemical companies are making the transition to new generation insulation lining designs to lower their operating costs and prepare for the years ahead.
Companies are taking a particularly hard look at the efficiency of their fired heaters. As the 'central processing unit' in refineries and petrochemical plants, they often consume more energy than any other single piece of equipment in the plant. Fortunately, refractory manufacturers are developing lightweight, energy saving products and unique refractory designs to significantly minimise heat loss in these units.
This article will discuss areas in which new technology insulating products and engineered design solutions will outperform traditional refractory materials in fired heaters, from the bottom up.

FLOORS

Floors in fired heaters have traditionally been lined with hydraulically bonded refractory castables. These dry powdered materials, which have a limited shelf life, must be mixed with water and are typically installed on site. While castables are physically strong, their performance is heavily dependent on installer expertise as well as external factors such as ambient conditions and startup procedure.
In hot conditions, castables can set too quickly, not developing their optimum strength. In cold, they can set up slowly or freeze, resulting in less than optimum strength and service life. Once the castable floor is installed, the initial heat up must be well controlled since heating up too quickly can cause explosive spalling.
Two alternatives to castables allow users to avoid these problems. These include insulating firebrick (IFB) augmented with backup block type insulation or newer, more thermally efficient monolithic ceramic fibre log floors.
Lightweight, economical IFB has been around for more than 60 years, but they are often overlooked for use in heater floors. However, they offer excellent thermal efficiency, low heat loss and good structural strength properties.
High temperature IFB comes in grades of 1427 -1649 'C (2600 -3000 ' F) and in densities of 50 -80 pel. With a thermal conductivity range of 2.4 -3.0 Btu x in.lhr x F x ft at 1090 'C (2000 'F), they are 25 -50% more thermally efficient than comparable temperature insulating castables. The recent development of an improved thermal

conductivity IFB, the ~-26 from Thermal Ceramics, offers even greater potential fuel savings over currently available competitive 1427 "C
(2600 "F) IFB.
The range of insulating firebrick grades temperatures rated from 1090 -1371 'C (2000 -2500 OF) exhibit thermal efficiency advantages over insulating castables often used in heater floors. Thermal Ceramics' line of KTM insulating firebricks are manufactured through an advanced casting technique that builds a network of microporosity into each brick. This, and other factors, results in lower thermal conductivity, better thermal shock characteristics and improved hot load strength. Since proprietary casting and firing can result in major differences in IFB use limits and hot strengths, lower priced offerings often perform poorly long term and increase maintenance costs. When used to line floors, IFB is generally augmented with backup block insulation. However, if end users are still concerned about perceived floor strength, a thin layer (1.5 -2.5 in.) of firebrick can be placed on the hot face. The other cost effective alternative to hard refractories uses the newer monolithic ceramic fibre log floor design called Pyro-Log@ The fibre log is laid down on the cold face of the floor and generally topped with one inch of a high strength vacuum formed board. The backup monolithic ceramic fibre log is considerably lighter and easier to work with than castables, yet it withstands comparable heat up to 1427 "C (2600 OF) for almost any fired heater service. First manufactured in 1980, Thermal Ceramics Pyro-Log is made with a proprietary lubricant that adds pliability during installation, before burning out at moderate temperatures, making the logs rigid enough to stand on. This feature, unique to PyroLogs, results in easy installation and long life. They are available in a variety of temperature rated compositions and up to 240kg/m3 density (15 pet). Floor linings made of IFB and ceramic fibre materials offer better thermal efficiency and lower heat storage than those insulated with castables, allowing for a thinner lining. Since these are finished products, they are not installation sensitive. Furthermore, these lightweight floor designs can be heated up quickly, with minimal danger of thermal shock, and if a section must be replaced, the user merely cuts it out and installs the new section without any special unit startup requirements.

LOWER WALLS

The lower walls of floor fired units are generally subjected to difficult service conditions due to flame impingement. They have traditionally been lined with insulating firebrick backed up by mineral wool block. While these low temperature insulation blocks are not necessarily a bad option, mineral wool based blocks deteriorate over time due to binder loss, causing long term hot spots.
High tech microporous materials, which offer the lowest thermal conductivity of any high temperature insulating materials on the market, allow users to avoid these problems while delivering considerable insulation benefits. For instance, just one inch of microporous insulation, such as BTU-810ck™ from Thermal Ceramics, delivers the same thermal efficiency of several, inches of standard ceramic fibre blanket. Lightweight microporous insulation

products also exhibit high compressive strength, good vibration resistance and low shrinkage at temperatures up to 980 °C (1800 °F).

It can be a real problem solver, as witnessed by a major ethylene producer that recently added capacity in Canada, the USA and South America. The company required stringent heat flow criteria, which it could meet only by using microporous block.

This lining design generally consists of structurally stable vermiculite block against the casing. Microporous insulation is then installed over the vermiculite block, and there are two layers of IFB on the hot face.

UPPER WALLS

In floor fired units, the upper walls are less prone to flame impingement, and traditional linings include ceramic fibre blanket or insulating firebrick with vacuum formed fibre peepsites. However, the vacuum formed pieces are generally expensive, easy to break and subject to mechanical stress during operation. Moreover, it can be difficult to mate the vacuum formed shapes with the surrounding fibre or firebrick wall lining.

Monolithic ceramic fibre modules, with temperature grades up to 1427 °C (2600 °F) and densities up to 15 pcf, can be cut and used as peepsites. They offer equal or better thermal conductivity and avoid the problems of broken peepsites and mating different materials. With their robust construction and hidden anchoring system, they withstand mechanical abuse and deliver longer life. In addition, they compress in all directions for better fibre-to-fibre and fibre-to-casing contact.

Furthermore, by utilizing high density monolithic ceramic fibre modules (15 pcf), users can experience reduced heat flow and substantial energy savings (Table 3). For these reasons, many major engineering design houses are now using high density monolithic ceramic fibre modules in this application.

SIDE WALLS AND BURNER BLOCKS

The side walls in side fired units have traditionally been lined with IFB with refractory castable burner blocks, but petrochemical companies have begun transitioning to ceramic fibre module linings. Due to extreme service conditions, however, castable burner blocks are still often used even with fibre linings, but the thermal shock issue with castable burner blocks often negates the gain from the use of fibre modules. Moreover, it is difficult to form a light heat seal between the fibre and castable blocks to avoid long term hot spots, and castable burner blocks require supplemental support from the casing.

Although ceramic fibre modules were once considered risky in this application, high density monolithic ceramic fibre modules effectively avoid these problems and transmit much less heat than either castables or brick. End users with Callidus, John Zink and Selas burners have all successfully retrofitted flat flame burner blocks with these high density monolithic ceramic fibre modules.

Thermal Ceramics manufactures the only monolithic ceramic fibre modules made specifically for burner blocks. Known as Pyro-Bloc® burner block modules, they offer true multi directional compression. First used in 1986, they deliver better fibre-to-fibre and fibre-Io-casing contact and their high density, edge-grained construction withstands a high level of mechanical abuse.

ARCH LININGS

These areas are commonly insulated with folded 150 kg/m3 (9.3 pcf) density ceramic fibre modules that only compress on two sides. They can be installed in two general ways: a parquet design turning each adjacent module 90 or a soldier course design with ceramic fibre blanket batten strips between the rows of modules. With the parquet design, the folded module corners are difficult to seal. With the soldier course method, the batten strips can fall out with vibration if they are not properly installed.

High density monolithic modules (12 -15 pcf) such as Pyro-Bloc, which compress in all four directions, allow users to avoid these problems. These modules are simple to install, do not require batten strips, seal well around adjacent modules and reduce heat loss.

CORNER BLOCKS

The areas around the external corners of fired heaters can be particularly difficult to insulate as they are subject to high velocity and mechanical abuse. Some users rely on butt jointed modules, which can easily slump and cause hot spots. Others attempt to design one piece of fibre that fits corners by compressing several layers of 25 mm (1 in.) thick L-shaped blanket together or using folded layers and cutting them, to fit. However, these methods waste considerable material, making this very expensive. Additionally, the layers can separate, resulting in inconsistent insulation, hot spots and heat loss.

Now, however, there is one cost effective product specifically designed for this application. Pyro-Bloc corner blocks are solid pieces of monolithic fibre cut from Pyro-Log fibre and prefabricated in L-shapes to fit snugly around corners. Due to their high density and edge grained construction, they resist mechanical abuse and lose less heat than comparative systems. The prefabricated modules can also be used to effectively line columns in fired heaters and other units.

CONVECTION SECTIONS

Convection sections experience considerable velocity and difficult service conditions, particularly the corbels. These spaces are traditionally lined with castables but users are now opting for a somewhat surprising alternative.

Many companies have relied on high density monolithic fibre modules, from 12 -15 pet, to insulate convection sections although conventional wisdom once implied that ceramic fibre could not be used. In fact, Pyro-Bloc

modules have been used in convection sections of ammonia reformers for 15 years, ethylene pyrolysis units for 12 years and other applications for a decade or more with no problems to date.
Note, however, that this option is not appropriate for areas with tubes designed to be steam cleaned, as lancing can damage the lining. Clean gas fired units, on the other hand, can be lined with monolithic fibre modules.

CONCLUSION

If one is interested in upgrading the insulation design in fired heaters, it is necessary to consider all the options before proceeding. Using parameters such as heat loss, hot face temperature and energy consumption, most refractory suppliers will work with the manager to design a cost effective, state of the art insulation system that will cut heat loss, reduce energy usage and help to prepare for an energy efficient future.

Table 1. Floor heat flow chart

	Standard floor	**IFB floor**	**Pyro-Log floor**
	3 in. Kaocrete® 26	1.5 in. high duty firebrick	1.5in. high duty firebrick
	5 in. Kaolite® 2200	4.5 in. K-23 IFB	1 in. Kaowool® HS45 board
		2 in. TR-19™ block	5.5 in. Pyro-Log 15 pcf
Hot Face	1204°C (2200°F)	1204°C (2200°F)	1204°C (2200°F)
Cold Face	140°C (281°F)	106°C (224°F)	104°C (220°F)
Heat Loss	554 Btu/ft2/hr	351 Btu/ft2/hr	334 Btu/ft2/hr
Heat Storage	22160 Btu/ft2	14500 Btu/ft2	13366 Btu/ft2

Table 2. Lower walls heat flow chart

	Standard wall	**New wall**
	4.5 in. JM®-28 IFB	1.5 in. high duty firebrick

	4.5 in. K-23 IFB	4.5 in. K-23 IFB
	3 in. mineral wool block	1 in. microporous (Btu block) 2 in. TR-19™
Hot Face	1315°C (2400°F)	1315°C (2400°F)
Cold Face	90°C (195°F)	77°C (171°F)
Heat Loss	260 Btu/ft2/hr	194 Btu/ft2/hr
Heat Storage	16650 Btu/ft2	17890 Btu/ft2

Table 3. Upper walls heat flow chart		
	Standard wall	**New wall**
	7 in. folded module 9.3 pcf	7 In. Pyro-Bloc 15 pcf
	1 in. 8 Kaowool® fibre	1 in. 8 Kaowool® fibre
Hot Face	1090°C (2000°F)	1090°C (2400°F)
Cold Face	92°C (198°F)	86°C (171°F)
Heat Loss	267 Btu/ft2/hr	237 Btu/ft2/hr
Heat Storage	1995 Btu/ft2	3138 Btu/ft2