The Broadening Appeal of Silicon Carbide Ceramics

Silicon carbide components provide outstanding thermal shock resistance but, unlike traditional ceramics, they also combine low density with high mechanical strength.

Silicon carbide production on an industrial scale began around 1890 with the invention of the Acheson process. Initially the material was limited to use as an abrasive, but as time has passed the exceptional properties of silicon carbide have found new applications in most areas of modern life. IPS Ceramics began to offer silicon carbide beams in the 1980s as structural elements for setting arrangements in kilns and furnaces.

Over the years, IPS has continued to find new uses for this amazing material. The growing range of silicon carbide components offers the industrial engineer high level performance in a number of crucial areas and is a fine example of the dynamic ability of technical ceramics to offer optimal solutions in new areas of manufacture and processing. Silicon carbide components provide outstanding thermal shock resistance but, unlike traditional ceramics, they also combine low density with high mechanical strength. Additionally, these products offer extreme hardness/abrasion resistance and outstanding chemical stability in aggressive environments. Here are reviewed some of the latest products for which it turned out silicon carbide was the material of choice.

Calcination trays

Silicon carbide is often used for applications working at higher temperatures (where other materials start to deform); however, this is not always the case. One IPS customer was refining precious metals via the calcination of metal salts at about 700 °C (1290 °F). For this process, there is a requirement for large trays that do not shed any grains of refractory that would contaminate the valuable product. The customer had used fused silica trays for many years, but there were supply issues and problems with residual porosity in the trays that affected quality.

Following a design review, IPS Ceramics supplied replacement trays in silicon-infiltrated silicon carbide (SiSiC). The SiSiC surface was smooth with no open porosity, significantly reducing product contamination and extending the service life of the trays. As a bonus, the wall thickness of the trays could also be reduced from 12 mm to 6 mm (0,24 in) due to the higher strength of the SiSiC material.

Keywords
calcination trays, flame deflectors, support post, burner tubes

Flame deflectors

Many ceramic materials can withstand high temperatures, but only if the heating is gradual and uniform; rapid or uneven heating will often create internal stresses that are large enough to cause an item to crack or even shatter. IPS Ceramics was recently faced with updating a kiln car superstructure for a USA customer with a rather unusual top-hat kiln. In this kiln the burners were positioned to fire vertically up through the kiln car base, directly under the load area. Having burner flames directly playing over the new superstructure would have carried a high risk of cracking or even melting (Fig. 1).

IPS Ceramics developed a SiSiC flame deflector to sit over each burner port, deflecting the flame sideways so that the batts supporting the load were protected from flame impingement damage. This very demanding application is subjected to both high temperatures and rapid thermal cycling; however, the SiSiC material has performed very well with no failures after over six months' intensive use.

Fig. 1
SiSiC flame deflectors

Support posts

Manufacturers need to maximise the fill in any furnace or kiln if they want to minimise energy costs. A suitable kiln furniture system can allow much greater levels of kiln utilisation, but can also be restricting if product lines need to change frequently. IPS Ceramics has produced adjustable systems for many years based on toothed support posts and slide-in batts. Recrystallised silicon carbide (ReSiC) is ideal for high-duty support posts operating at high temperatures. This material has very low levels of high temperature creep, so that the posts remain straight after many, many firings. IPS has supplied posts nearly 2000 mm (79 in) long for a manufacturer of technical ceramics, for example. These toothed posts have been in service at 1600 °C (2910 °F)

Brian Wycherley
IPS Ceramics Ltd
Newcastle-under-Lyme
Staffordshire ST5 7UH
Great Britain

E-mail: b.wycherley@ipsceramics.com
www.ipsceramics.com

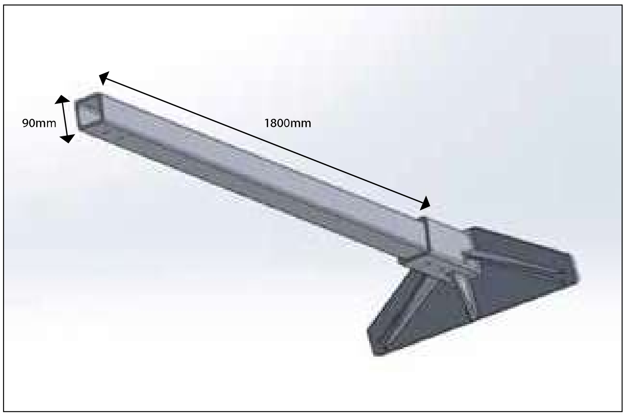

Fig. 2a
ReSiC agitator, showing body dimensions

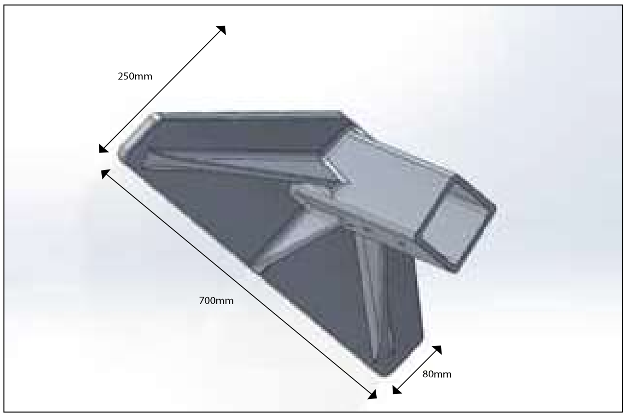

Fig. 2b
ReSiC agitator, showing head dimensions

Fig. 3
SiC burner tubes

for one year without distortion or breakage. The post design was optimised so that the spacing of the teeth matched the customer's specific product line.

Aluminium recovery

In another innovative project, IPS Ceramics is currently working with an aluminium scrap recycling company on the development of an improved agitator for aluminium holding furnaces.

Traditionally, mild steel agitators have been used but these slowly dissolve when they are immersed in the melt at 800 °C (1470 °F); complete replacement is often needed after only two weeks' use. The steel that dissolves also contaminates the melt, increasing the amount of refining that must then be carried out.

IPS Ceramics has produced a prototype agitator made from its ReSiC material. The complex head of the agitator is one of the largest ReSiC pieces the company has ever supplied. 3D-modelling was used to optimise the shape of the head to cope with the heavy handling experienced as the agitator is moved within the furnace via a boom mounted on a forklift truck. Mechanical loads are predicted to be high as the head of the agitator is dragged through the furnace to remove dross from the melt. Extensive field trials are underway to assess the new ReSiC agitator (Fig. 2a–b).

Burner tubes

In any industrial heating process, perhaps the most critical aim is to provide a carefully controlled temperature profile within the kiln or furnace. Whether the fuel is natural gas, LPG or oil, the location of the burners is a potential hotspot within the kiln. Burner flames can be long enough to make contact with the product or kiln furniture causing very severe overheating which is damaging to both. Even when the exposed flame is kept at a safe distance, direct radiant heating can cause localised overheating of product and subsequent quality problems.

Burners that use silicon carbide tubes (Fig. 3) offer several advantages:

- The tube forms a chamber within which most of the combustion takes place. Only a minimal amount of flame is directly exposed to the kiln load, almost eliminating radiant hotspots.
- The tube exit is normally tapered to increase exhaust velocities. Greater velocities enhance mixing within the kiln, improving temperature uniformity.
- Greater exhaust velocities also increase the entrainment of kiln atmosphere from around the burner, diluting the hot exhaust stream and ensuring rapid energy transfer.

IPS Ceramics can now offer most sizes of silicon carbide tube to match existing kiln burners.

Benefits include:

- Used in most kilns types – tunnel, roller and shuttle
- Suitable for both brick and fibre linings – no burner quarl is required
- Low thermal expansion and high conductivity gives exceptional resistance to thermal shock cracking
- Dimensionally stable (with no significant deformation or creep) and resistant to oxidation and corrosion – giving a long service life.

SiSiC is recommended for most kilns and furnaces working below 1350 °C (2460 °F); however, IPS Ceramics can also offer ReSiC material for applications working at higher temperatures.