
Filling the void: clay aggregate Ultralite is used primarily as a refractory infill for kiln cars used in the ceramics industry

Ceramic Gas Products Ltd

Filling the void

Insulation aggregates have a multitude of applications, notably as infill in the ceramics industry. *Paul Hipkiss* discusses the manufacture of its foamed clay aggregate, Ultralite, and why consumers are moving towards ceramic-based grades

Ultralite™ is a specialist foamed clay aggregate product that was formulated by ceramic experts in the UK and which has been manufactured in its various forms for a number of years at the Stoke-on-Trent, UK factory operated by Ceramic Gas Products (CGP), part of the Mantec Group's Technical Ceramics Division.

The lightweight refractory aggregate, which combines high quality raw materials and a bespoke manufacturing process (unique in the ceramic field), is designed to be a modern substitute for more traditional insulation materials across a number of quite distinct applications.

The special refractory formulation that is used to produce Ultralite has given it an edge over, for instance, micaceous and siliceous minerals, and it offers a suite of benefits, such as:

- Use of ceramic raw materials;
- High open porosity;
- Low mass;
- High internal void space;
- Low thermal conductivity;
- Low bulk density;
- Free-flowing easy void filling;
- No ceramic fibre or free silica;
- High energy-saving characteristic

Pore size control

Expanded clay aggregates are nothing new, of course, and have often proven to be a good alternative when decent insulation properties are called for. However, most naturally occurring expanded minerals used for insulation applications, for example perlite or vermiculite, can lead to a final product that is problematic in terms of extremely variable pore size that has a limited thermal stability at elevated temperatures.

Ultralite does involve the use of a proprietary chemical foaming agent, but crucially it is mechanically not chemically foamed and this imparts its uniform internal pore structure. This type of processing results in a much more stable and closely graded product, which in turn gives more reproducible results and excellent thermal insulation properties throughout its service life.

Ultralite is predominantly a ball clay material mixed together with a combination of other ceramic and organic materials to aid CGP's proprietary foaming process.

The exact combination of materials has been selected to optimise the generation of a highly porous open structure with a uniform wall thickness and honeycomb microstructure (*see micrograph*). All of the raw materials are finally mixed and extruded onto a drying belt.

After drying to the correct moisture content, the material is then calcined in a gas kiln to impart its fired strength to the formed ROK granules (prill) and to prevent shrinkage of the aggregate when in use. Some typical specifications for the standard product manufactured by this route can be seen in Tables 1-3.

Safety benefits

There are a whole host of cost and performance benefits associated with this refined material (*discussed later*), but important health and safety benefits can also be emphasised. Systems based on existing historical products often have some drawbacks such as temperature stability and health and safety issues which are subject to increasing scrutiny – such as the European Union's Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) programme.

Ultralite, in its various forms, is a chemically inert material and offers some advantages in a number of areas:

- No specialist safety handling equipment is required;
- Product is free-flowing and stable;
- Creates a fibre-free environment;
- Non-carcinogenic;
- No volatiles produced;
- Disposal at end of life is problem-free – standard landfill disposal is acceptable.

At the very least, these qualities mean improved employee welfare in customers' factories and assistance to those customers in maintaining ISO 9001 and ISO 14000 quality, safety and environmental standards. The fact that after use disposal is a straightforward procedure also has a cost-cutting implication to boot. This is not the case, of course, with alternative hot face and insulating materials such as refractory ceramic fibre.

Ceramics insulation

The ceramic sector is currently the largest end user market for Ultralite, comprising a fairly disparate spread of end products – tableware, bricks, sanitaryware, refractories, tiles, and electroporcelains to name just a few. Each product's manufacturing cells rely on excellent thermal insulation properties as a basic prerequisite.

Since its introduction, Ultralite's superior thermal characteristics have been proving themselves in key parts of high-volume ceramic manufacture. There was early success in this context in the UK, but demand has also come from overseas markets – which is keeping the Stoke-on-Trent facility busy.

When employed as a loose fill insulating material, there are significant energy savings and large reductions in the costs associated with ceramic factory kiln operations. This is well demonstrated by the application of Ultralite in the sanitaryware sector.

Volume ceramic sanitaryware firing units are characterised by tunnel kilns with a large fleet of kiln cars. The traditional set-up of the kiln car base has a base layer of mineral wool (rock wool type) to a depth of around 50mm, on top of which sits a layer of densely packed ceramic fibre to a thickness of around 175mm.

This configuration then requires dense castable refractory support posts, extending up from the base of the kiln car, and 12mm-thick cordierite cover tiles. These elements are heat sinks, meaning that a certain amount of the energy input is completely wasted, used purely to heat the kiln car.

The first effect of designing kiln car configurations around Ultralite ROK loose fill media is to totally eliminate dense packed ceramic fibre. Also, at the base of the kiln car, the mineral wool layer can be replaced by a super-thin low thermal conductivity board support.

All of these factors are compelling. In a traditional car – of which there may be between 50 to 80 of these travelling through the kiln and more than twice that number in the fleet – heat transfer occurs naturally through the base of the car at a constant rate. Crucially, the degree to which this occurs is dependent upon the insulation material, the hot face temperature and the base construction.

Air is a good thermal insulator, so materials that trap air – as Ultralite does very effectively – are excellent as insulation media. With an Ultralite kiln car fill, there is a high proportion of air open space within the structure, resulting in low solid density. This means that the heat transfer through the material at elevated temperatures is significantly less than that of more traditional insulating materials, such as firebrick and ceramic fibre. All of this leads to tangible energy savings.

Static Heat Flow (SHF) calculations have been carried out by an accredited test centre which show the comparisons between a traditional kiln car construction and one using Ultralite ROK loose fill material. These measurements (*see Table 4*) were conducted in a plant operated by a major ceramic sanitaryware producer.

As can be seen from the SHF calculations, the amount of heat stored in the kiln car base, combined with the heat-flow through the base, is nearly 33% less with the Ultralite construction. Experience from this particular sector also suggests that as opposed to the average two-three years' time elapsed between necessary maintenance programmes, an interval of closer to four-five years can be expected by switching to Ultralite.

The savings on energy, maintenance and replacement are of such a magnitude that even where a plant is located in a low labour cost area, there remains a very good case for making the switch. This has occurred in India for instance, with CGP having just announced an order for 80m^3 of Ultralite insulation from Anchor Sanitaryware. This is the company's first independent order in India and the shipment will be to Gujarat, the heart of India's ceramic manufacturing industry.

Anchor Sanitaryware operates two major facilities in Thangadh and the company currently produces around 4,000 pieces per day, so this is a major reference. Director Dushyant Sompura, commenting on confirmation of the initial order, said: "Innovative ideas are the key word for us here at Anchor Sanitaryware and using Ultralite certainly matches that goal. I do feel that Ultralite is answering an urgent need in our factories at a time when energy costs are so high – it is a proven energy saver."

This success has followed other major orders in China, India, Malaysia, and Sri Lanka.

Uptake in the heavy clay sector

Despite distinct differences in plant layout and the drying and firing cycles, Ultralite is equally applicable in the building ceramics sector – which involves the manufacture of clay brick, split tile, roofing tiles and pavers.

The aggregate helps to overcome several problems encountered in the kilns used in this sector. The first of these is where, in a traditionally set-up kiln car, the setting sand (or 'placing sand') gradually drops down between the cracks of the decking tiles and, having nowhere else to go, ends up gathering between the tiles and the existing traditional insulating materials causing expansion to occur.

With the constant expansion and contraction during brick firing, this eventually results in an actual increase in the physical dimensions of the kiln car. Unchecked, this can affect the car width to the extent that it is unable to fit through the kiln entrance.

The only way to prevent this is to disassemble the top of the kiln car, clear away the sand debris, replace the insulation and then reassemble. Furthermore, any ceramic fibre has to be disposed of in controlled conditions. Across an entire operation, this involves a great deal of costly maintenance and unwanted down time.

By using Ultralite, this is eliminated as the sand drops through the loose fill insulation settling at the base, where, during scheduled maintenance the aggregate can easily be removed, the sand vacuumed out and both materials are ready for reuse.

Another consequence of Ultralite's thermal superiority is a noticeable reduction in undercar temperatures – typically from as high as 150°C down to less than 80°C. One advantage is much less maintenance required on kiln car wheel bearings.

Table 1: Typical chemical analysis of Ultralite

Mineral	Content (%)
SiO_2	59
Al_2O_3	32.5
Alkalis	<3.5
CaO+MgO	0.99
Fe_2O_3	0.98

Table 2: Typical conductivity hot face*

Temperature	Conductivity
200°C	0.081 W/mK
400°C	0.103 W/mK
800°C	0.173 W/mK
1,200°C	0.318 W/mK

*75mm sample thickness

Table 3: Typical mean physical properties*

Property	Result
Grain shape	Cylindrical
Grain size	5mm-20mm (l) x 3mm (dia)
True porosity	>90%
Fill density	60-90 kg/m^3

*ROK granule formulation

Table 4: Static heat flow in traditional kiln car vs. Ultralite construction

SHF calculation	Original construction	Ultralite construction
Cool face temperature	127.7°C	100.7°C
Total heat flow (per car per firing cycle)	131.226 MJ	88.016 MJ
Total heat stored per car	219.609 MJ	148.604 MJ
Total combined heat	350.835 MJ	236.620 MJ
Energy saved (%)	-	32.56

Ultralite Castable properties

Cavity fill is one of the most popular applications of Ultralite Castable, enabling the cavity of kiln walls and other voids to be filled thus preventing heat from leaving the heat zones and creating a cooler exterior.

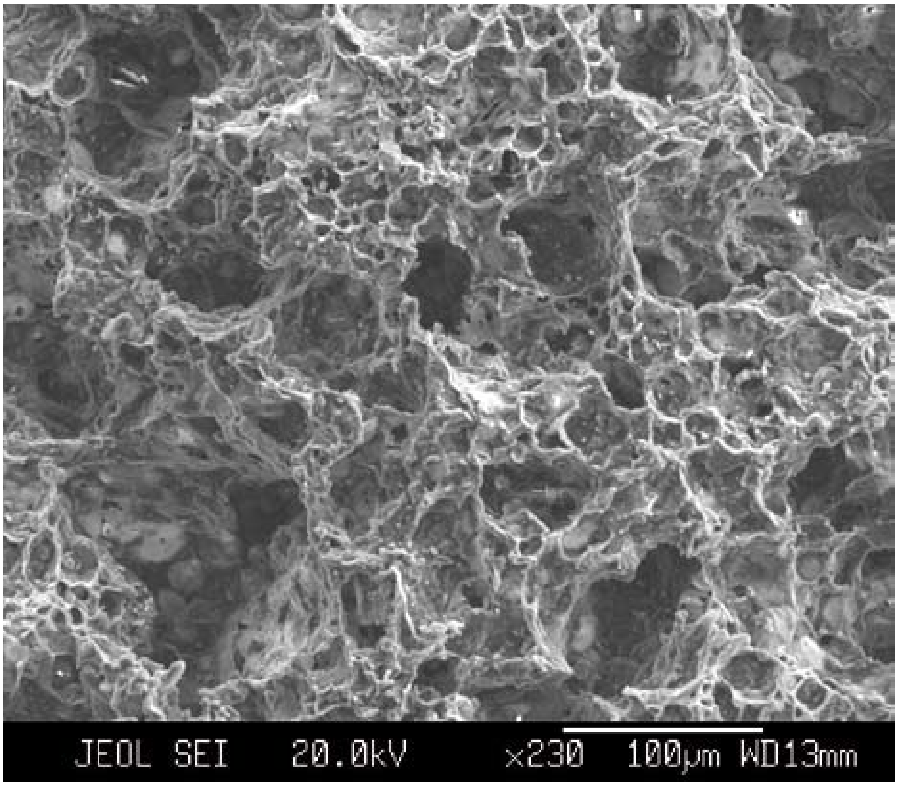
The broad details for the four Ultralite Castable grades are as follows:

Main properties of Ultralite Castable

Property	Ultralite Castable 01	Ultralite Castable 02	Ultralite Castable 03	Ultralite Castable 04
Recommended max. service temperature	1,100°C	1,200°C	1,300°C	1,300°C
Powder loose bulk density	420-460kg/m³	420-460kg/m³	510-560kg/m³	550-600kg/m³
Bulk density	510-560kg/m³	510-560kg/m³	510-560kg/m³	510-560kg/m³
Modulus of rupture	0.73 MPa	1.36 MPa		1.32MPa
Cold crushing strength	1.5 MPa	2.91 MPa	4.1 MPa	3.7 MPa

Ultralite Castable thermal conductivity (W/mK)

Mean temperature	01	02	03	04
150°C	0.28	0.22	0.24	0.20
320°C	0.22	0.22	0.24	0.22
500°C	0.23	0.25	0.25	0.21
690°C	0.24	0.20	0.22	0.24



As the micrograph indicates, Ultralite has a highly porous open structure with a uniform wall thickness

To cite an example, Ultralite's main brick industry customer has found that in practice, since switching over to the new material, reduced undercar temperature means the replacement cycle of bearings has been extended from 12 months to three years. As can be seen, once again, less work needed and more money saved.

Heat flow calculations have been carried out on this particular plant and comparisons drawn between the original kiln car construction and the new one featuring Ultralite loose fill material. The results have clearly demonstrated that the heat stored in the kiln car base and the heat-flow through that base is 26% less than previously – a massive energy saving.

Broadening customer base

CGP also offers Ultralite for completely different applications, where the material's properties can be used for other benefits. The grade used in the ceramic industry is a product delivered as a large granule in 1m³ IBCs or 20-litre sacks. However, the prill can be milled and Ultralite supplied in a finely graded format for a wide range of uses, including:

- Fire retardant products – eg. as an infill material between the panels in fire doors;
- Plastics – where it is incorporated into flat products such as signage and panelling;
- Brake linings – these use a higher calcined version which is then very finely ground and incorporated into the lining body to form a composite;
- Shower trays – where the material is used primarily to impart increased strength, as a composite addition.

These few examples show the great potential for future expansion; certainly for many end products the cost of incorporating an element of Ultralite into the mix are relatively low in the context of the overall materials expenditure.

Castables

The company has also successfully taken the thermal insulating material and blended it with high-grade refractory powders to formulate Ultralite Castable. This is available in four specific grades to allow a variety of applications to be accommodated, from the creation of cast shapes that are lightweight with exceptional heat insulating properties through to a cement for refractory linings.

A wide variety of bricks, slabs and other shapes can be formed from the castable material, extending the thermal benefits of Ultralite to applications where some solidity is required without adding unnecessary weight.

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