Kaolin's green dream

Atil Parikh of 20 Microns discusses the company's calcined kaolin operations and new target markets for environmental products

India's largest producer of micronised minerals, 20 Microns Ltd, began its kaolin operations in 1994 in Bhuj; located in the western region of India. In addition to kaolin, 20 Microns produces a number of other industrial minerals including: barytes, calcium carbonate (dry and wet), mica, nepheline syenite, silica and talc. The company also manufactures speciality chemicals, inorganic thickeners, opacifiers and matting agents.

Kaolin's main end markets include ceramics, paints and coatings, paper, polymers, catalysts and pharmaceuticals, where it is used primarily in three forms: hydrous kaolin (refined and classified according to particle size and purity), calcined kaolin (heat treated to change its optical and physical properties, such as brightness and opacity), and metakaolin (heat treated for use in construction and cable industries).

The applicability and commercial value of kaolin is primarily based on the mineral's whiteness and its fine particle size, which is capable of being optimised during processing. Particle size affects fluidity, strength, plasticity, colour, abrasiveness and ease of dispersion. Other important properties include its particle shape, which increases opacity or hiding power, its soft and non-abrasive texture (owing to the absence of coarser impurities), and its chemical inertness.

Mining

20 Microns started its kaolin operations by acquiring mine leases from the Indian government. At present the company operates a number of pits in its kaolin deposits in the Bhuj area. These deposits are initially evaluated by the mining engineer, who designs the mining plan for each pit. The kaolin ore also contains a significant amount of silica, which has to be separated during processing. 20 Microns examines the sizing of the deposit, variations and the colour of the kaolin, and the amount of overburden to be removed from the mining operations.

Mining takes place using open pit methods. The Bhuj kaolin is a comparatively softer mineral and hence is easily mined with the use of scrapers, drills and excavators. Kaolin lumps are later sorted at the mines and the higher quality material is then transported via trucks to the nearby plant for processing.

Kaolin processing

In order to produce a calcined kaolin grade, hydrous kaolin is first processed as it is the basic feed material and its quality must be maintained for the final calcined product. Kaolin operations are essentially a mix of wet and dry processes.

Initially, the sorted product from the mines is brought to the nearest plant and mixed with water and chemicals in the blunger. This forms a kaolin slurry which is screened for impurities and then taken through the levigation process – whereby insoluble heavy impurities are settled – in order to separate silica from the kaolin. The silica is transported to the plant and the kaolin goes for further processing through a magnetic separator.

The high strength cryogenic magnetic separator installed at 20 Microns operates at -269°C and removes all magnetic and paramagnetic particles from the kaolin slurry to improve brightness. This clean slurry is then taken into a filter press where the moisture content is reduced and later passed through a drier to remove further moisture. The cake is then pulverised into a fine powder form, which can be sold into the market as hydrous kaolin.

In the next stage, pulverised hydrous kaolin is fed into high end calciners through conveyors belts, where the material is heated though a gasification system – developed in-house by 20 Microns – to temperatures between 700-1,200°C depending on customer specifications. Once calcined, the kaolin is pulverised and classified.

20 Microns uses a unique gasification system which produces clean gas for higher efficiency of the calciners; also contributing to a greener environment and saving costs.

The fine milled product is then stored in a hopper before it is transferred to the bagging plant. All of 20 Microns' kaolin grades are packaged in powder form and available in three sizes; 25kg, 50kg and 1 tonne bags. Dust extraction systems operated during packaging prevent potential contamination of the product.

Following production at Bhuj, kaolin operations were established in Tirunelveli. These facilities manufacture a range of calcined products and cater primarily for customers in southern India and south Asia, with a similar set-up to the operations described at Bhuj.

Products & markets

20 Microns manufactures a wide range of hydrous, calcined and metakaolin grades. These are sold into various industries such as paints and coatings, paper, cable, and ceramics. The company produces multiple grades of hydrous kaolins with ISO brightness ranging from 75-85 and an average particle size ranging from 0.3 to 2 microns.

Also produced are high brightness calcined kaolin products ranging from 85-94 ISO brightness and an average particle size ranging from 0.5 to 1.5 microns, scattered across various products.

The Indian company supplies its calcined kaolin products to the paints industry, where its properties provide increased opacity, whiteness and scrub resistance. In addition, calcined kaolin is able to provide partial replacement of titanium dioxide (TiO_2) pigment – traditionally an expensive mineral – by up to 10% in water-based systems.

Calcined kaolin is widely supplied to the ceramics industry, mainly to confer whiteness to the ceramic body.

In the global paper industry calcined kaolin is used as a filler (to reduce cost and improve optical characteristics) and as a coating to enhance paper's surface properties, such as brightness, smoothness, and ink receptivity.

In PVC cables, calcined kaolin can be used as a filler to improve electrical properties. 20 Microns feels there is a huge potential in the kaolin market in the coming years for calcined and hydrous grades, and hence is developing expansion plans in 2010 to cater to domestic and international demand.

Apart from Australia, China, India, and the USA, the company believes there are no other major producers of calcined kaolin globally. Further, plant closures and industry consolidation over the past decade have contributed to an increased demand compared to the current global supply. 20 Microns sees this as an opportunity in the coming years and is planning its strategy accordingly.

Part of this strategy is exports, with 20 Microns supplying 47 countries at present.

The company's largest exported product is calcined kaolin, which it supplies to countries including: Brazil, France, Germany, Italy, Mexico, the Middle East, Nigeria, south and south-east Asia, UK, USA and Venezuela.

Metakaolin

A growing environmental use for kaolin is its incorporation into cement; one of the methods for reducing the carbon content of building and construction products. 20 Microns has added to its product range a high reactivity metakaolin (HRM), which is marketed as an engineered, high strength pozzolanic additive – aimed at increasing compressive strength and reducing the permeability of concrete and cement products.

Metakaolin is a chemical phase that forms upon thermal treatment of kaolinite, The chemical composition of kaolinite is $Al_2Si_2O_5(OH)_4$ and as a result of thermal treatment in the range of 800-1000°C the water is driven away to form an amorphous aluminosilicate called metakaolin.

The temperature range depends on the characteristics of the kaolin – eg. its degree of crystallinity and particle size. In order to produce a pozzolan – a supplementary cementing additive – nearly complete dehydroxilization must be achieved without overheating (ie. thoroughly roasted but not burnt). This produces an amorphous, highly pozzolanic state, whereas overheating can cause sintering to form a dead burned, non-reactive state.

Metakaolin is an economical alternative to micro silica for concrete and other systems containing hydraulic cement. It improves the properties of concrete and cement products considerably by increasing their compressive and flexural strength while resisting chemical attack, reducing permeability, efflorescence and shrinkage, preventing alkali-silica reactions and corrosion.

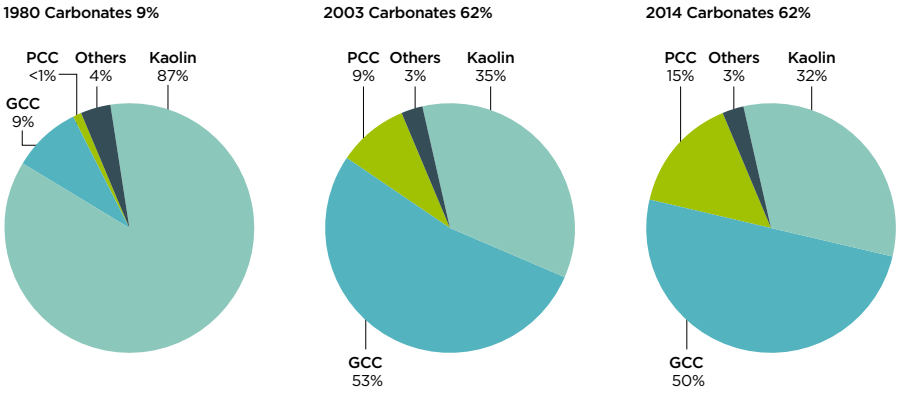
In addition to improving the engineering properties of traditional Portland cement with a partial substitution of around 20%, metakaolin also addresses environmental concerns regarding the construction industry by reducing greenhouse gas emissions.

According to 20 Microns' test work, metakaolin emits significantly less CO_2 than Portland cement – which requires enough fuel to stimulate an endothermic chemical reaction. Compare this with metakaolin, which only requires enough heat for it to be fused into an amorphous state.

20 Microns believes that using HRM as part of a concrete mix significantly aids permeability and durability:

- metakaolin chemically combines with water and calcium hydroxide through pozzolanic activity, producing additional cementitious compounds that result in a denser, higher strength concrete
- calcium hydroxide in the paste be soluble and migrate to the surface, resulting in increased porosity and permeability of the paste – yet the rapid pozzolanic reaction of HRM stabilises the calcium hydroxide as a cementitious product: this reduces porosity and permeability
- this subsequent permeability is effective against the penetration of ionic species – such as chloride ions – which negatively affect steel reinforcement in concrete
- concrete density is also increased by the small, finely divided particles of HRM which act as micro aggregates
- alkali-silica reactivity (ASR) in concrete can induce expansion and cracking; increasing the permeability of the concrete. The expansion caused by ASR can be mitigated if a fraction of the Portland cement is partially replaced with a suitable metakaolin addition of metakaolin enhances the performance of traditional Portland cement.

Decreasing use of kaolin in paper coating



Source: Ian Wilson (2008)

Table 1: World kaolin production, 2008-2009

Country	2008 ('000s tpa)	2009 ('000s tpa)
Brazil*	2,500	2,130
Czech Republic	3,830	3,400
Germany	3,610	3,250
Greece	60	50
Italy	580	500
Korea	955	900
Mexico	85	75
Spain	450	420
Turkey	620	400
Ukraine	2,400	2,000
UK	1,800	1,550
Uzbekistan	5,500	4,600
Other countries	7,230	6,150
TOTAL	**35,900**	**30,600**

*beneficiated

Source: US Geological Survey, Clays (2010)

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