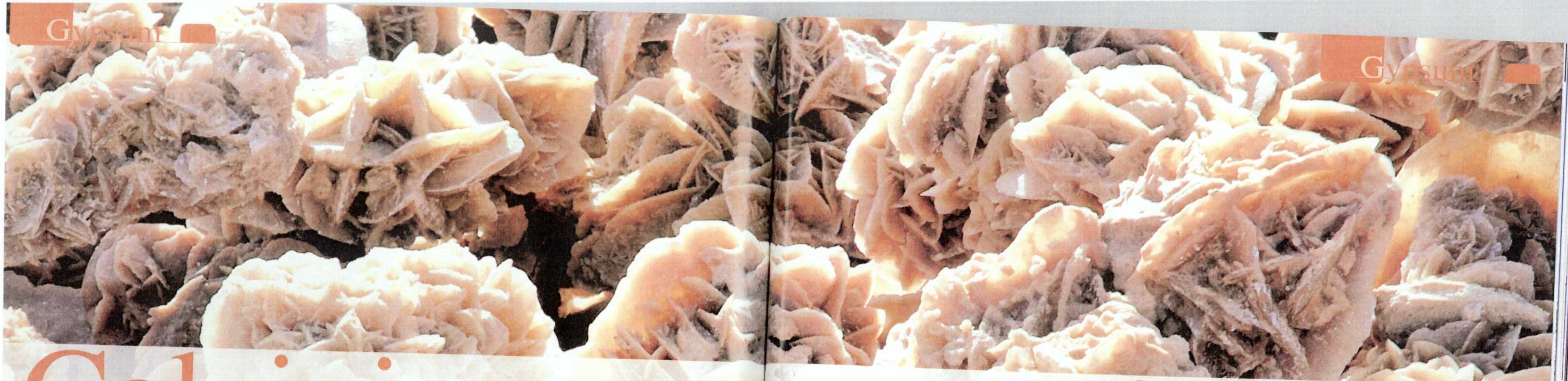

Calcining Technologies for Gypsum

Alfred Brosig, Grenzebach BSH GmbH, Germany, explores the use of different types of raw gypsum and the developments in calcining technology in the production of stucco.

Introduction

With almost 80 years experience in the worldwide gypsum industry (Figure 1), Grenzebach has developed processes for the conversion of natural gypsum, FGD gypsum and phosphogypsum into Beta-Hemihydrate and Alpha-Hemihydrate. The company is in a position to identify the most suitable calcining process to use by considering the properties of the finished product, the operating conditions during manufacture and the raw gypsum available.

This article covers the developments of calcining technologies for the different raw gypsum sources for manufacturing stucco (Beta-Hemihydrate). Stucco is the main intermediate material for the widest variety of gypsum products. Developments from the last six decades are included.

Calcining plants

The majority of all rotary kilns for calcining natural gypsum were installed in Europe and the Middle East. In Europe, the peak years of investment were in the 1970s, whereas most plants in the Middle East were installed in the 1980s. Gypsum kettles supplied to the European gypsum industries in the period of 1960 to the early 1980s were for calcining natural gypsum. At the end of the 1980s, kettles were also used for calcining FGD gypsum.

Since the development of the rotary tubular calciner in the early 1970s, there has been a regular and frequent supply to the gypsum industry for calcining natural, phospho- and FGD gypsums. Due to the higher free-moisture of synthetic gypsum, such as phosphogypsum and FGD gypsum, flash dryers were installed to dry this gypsum before it is calcined in rotary tubular calciners or kettles.

The development of special flash calciners, and later hammer mills, made the direct calcining of moist synthetic gypsum possible and is now standard technology for the gypsum industry.

Grenzebach has supplied flash calcining systems for natural gypsum, utilising roller mills with simultaneous grinding and calcining, from the mid-1980s.

Stucco coolers developed by the company in the 1970s received their widest acceptance in the gypsum industry from the mid-1990s. The production of gypsum plasterboard at high capacities requires very stable and homogenous stucco. 50 units have been supplied to the gypsum industry since the mid-1990s.

Gypsum raw materials

With regard to the use of different raw gypsums, the last three decades varied greatly (Figure 2). The 1970s was the peak period for installing phosphogypsum calcining plants in Europe, whereas to Asia, most equipment was supplied in the 1990s. The environmental legislation on desulfurising coal fired power plants initiated in Germany and other European countries, led to a demand for calcining FGD gypsum. A large number of plants have been supplied since the mid-1980s.

Natural gypsum

Natural gypsum is a naturally occurring mineral that is mined in quarries and underground mines (Figure 3). It is usually supplied as precrushed rock to the calcining plant. Before being calcined, a downsizing of the natural gypsum by means of secondary crushing or grinding is inevitable in most cases. The maximum size of feed material utilised in a kettle or rotary tubular calciner is less than 2 mm. A size of 25 - 50 mm is preferred for a rotary kiln or a roller mill.

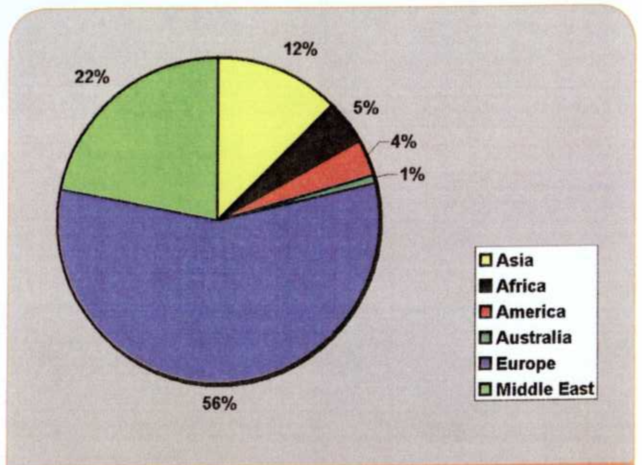

Figure 1. Gypsum plants worldwide.

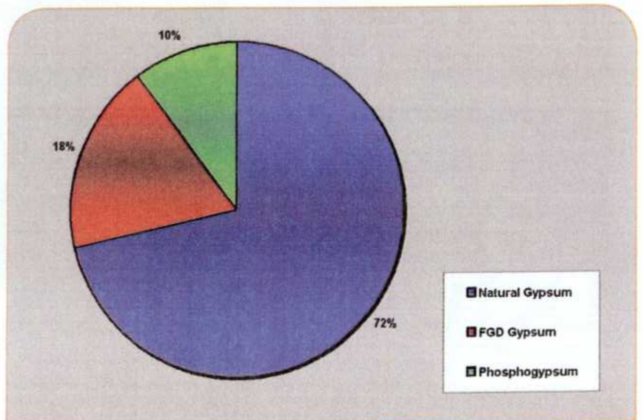

Figure 2. Gypsum raw materials.

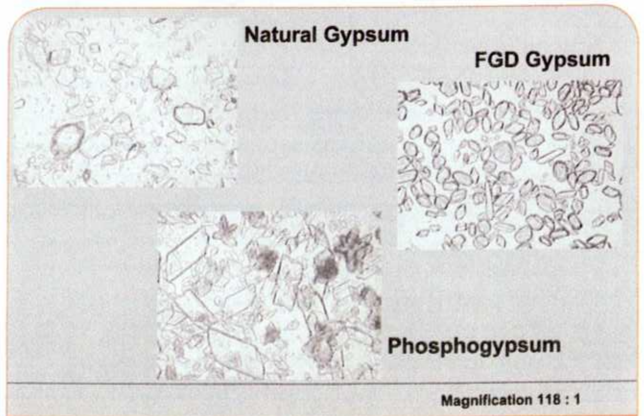

Figure 3. Gypsum crystals.

FGD gypsum

Flue Gas Desulphogypsum (FGD gypsum) is chemical gypsum occurring in most flue gas desulfurisation processes. Limestone or lime is used for the neutralisation of SO_2 gas. FGD gypsum does not require preconditioning before being calcined as its properties satisfy the requirements of the gypsum industry. FGD plants linked to power stations are designed to meet the raw material requirements and contractual obligations of the gypsum industry.

FGD gypsum is obtained in a fine crystalline form as a filter cake with free moisture of up to 10%. Grenzebach developed calcining systems that allow the direct application of FGD gypsum and recommends an indirect heated rotary tubular calciner or a special designed hammer mill.

Phosphogypsum

Phosphogypsum, as a by-product in the production of phosphoric acid for fertilisers, is obtained in a fine crystalline form as a filter cake. The decisive factors for applying phosphogypsum are an economical, legislative and/or marketing issue. In areas where natural gypsum or FGD gypsum is not available and the cost of imported gypsum is high, the cost for purification of phosphogypsum becomes feasible.

Soluble or even co-crystalline impurities in the phosphogypsum are normally separated before calcining. The same calcining equipment used for FGD gypsum can be used for calcining purified phosphogypsum.

The biggest limiting factor in the use of phosphogypsum is radium. This is present as small crystals of radium sulfate, a radioactive element in some phosphogypsum. The first decay daughter of radium-226 is the noble gas radon-222. During the decay of radium-226 ionising radiation occurs, resulting in an increased dose rate inside of buildings. Therefore, the utilisation of phosphogypsum is banned in many areas of the world. Phosphates, as from Phalaborwa (South Africa), Kola (Russia), Silinjärvi (Finland) and some locations in China have a low radiation and can be used without any restriction.

Calcining plants and equipment

Rotary kiln

A smaller gauging quantity is required with stucco produced in a rotary kiln to obtain the same consistency when compared with indirect calcining systems, such as gypsum kettles or rotary tubular calciners (Figure 4). The stucco paste can thus result in a lower density, so less plaster is used in the manufacture of prefabricated building elements. The initial and final set is faster and the gypsum phases are not as stable as with indirect heated calciners.

The feed material should be lumpy at a size of 25 - 50 mm. Special durable inserts distribute the

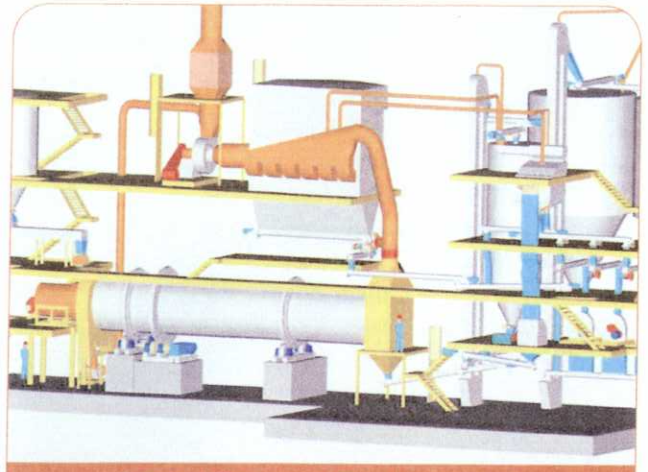

Figure 4. Calcining plant with rotary kiln.

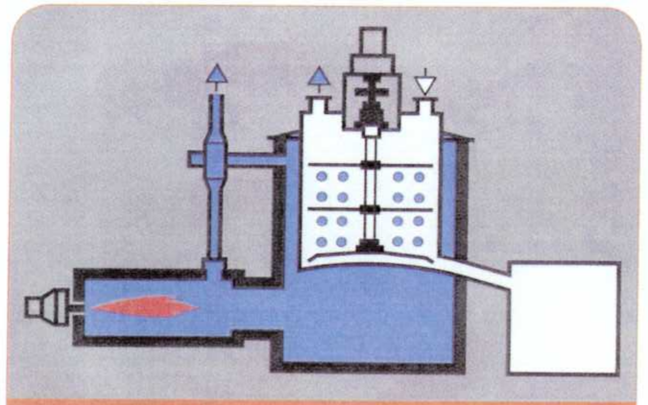

Figure 5. Gypsum kettle.

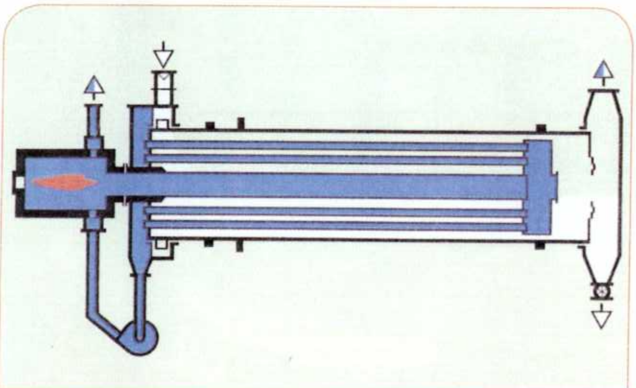

Figure 6. Indirect heated rotary tubular calciner.

Figure 7. Rotary tubular calciner, steam heated.

gypsum lumps uniformly over the cross-section of the kiln and, with every rotation of the kiln, the lumps are rearranged. The gypsum lumps travel through the rotary kiln co-current in direct contact with hot gases produced in a hot gas generator. The gas velocity sorts the lumps pneumatically into particle sizes.

Initially the gypsum lumps release their crystal water on the surface zones so that the bonding force is lost. Abraded material is conveyed to the outlet at an accelerated speed in the form of a pulverous material entrained in the hot gas stream.

Gypsum kettle

Stucco produced in a gypsum kettle (Figure 5) has good working properties with a low proportion of anhydrite III. Since a greater quantity of stucco can be mixed with water to provide the same consistency, high strength is obtained in prefabricated building elements.

For the most economical operation of high-performance gypsum kettles it is recommended that the feed material is pre-dried and ground to the required final fineness.

Calcination occurs in an indirect heat exchange between the material and the flue gas. This stucco is uniformly calcined under conditions of careful heat treatment. A specially designed agitator provides homogenous mixture of the material.

Rotary tubular calciner

The properties of the stucco produced in an indirect heated rotary tubular calciner (Figure 6) are equivalent to those produced in a gypsum kettle. The continuous revolution of the rotary calciner produces even more homogenous stucco than that produced in a gypsum kettle.

In order to reduce the investment cost by reducing the heat exchange surface, it is again recommended that the feed material is pre-dried and ground to the required fineness.

A rotary tubular calciner has a very high thermal efficiency. Hot gases are first conveyed in parallel flow through the central inner tube and second in counter flow, passing multiple flue gas tubes arranged over the entire cross-section of the calciner. The large number of flue-gas tubes makes it possible to accommodate a large heat transfer surface in the smallest possible space, providing the maximum utilisation of the hot gas.

At some locations, steam is available at low cost, such as in the vicinity of power stations (Figure 7). The very high heat content of steam benefits in the application of rotary tubular calciners by reducing the heat exchange surface.

Roller mill

Flash calcining by roller mills is primarily applied in the manufacture of stucco with shorter setting times for the fabrication of gypsum building elements such as plasterboards, gypsum fibreboards, gypsum blocks and ceiling tiles (Figure 8). The shorter setting time permits these plants to have a higher production

capacity.

In the event of the presence of abrasive impurities in natural gypsum, such as quartz and dolomite, an impact or hammer mill would not be proposed. The maintenance cost or frequent replacement of the grinding elements limits the application of impact mills in that case. A roller mill is more reliable with regard to wear and tear and results in longer lifetime of the grinding elements.

Roller mills are not recommended for synthetic gypsum, such as FGD gypsum or phosphogypsum. Synthetic gypsum tends to bridge, block and scale-up in the equipment. However, a roller mill can accept up to 45% of FGD gypsum or 20% of recycled plasterboard as a mixture with natural gypsum.

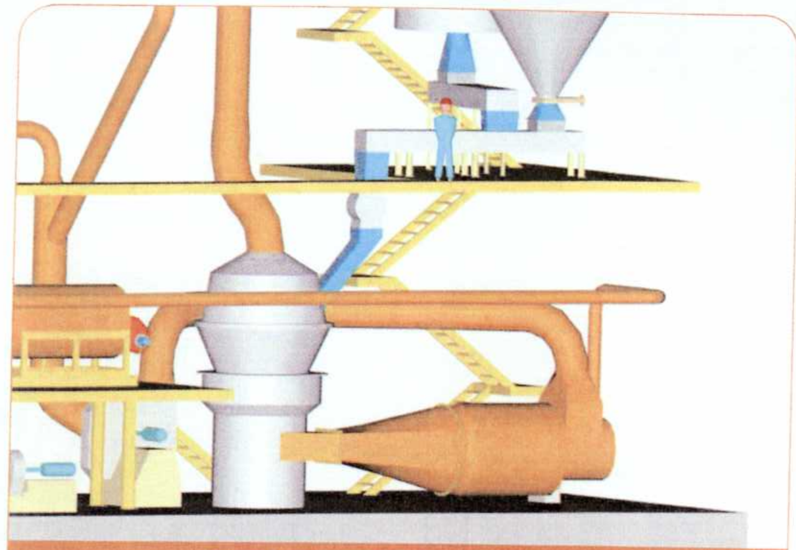

Figure 8. Calcining plant with roller mill.

Hammer mill

Originally designed for the processing of chemical gypsums with high free-moistures such as phosphogypsum, hammer mill calciners have found increasing acceptance for the calcining of FGD gypsum (Figure 9). This hot gas air-swept flash calcining process is carried out without pre-drying the FGD gypsum in a separate drying loop.

The moist FGD gypsum is disagglomerated by the action of the mill rotor, and in contact with hot gas, it is dried immediately, then calcined and ground. The solid stucco particles are separated from the gas in a dust collector. Exhaust gas from the calcination loop is recirculated to the hot gas generator for temperature and flow adjustment of the hot gas.

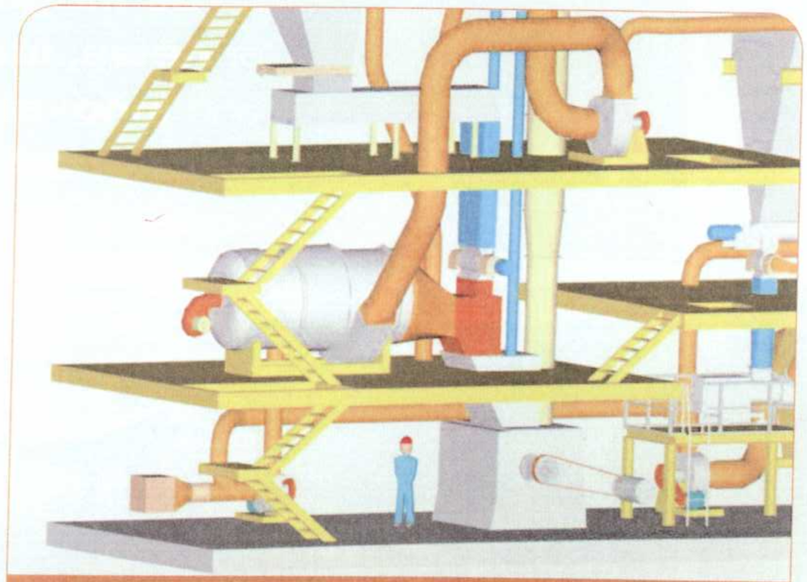

Figure 9. Calcining plant with hammer mill.

Rotary tubular stucco cooler

The plasterboard industry requires stucco with low variation in properties. A rotary tubular stucco cooler (Figure 10) can provide a very stable stucco by stopping the uncontrolled calcination of hot material as it is conveyed to or in silos. A high vapour content environment is controlled in the rotary tubular stucco cooler by the introduction of process gases from the calcining process. It has been demonstrated in many plants that this vapour provides a re-conversion of Anhydrite III to Beta-Hemihydrate. This results in the stucco having a lower and consistent water demand.

Utilisation of clean hot air as combustion air for the hot gas generator of the linked calcining system provides exceptionally favourable thermal efficiency of the overall calcining system.

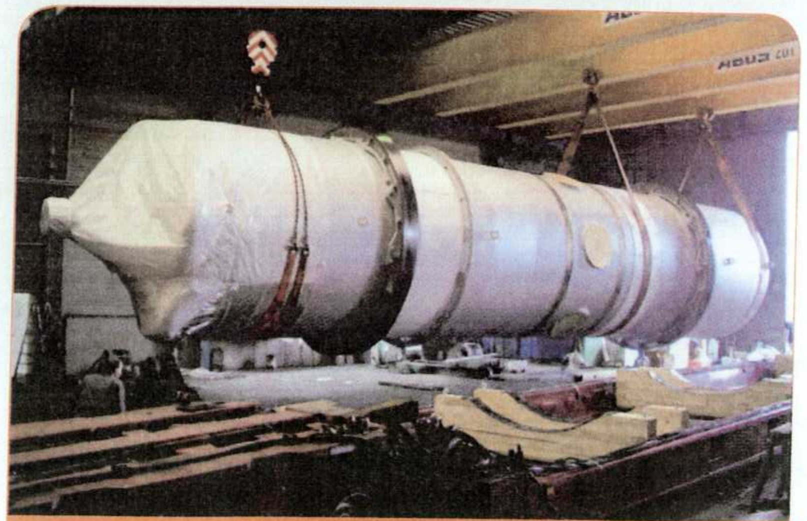

Figure 10. The world's largest rotary stucco cooler.