Sonderdruck aus cfi ceramic forum international Berichte der Deutschen Keramischen Gesellschaft 3/2002

Dry Fine-Milling and Classification of Ceramics with Practical Examples of Applications

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Résumé of the lecture presented at the DKG-Annual Meeting 2001

Dry Fine-Milling and Classification of Ceramics with Practical Examples of Applications

In the ceramic industry the mechanical treatment of raw materials, processed or finished powders is an important part of many production processes. At the same time the grinding- and classifying processes are also of primordial importance, in order to ensure a range of particle sizes which is usually exactly defined for the particular process.
The grinding principle of jet milling has proved itself to be particularly effective for the grinding of ceramic and abrasive materials. They can be ground to high finenesses, with an exact upper particle size limit, in one working step.

The Basic Factors Concerning Jet-Milling

Fluidized bed jet mills work according to the principle of the expansion of compressed gases and are therefore particularly well-suited for the fine-milling of medium-hard to hard products, due to their relatively low wear. Specific product characteristics which are often additionally required, such as intensity of colour or contamination-freeness are also easier to obtain in practise with this milling principle.
The product to be milled is fed into the machine by means of a double-flap valve via an inlet pipe (1),(Fig.1). Air jet nozzles (3), which blow compressed gas horizontally into the center of the milling chamber (2), are located around the circumference near to the bottom of the mill.
A classifier wheel (4), which separates the fine particles ascending with the air-stream, is integrated in the head of the mill. The resulting fineness can be adjusted by changing the speed of the classifier wheel by means of a frequency converter installed at the driving motor (5). An expansion chamber (6) for reducing the flow speed and thus the wear and for guaranteeing a vortex-free exit out of the mill, is located at the product outlet after the classifier wheel .

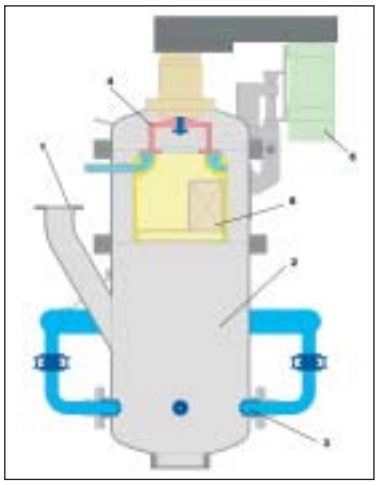


Fig. 1 Principle of a fluidized bed jet mill

An immersion tube, which rotates with the classifier wheel (patented), ensures that the resulting product is free of oversized particles. As the immersion tube can be exchanged, the plant can be further adapted to suit the requested final particle fineness, by selecting another immersion tube diameter.
In general, milling gas pressures of 6-10 bar (g) and laval nozzles are used for medium-hard to hard products. For some special applications it has proved more favourable to work in a low-pressure area of approx. 2,5-3 bar (g). In this case nozzles with a cylindrical outlet shape are generally used (Fig. 2).

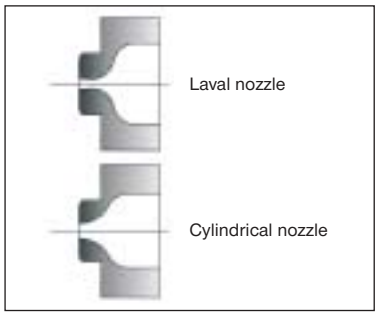


Fig. 2 Various nozzle types

Hot Gas Operation

When milling products which are not temperature-sensitive, the specific energy consumption can be reduced by approx. 30 % using hot-gas milling at approx. 160°C. During this process the temperature increase in the compressor is utilized and the milling air is used without a recooling step. Depending on the milling air pressure and the product sensitivity, the milling air temperatures can be between 80°C and max. 200°C.
Fig. 3 shows the specific grinding air consumption for set finenesses for the milling of glass frits. The difference in grinding air consumption

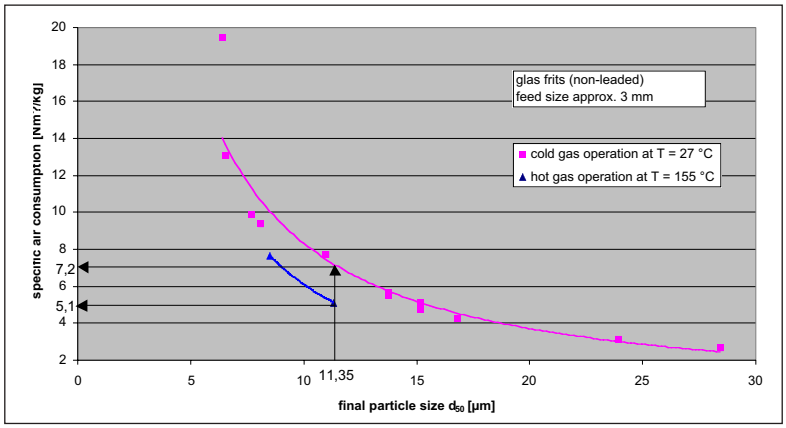


Fig. 3 Specific air consumption dependent on the final particle size

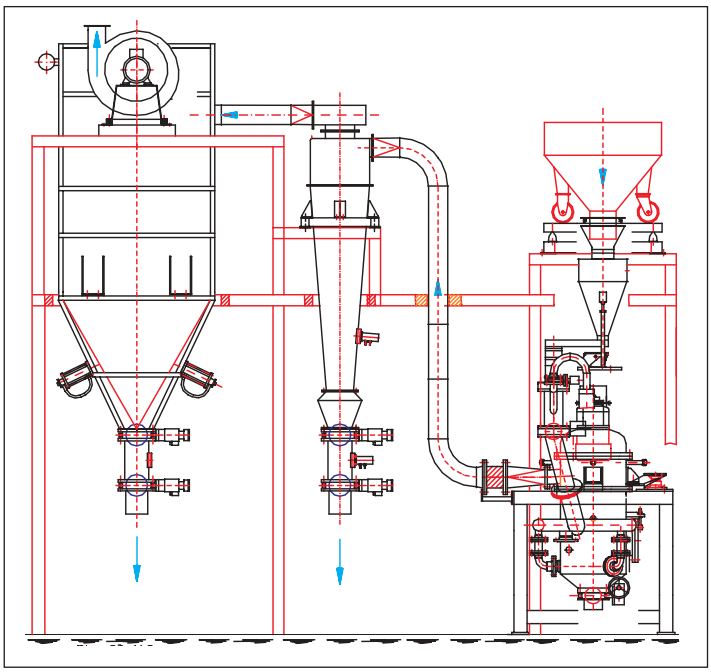


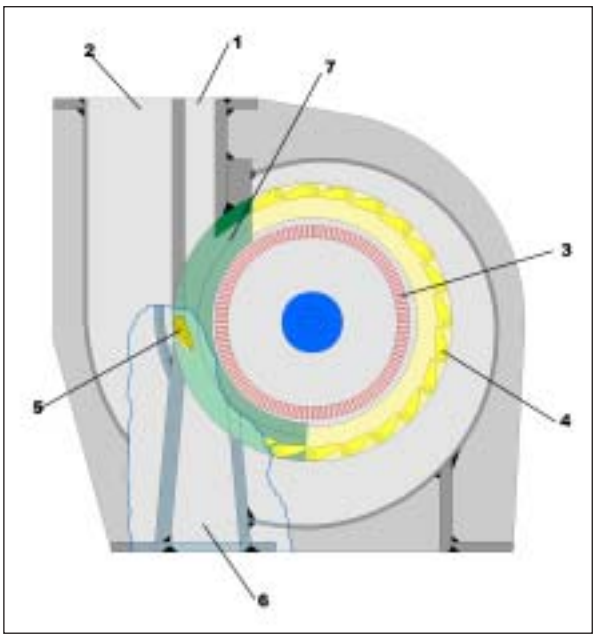
Fig. 4
Milling plant with fluidized bed jet mill

per kilogramm of ground product between hot-gas and cold-gas operation is shown clearly. This type of operation is often used for ceramic materials. These are generally not sensitive to temperature and often require a high energy supply due to their hardness.
A decrease of the specific milling air requirement during hot-milling can generally be observed for all ceramic and mineral materials. In addition, hot-gas operation can also be used for milling with simultaneous drying of the product.

Applications

Products with a particle size of several millimeters can be fed into the „Condux Fluidized Bed Jet Mill" and milled to final finenesses in a range of $d_{99} \approx 2...70$ µm. Typical applications are the milling of glass frits, ceramic pigments, oxide- and non-oxide ceramics as well as in the mineral sector e.g. kaolin, talcum, mica, graphite or other mineral fillers. Further applications with the most extreme requirements for the purity of the product are in the areas of medical ceramics such as e.g. dental ceramics for dentures and fillings.
In Fig. 4 a milling plant with a „Fluidised Bed Jet Mill CGS 50" is shown. A typical grinding plant consists of feeding device, mill, gas-filtering system and additional accessories. In order to facilitate cleaning, a cyclone can be connected in series between the mill and the filter bag house. This is particularly recommendable for production processes in which the product is frequently changed or if the feed product has a very intensive colour, such as some ceramic pigments. Such a plant can be cold- or hot-gas operated. In the case of hot-gas operation, care must be taken to ensure that insulation and a protection barrier for the safty of the operators are provided.

Fig. 5
High performance classifier CFS HD-S



The Basic Factors Concerning Air-Classification

High-performance classifiers of the „CFS/HD-S" series as shown in Fig. 5 are used for the fine-classifying of products which have already been milled, e.g. to remove undesirable fine or oversized particles. The product is fed into the machine via a feed chute above the machine (1). The processing gas is fed into the machine via a second inlet opening (2). This gas passes a stationary guide vane basket (4) and predisperses the feed product extremely fine and then directs it to the classifier wheel (3). The fines leave the classifying room in the center of the classifier. Coarse particles are rejected by the classifier wheel and carried out of the screw-shaped machine housing (7) at the back downwards (6).
A further design characteristic, which is used in the Condux air-classifiers as well as in Condux mills, is the immersion tube which rotates with the classifier wheel. This serves to eliminate oversized particles in the fines fraction. For all mills and classifiers two different types of classifier wheels can be used. The $H_{f\text{-}const.}$-wheel with a constant height over the complete diameter of the wheel and the Convor-wheel. With the Convor-wheel a constant radial flow speed can be obtained due to the inner shape. This wheel is used in areas in which extreme finenesses are required [1]. In the production, even when using large classifiers, the values obtained in the test lab can be set with just one classifier wheel.

Applications

In Fig. 5 a typical classifying plant with a „Condux High Dispersion

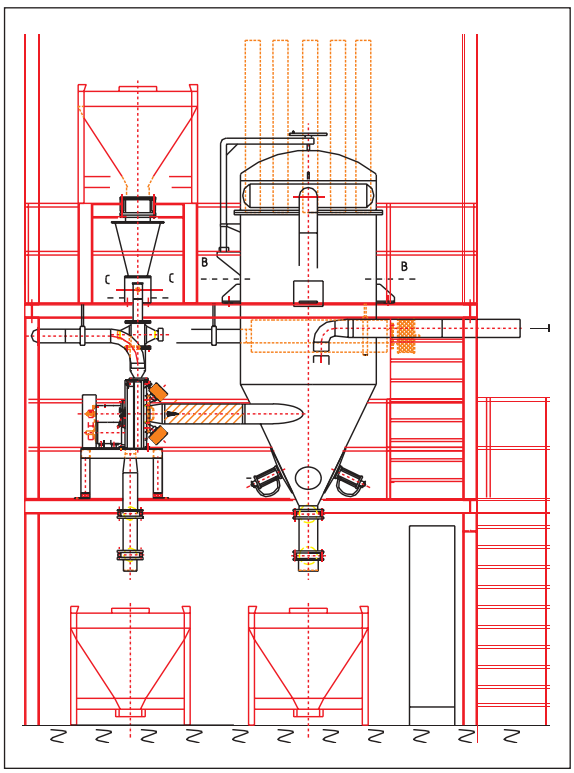


Fig. 6 Classifing plant with a high dispersion classifier CFS 85 HD-S

Classifier CFS 85 HD-S“ is shown as stand-alone-system. This classifying plant consists of a feeding device for uniform feeding of the product, classifier, gas-filtering and collecting system for fine product, as well as a collecting system for the coarse product. The ventilator for process air is generally arranged behind the filter unit for working at underpressure in the complete system.

The classifier shown can also be arranged as an inline-system for dedusting or eliminating oversized particles directly from upstream processes. For feeding the classifier, an injection system can also be used. Using this method of operation it is possible to convey the product pneumatically over a long distance to the inlet. However, it is strongly recommended to make sure that the injector air volume is only a small percentage of that of the processing air stream. Furthermore, in order to obtain the most optimal classifying results, the injector air stream must not be subject to fluctuations.

Most of the applications for Netzsch-Condux classifiers are for dedusting milled products or the elimination of oversized particles after a grinding process without exact coarse particle limitation e.g. after processing with a ball mill. For these applications, the coarse material is often returned to the mill by means of a loop operation.

Fig. 7
Classifier with a special wheel exececution

Wear Protection

When hard products are milled or classified, wear protection designs are imperative. The most important thing to be taken into consideration, is the wear protection on the classifier wheels. In general, these are subject to the highest wear due to product contact, in particular at high classifier wheel speeds, and must be provided with a suitable protection. For this reason, special classifier wheel executions made of hard metals or with ceramic-lined guide vanes, have been developed (Fig. 7). Housing and plant parts such as pipings and filter cones are lined preferably with „Vulkollan“. In the standard wear protected execution, the guide vane basket of the Condux classifiers as well as the fines outlet chamber of the Condux jet mills (Fig. 8) are lined with alumina. These linings have proved to be excellent for the protection of these machine housing parts.

For hot-gas operation, parts which are usually coated with Vulkollan must be lined with ceramics, as Vulkollan can only be used up to temperatures of 70°C.

For an extremely abrasive product, a special type of lining for the milling chamber of a production plant was developed in cooperation with the customer. In this case, the complete milling chamber was lined with armour plates. These consist of a base plate of carbon steel, on which a layer of hard metal is welded.

Prospects

Naturally Netzsch-Condux grinding and classifying plants can also be used for explosive materials. As well as pressure shock resistant design, plants are more and more freqently arranged in closed loop gas operation. These plants are intitially flooded with inert gases in order to reduce the oxygen content to below 4…6 %. In this way the ignition point cannot be reached in the complete plant. During operation the inert gas supply is then restricted by means of a special monitoring system, so that only an amount equal to the leak rate of the plant is admitted. Furthermore, combined processes such as e.g.

- milling with simultaneous coating of the particles or
- milling with a simultaneously running reaction in the milling area

are being tested more and more in the test lab and realized together with customers. In particular the characteristics of the fluidised bed jet mill can be positively applied here. The fluidised bed functions like an ideal mixer, which is necessary for reactions or coating processes. Furthermore, the energy supply in hot-gas operation can be used to control reactions as well as for the melting or activation of additives such as waxes or flow improving additives.

This relatively new way of operating a fluidised bed jet mill opens up a wide field of new applications, which will continue to make this milling process very interesting in the future. The task for the future will be to test new ideas and to convert them into production plants.

Fig. 8 Detail of an alumina-lined outlet chamber

References

[1] Nied, R.: CFS-HD: A new classifier for fine classification with high efficiency; International Journal of Mineral Processing (1996) [44-45] 723-731

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