Ultrafine jetmill grinding

New developments

by Horst Thaler and Jürgen Roth*

Today, when production and energy costs are rising, and at the same time requirements in fineness and purity of industrial mineral products are getting tighter, the industry has had to look for more efficient grinding systems to produce these products more economically. As a result, many new developments in high energy jetmill pulverising have been made. In some cases, especially in the filler minerals sector where laminar minerals are used and higher aspect ratios are required, the spiral jetmill principle has advantages. To grind minerals down to products with a $d_{97} < 3$ µ, the specific energy consumption increases up to 2,000 kWh/t – 3,000 kWh/t or even more, depending on the grindability of the mineral. So, the production of these fine materials is quite an expensive process. But jetmill grinding is and will be the most favourable method to produce micro-products and in the near future, nano-products, despite high energy consumption.

Jetmills are comminution aggregates, where expanding gases with high velocities, up to 1,200 m/s, are used to comminute particles by impact with other particles (*Figure 1a*), or built in targets (*Figure 1b*), or just by utilising high velocity differences (*Figure 1c*). These are more or less all the jetmill systems which have been developed. The objective of these different systems and the developments behind them is to produce the finest products by using more economical systems.

Should the specific energy consumption increase to a non-proportional extent in mechanical systems, the usage of jetmills is recommended. Therefore, it is necessary to select the appropriate type of mill according to the characteristics of the material which has to be pulverised.

Another problem for the industry was that the current jetmill market had no aggregate able to produce extreme fineness with industrial scale capacities.

In the following article, the design and the new developments of the PMT Jetmill SJ50 compared to common spiral systems will be described.

* PMT-Jetmill GmbH, Leoben, Austria

Jetmills

Opposed jetmill

Figure 1a shows the principle of this type of mill. Compressed air is converted in two to four counter-blowing nozzles into a high velocity air stream. In the centre, the highly accelerated particles are shot against each other. This impact causes size reduction.

Around this zone an upward air stream transports the ground material to a classifier, where coarse and fine particles are separated.

This system is one of the most common used today, because it is used in most fields of industries producing fine particles of any hardness, eg. industries producing raw materials for pharmaceutical, filler, toner, and ceramic applications.

The best operational area of this mill includes minerals with more than 4 Mohs hardness and those with cubic structures. By using it with laminar minerals, the typical structure gets damaged and the high aspect ratio decreases, because of grinding the fine particles by the typical particle – particle collisions in the air streams.

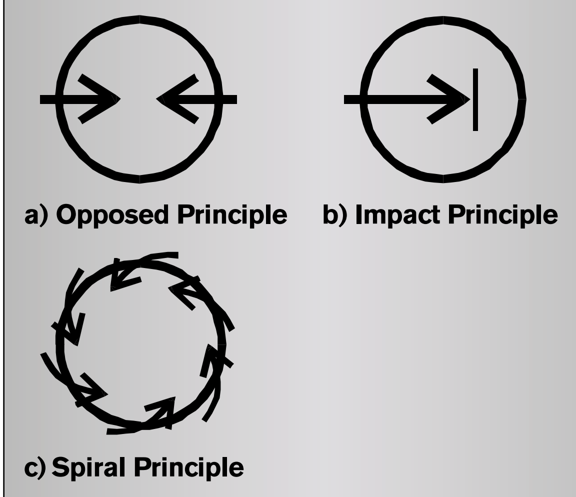

Figure 1. Principles of Jetmill Systems

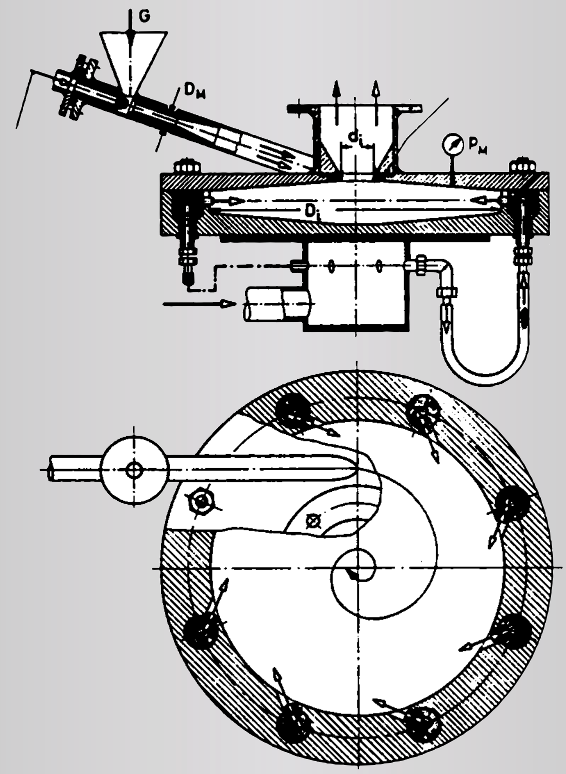

Figure 2. Scheme of a spiral jetmill with injector and spiral stream classifying

Another advantage is iron free and wear free grinding. The particles are shot against each other and have no contact with the grinding chamber.

Impact jetmill

The principle is shown in *Figure 1b*. These type of mills are the so called Nippon Jetmills, where the highly accelerated particles are forced to collide against a target plate, which is made of ceramic or boron carbide material. There have also been different investigations carried out to find the optimal position and design of the target plate.

Its field of application is also more or less with the hard minerals ranging from 4-10 Mohs hardness, and materials which are relatively elastic and therefore difficult to pulverise. When grinding these hard materials, a lot of wear of the target plate has been observed which caused no iron free or clean products as a result.

The oldest known jetmill working with this principle is the so called Anger-Mühle.

Spiral jetmill

The first developments were made in the USA in 1927. This type of machine is made of a flat milling chamber where nozzles are built tangentially around the chamber and generate a high speed air stream rotating inside this chamber.

The material is conveyed into this milling zone by an injector or a screw conveyor. There it is accelerated and ground by the air stream. The final product outlet is in the middle of the chamber where the stream generates a spiral stream which classified the material. Particles which are too coarse are drawn back into the milling zone by the centrifugal force, whereas particles which are fine enough are able to pass through the spiral stream and out of the chamber. *Figure 2* shows such a scheme of a spiral jetmill.

PMT Spiral Jetmill System SJ

The use of spiral jetmill technology for producing fine industrial mineral powders is predestined through its grinding characteristic for soft and laminar minerals like graphite, mica, barytes, talc, kaolin, diatomite, and so on. For the users of these mineral powders, it is necessary to protect and not damage the functional properties of the laminar particles.

Another objective was to scale up the size of such a facility because it also has to be possible to produce reasonable volumes. The development of *PMT Spiral Jetmill System SJ50* (*Figure 3*) shows the differences to common systems by replacing the injector for the feed through a simple pneumatic conveying system, an internal classifier, the so called Rotor–Motor–Unit, by enlarging the grinding chamber, by changing the position of the nozzles and by using a self developed controlling system.

Injector feed

In most of the literature one can read about the enormous energy consumption of an injector type feeding system. One can also find a lot of new and specially designed injector feeds and positions in the aggregates itself. But there are no developments that do not use an injector for feeding the material.

PMT has made tests with injectors and with other feeding systems. Without these injectors the specific energy consumption decreased by at least 20%. This is also simple to verify because the grinding inside a spiral jetmill is conducted essentially by high velocity differences. If the material is fed into the chamber with higher speed, the velocity differences are very little and therefore the grinding effect is also rather small.

If the particles are conveyed into the grinding chamber at a low speed, the highest velocity difference between the particles and the high speed air stream can be achieved.

Another advantage is that the whole energy from the compressed air can be utilised for grinding and not for feeding the material.

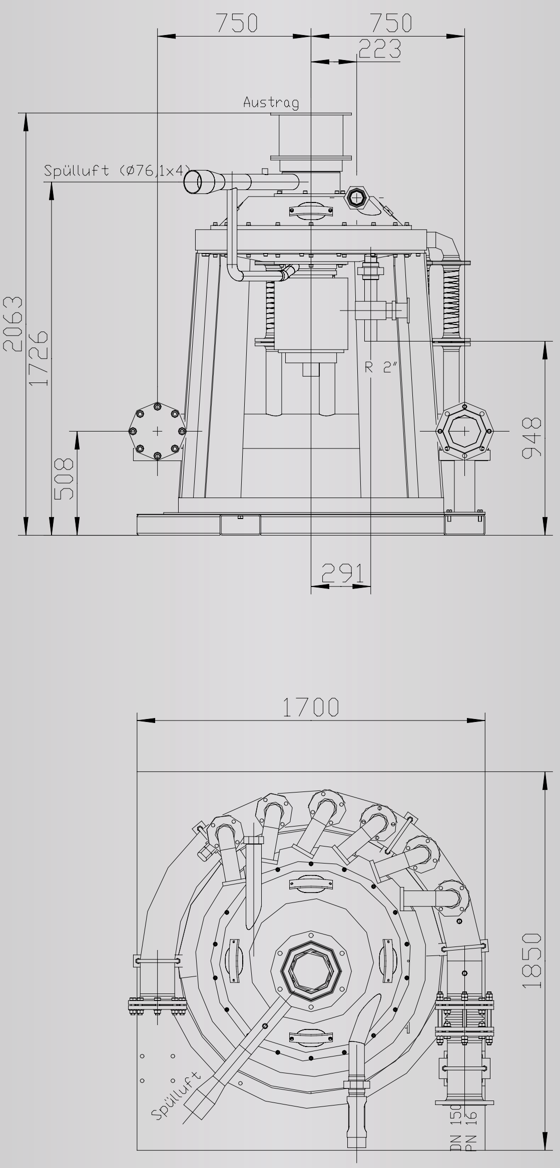

Figure 3. Scheme of PMT Spiral Jetmill System SJ50

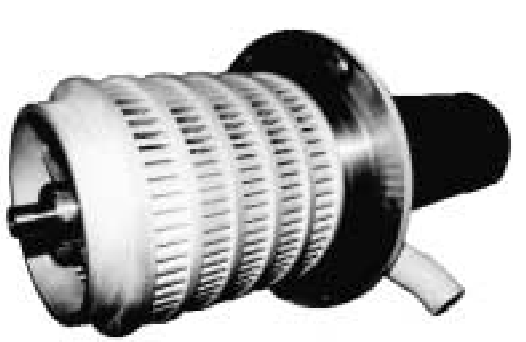

Figure 4. PMT Motor-Rotor-Unit

Integrated classifier rotor

A new and required part of this jetmill with the enlarged milling area is the classifier rotor, which is built in the mill with a centric or eccentric vertical axis. The rotor unit is directly combined with a motor unit *(see Figure 4)* with the advantage of maintenance-free and high-speed bearings.

Together with the basic structure of the new rotor unit made from high strength aluminium alloy, the highest circumferential speeds of up to 160 m/s are possible. This high speed combined with the new form of the rotor leads to the lowest possible final product grain sizes with a d50 < 0.5µ.

Because of the rejecting effect of this rotor against the coarser or not quite fine enough particles, a high load rate can be reached. Independent of the load, the fineness of the final product can be adjusted by the speed of rotor. That means that one can adjust the optimum load and therefore reach significant increases in efficiency.

This is an important difference to conventional jetmills, because these aggregates have a cyclone type reject gate in the centre where a controlling of the fineness is only possible by increasing or decreasing the load inside the mill, representing respectively an increase or decrease of the material input.

Milling body

The milling body is different to commonly used jetmills, which are designed to keep the space inside as small as possible to prevent the product from escaping from the milling process. In this jetmill the body has a wider space with a higher upper part. The purpose of this higher body is to feed as much product as possible into the milling area.

This large amount of product will be fluidised by the air which enters the area through the milling nozzles. Additionally, it can be assured, that the whole energy of the air stream can be transferred to the product, which is present in an oversupply in the milling area. This construction aspires to a fluidised bed technique when using jetmills, that means that the air stream fluidises the material-bed and lifts as many particles as possible into the stream.

Nozzle position

By comparing a common system (*Figure 2*) and the system of PMT one can observe the difference of the position of the nozzles giving a different energy input into the grinding chamber. To concentrate the energy to a smaller area and not around the whole circumference the grinding efficiency increases and thus also the output of the facility.

Special controlling

Optimal grinding conditions in the mill independent of the production fineness require an automatic feed control in relation to the inside load of the mill.

For this feed control the input of current of the classifier rotor is the relevant measurement which controls the optimum product feeding rate.

Advantages of the PMT Spiral Jetmill System SJ

With all its described developments and changes compared to commonly used aggregates, the PMT Jetmill offers the following advantages:

1. Exact top cut
2. Reduction of the specific energy consumption
3. Coarse product reject outlet for hard grindable

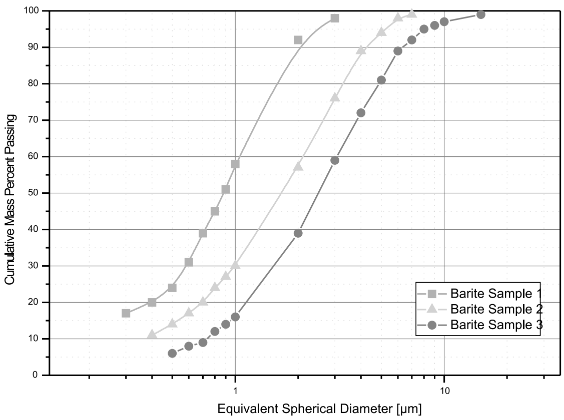

Figure 5. PSD of barytes samples, ground with PMT Spiral Jetmill SJ50

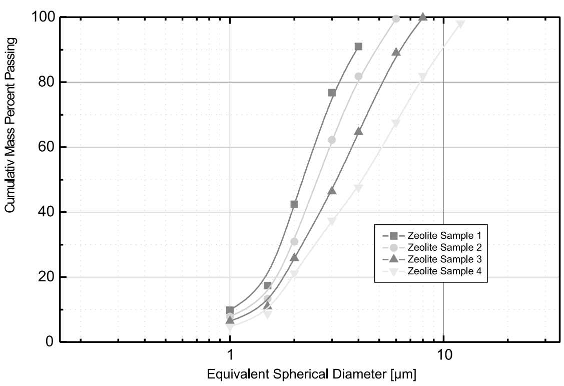

Figure 6. PSD of zeolite samples, ground with PMT Jetmill System SJ50

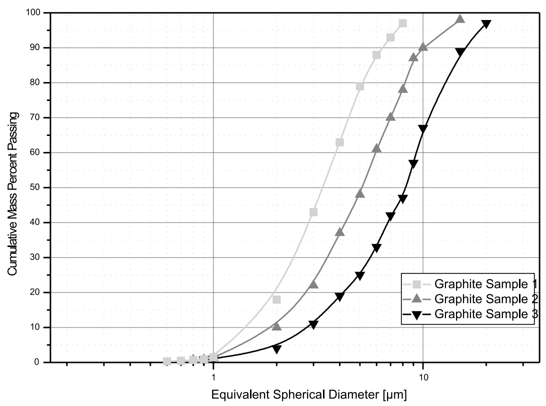

Figure 7. PSD of graphite samples, ground with PMT Jetmill System SJ50

Figure 8. PMT Spiral Jetmill System SJ

materials
4. Operational reliability
5. Industrial scale throughput

Product samples

These samples, and a lot of other particle size distributions were made in PMT´s own testing facility in Leoben, Austria, where the aggregate was developed and will be further developed for the high requirements of the industrial minerals industry.

In this plant, toll grinding can also be done or grinding to give customers samples for application testing during the installation phase or even to support them when developing new markets.

Conclusion

For the increasing requirements of the industrial minerals industry this new ultrafine comminution aggregate offers:

1. Reduction of the specific energy consumption of up to 30%.
2. Increasing the grinding efficiency due to its patented controlling system, which stands for constant loading rates inside the grinding chamber.
3. Easy adjustment of fineness by regulation of the speed of the rotor with an excellent top size reduction of the final product.
4. Coarse product outlet for hard and non-grindable minerals, eg. quartz. IM