Homing In On the Best Size Reduction Method

Start with particle-size distributions and hardness to simplify the task

Hosokawa Micron Powder Systems

Old-time textbooks called the unit operation crushing and grinding, but it has acquired a better name, size reduction. As long as materials enter a process in big pieces, but must be treated in smaller pieces, there will be a need for rugged mechanical equipment to do the job.

The designer, faced with the task of buying the best machine, finds plenty of equipment descriptions, but really needs a guide that accelerates homing in on the most appropriate type. This article is intended to be that guide.

We were able to categorize the machines into nine types. For a first pass, an engineer works with two parameters: output particle size and Mohs hardness. This narrows the choice of equipment to one, two, or three categories. Finally, applying special requirements of a particular industry segment will reduce the choice to a single category. Now, the task becomes selecting the best vendor among those offering similar equipment.

This article is organized so as to introduce the first-pass process, and then to follow on with a description of machines in each category. This spotlights many special requirements that may dictate putting two types of machines in series, or adding a classifier.

Size and hardness come first

End-product fineness is one factor that determines the energy input for grinding. For example, mechanical-impact grinding mills are good for easy-to-grind materials requiring medium fineness. Products requiring high fineness are processed with either media mills or fluid-energy jet mills. Media is a common term for the solid material doing the communition.

Consider the shape of the particle-size distribution in the selection of a grinding system. If a steep particle-size distribution is required, then mills with internal or external classification will be the likely candidates. Table 1 describes and names the increments of size reduction and the appropriate size-reduction methods.

The second big factor is the hardness or abrasive properties. Material hardness and the potential for abrasion will also dictate the type of mill selected. Solids with Mohs hardness greater than 3, or carrying a significant quantity of abrasive impurity, require special handling. In the Mohs scale of material hardness, a higher-hardness material will scratch the surface of any material with a lower Mohs hardness. Table 2 gives examples of the Mohs scale.

Matching the special requirements of each job requires paying attention to the industry segment. Specific applications for each type of machine will be covered under the descriptions. The order will match Table 1.

Cutting mills

Cutting mills, also known as granulators, make use of rotating and stationary knives that cut materials on the shearing edges. A set of rotor-knives rotates inside a set of stationary knives. This mimics the action of a high-speed scissors doing hundreds of cuts per minute. Production rates are determined by the length and number of knives, rotational speed and the input power, which ranges from 250 W to 1.5 kW. There are several knife designs, including cross-scissors-cut, straight- and open-rotor. The demands of the application determine if the granulator housing can be fabricated or cast.

TABLE 1. SELECTING APPROPRIATE MILL TYPE BY SIZE RANGE

Particle description	Size	Cutting mills	Crusher	Universal and pin mills	Hammer mill	Mechanical mills with internal classifier	High-compression roller mills and table roller mills	Jet mills	Dry-media mills	Wet-media mills
Very coarse	>5 mm	Yes	Yes	No	No	No	No	No	No	No
Coarse	1-5 mm	Yes	Yes	Yes	No	No	No	No	No	No
Medium fine	500-1000 µm	Yes	Yes	Yes	Yes	No	No	No	No	No
Fine	150-500 µm	Yes	No	Yes	Yes	Yes	No	No	No	No
Very fine	50-150 µm	No	No	Yes	Yes	Yes	No	No	No	No
Super fine	10-50 µm	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Ultra Fine	<10 µm	No	No	No	No	No	Yes	Yes	Yes	Yes
Colloidal	<1 µm	No	No	No	No	No	No	No	No	Yes

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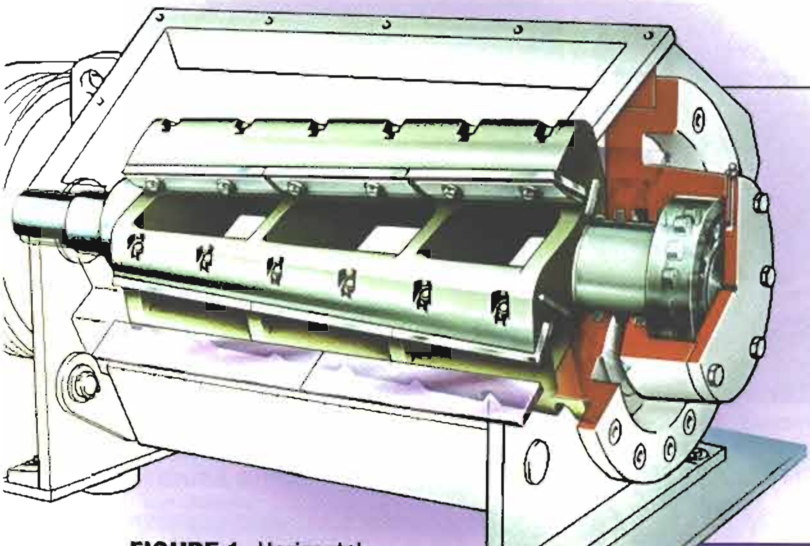

FIGURE 1. Horizontal cutting mills are used on fibrous materials

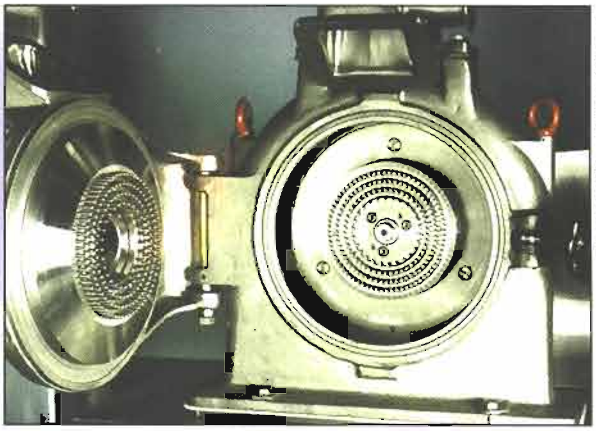

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FIGURE 2. A universal mill equipped with pin discs consists of one stationary set of pins, and one rotating set of pins

TABLE 2. THE MOHS SCALE OF MATERIAL HARDNESS †

Degree of hardness	Mohs scale	Example
Soft	1	Talcum
Soft	2	Gypsum
Soft	3	Calcite
Medium-hard	4	Fluorite
Medium-hard	5	Apatite
Medium-hard	6	Feldspar
Hard	7	Quartz
Hard	8	Topaz
Hard	9	Corundum
Hard	10	Diamond

† Green, D. W., et. al, "Perry's Chemical Engineers' Handbook," 7th ed., p. 20-11, McGraw-Hill, New York, 1997.

Cutting mills (Figure 1) are used on fibrous materials, such as vegetable matter, spices, herbs, many plastics and paper. These cut up bottles, plastic film, fiberglass scrap, fiberglass drums, automobile bumpers, dashboards and door linings. The end-product particle size is 1–6 mm.

Heavy-duty granulators are used in the process of recycling electrical cable scrap and the subsequent recovery of metals including copper, aluminum and lead. They are also used in a process for recycling tires.

The throughput of these lines is in the range of 70–6,000 kg/h. Special large-volume feed-chutes or pneumatic feed-inlets can be used when large parts are to be recycled.

A variety of film materials including polyester, polypropylene, polyethylene, and polyvinyl chloride can be handled, with throughputs of 45–200 kg/h. Unwind stations for film reels and pinch rollers are included on some machines.

Crushers

Coarse crushers make use of the compressive force between two solid surfaces to cause size reduction. Coarse crushers are noted for their rugged construction, extremely high production rates, and the ability to handle material sizes up to 0.1 m^3 in volume.

Crushers are used mostly for the size reduction of minerals, gravel and ores, resulting in particle size distributions from about 1 mm to 100 mm. A specialty use is as a precrusher, to provide a uniform feed material for the next step in size reduction. Examples of this type are jaw-crushers, cone-crushers and gyratory-crushers. The production rates of these mill types are in the range of several tons per hour, and most are located at mine sites.

Universal and pin mills

Universal mills are often also referred to as fine-grinding impact-mills. In all of the options, particle-size reduction occurs by impact against the grinding media, and through inter-particle collision and attrition. For example, a universal mill equipped with pin discs consists of one stationary set of pins, and one rotating set of pins. Material enters the center of the grinding chamber via gravity, and is accelerated by centrifugal force against the meshing pins. The speed of the discs, which can be as high as 200 m/s, sets the strength of this force. Particle size is determined by the feedrate and the peripheral speed of the pin discs (Figure 2).

The ability to utilize a variety of grinding media within the same milling chamber allows for complete flexibility in resulting particle size distributions. For instance, by changing the pin-disc components to a peripherally-mounted sieve-insert or peripherally-mounted grinding-track, the range from medium-fine to very-fine particles can be processed. The overall result is a host of practical equipment combinations to cope with many size-reduction tasks. Some mills are equipped with hammers, beaters and screens, depending on the application (*CE*, April 1997, pp. 84–90).

Universal mechanical milling is well suited to fine-grinding applications that do not require the higher energy input of jet milling or the strict upper size control of an air-classifying mill. In all mechanical impact mills, material hardness is limited to 3 Mohs maximum because of pin materials.

Typical resultant particle-size distributions can range anywhere from a fairly coarse D_{97} of 200 micrometers*, to as fine as D_{97} of 10 micrometers. These mills do an ideal size reduction when the desired particle-size distribution is narrow. Due to their versatility and accessibility, universal mills are often used as fine grinders for a wide variety of applications, including the milling of pharmaceuticals, food confectioneries, animal feeds, mineral powders (e.g., limestone and gypsum), and many chemicals (e.g., fertilizers, pesticides, paints and pigments) and the cryogenic milling of herbs and spices. The pin-mill configuration can be equipped with a wider milling chamber, to dissipate and minimize the heat generated within the grinding zone. For example, pin mills with wider chambers are often used for such heat-sensitive products as cocoa powder.

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* Particle-size distributions can be expressed with a symbol. D_{97} means that 97% of the particles by weight are smaller than the size mentioned. Similarly D_{50} refers to 50%.

Hammermills

A hammermill does reduction of particles by impact against rigid surfaces — for example, the mill housing and a screen. Three basic variables affect the grinding process: screen hole size and shape, hammer type, and peripheral speed of the hammers, which can range from 20 to 60 m/s.

Hammermills are ideal for a wide variety of particle-size ranges, as it is simple to stop the mill and change the screen size. These machines are used to process medium to medium-fine particle sizes, and they handle mostly soft to medium-hard materials (Figure 3). Applications include grinding of pigments, spice and various food ingredients. Particle-size distributions can vary from 90 to 850 micrometers, with production rates as high as 30,000 lb/h.

Special design features in the hammermill configuration permit cryogenic grinding, which employs liquid nitrogen to reduce material temperatures (*CE*, April 1997, p.86). This embrittles the material prior to size reduction and makes the grinding of tough, fibrous materials or thermoplastics or heat-sensitive materials much easier.

Mills with classifiers

When the required particle-size distribution is narrow, the best equipment is often a hammermill with an integral air-classifying wheel. The classifier, an integral component of the mill, allows only particles below a specified size to pass. Material to be ground is conveyed into the mill chamber to a rotor equipped with pins or hammers. As particles decrease in size, they are entrained by an airstream, and eventually pass through the classifier wheel to the product collector. Those particles rejected by the classifier are continuously recycled back to the hammers for further size reduction.

Due to the constant airflow passing through this air-classifying mill, the overall temperature remains relatively low, making this an ideal grinder for handling materials with a low melting- or softening-point, such as sugar. Particle size is controlled by rotor speed, classifier-wheel speed and airflow, and usually displays a tight distribution. Throughput of a particular mill rating is a function of airflow and the required particle size.

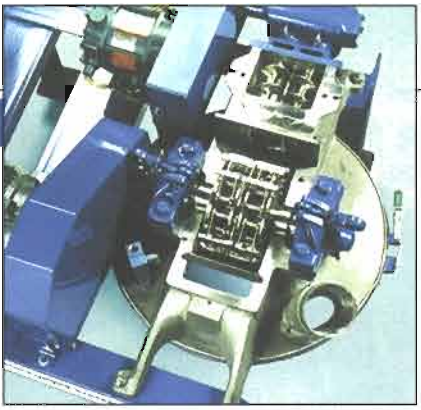

FIGURE 3. A hammermill reduces particles by impact against rigid surfaces, such as the mill housing and a screen

The air classifying mill is also ideal for processing various heat-sensitive materials and minerals, such as kaolin, talc and diatomaceous earth. Particle sizes as fine as 30 micrometers are possible, depending upon the material and application. Most mills feature an easy-clean design, making them ideal for processing pharmaceutical products and powder coatings.

High-compression roller mills

High-compression roller-mills exert greater compressive forces on particles — about 50–500 megapascals (MPa) (7,250–72,500 lb/in.^{2}) — than do coarse crushers, which exert about 5–100 MPa. Size reduction is a result of the compression of one particle against another particle between one stationary and one floating roll, to result in a slab form. The slab is reduced to its component particles (de-agglomerated) downstream by a mechanical-impact mill, such as a hammermill or universal mill. Then, the resulting free-flowing powder is air-classified to yield a fine-product stream and a return stream of the coarse fraction that goes back to the grinding stage.

The yield of acceptable-sized product is influenced by the pressure applied between the rolls. Production rate is a function of the length and diameter of the rolls and the speed of the rolls. The selection of the air-classifier or sieve will determine how fine a product will exit the high-compression roller-mill system. A roller-mill with a high-energy, forced-vortex classifier can produce powders with D_{97} from 5 to 45 micrometers. Other classifier types or sieves can be used to produce coarser particle-size distributions.

High-compression roller-mills can be applied to any brittle crystalline material up to a Mohs hardness of 10. Typical examples are limestone, feldspar, wollastonite, quartz, dolo-mite, zircon sand and ceramic raw materials. These mills compete with dry ball-mills but offer advantages in space requirements, wear, noise and reduced specific-energy input. Compared with ball-mills, in some cases, power use will be up to 50% lower. For example, limestone can be ground to D_{97} = 10 micrometers at a specific grinding energy of 19 kWh/ton. In a ball mill, 35 kWh/ton are needed. Common throughput rates for roller mills are 0.75 to 24 tons/h.

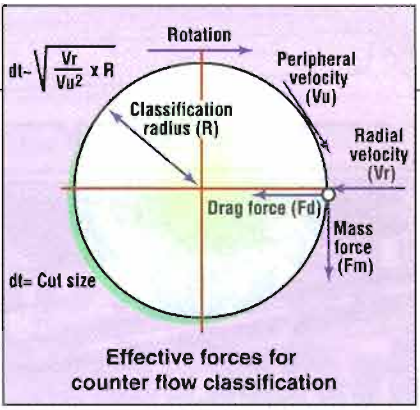

FIGURE 4. Particle classifiers operate by balancing mass force and drag force. F_d and F_m act on the particle

TABLE 3. CLASSIFIER OUTPUT IS INFLUENCED BY TWO PARAMETERS

Air volume	Classifier speed	Particle size
Constant	Constant	No change
Constant	Higher	Finer
Constant	Lower	Coarser
Higher	Constant	Coarser
Lower	Constant	Finer

Table roller-mills are applied to many of the same materials as a high-compression roller-mill, up to a practical hardness value of 6 Mohs, or with up to 6% of 7-Mohs quartz content. Among the materials that can be successfully processed are talcum, dolomite, quicklime, $Ca(OH)_2$, gypsum and phosphates. Normal product is 10–50 micrometers.

The table roller-mill has a strong advantage over a high-compression roller-mill. The internal air classifier results in a more compact installation, eliminates the hammermill for breaking up the slab, and offers more-precise process control. Adjustment of cut point, and therefore product particle size, is affected primarily by a change of classifier speed, and secondarily by a change in airflow. (Table 3 and Figure 4 together describe this relationship.) Because the air classifier is internal, external recirculation and conveying of coarse material back to the mill is also eliminated.

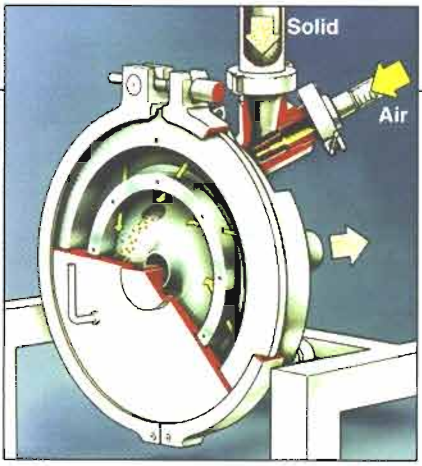

FIGURE 5. The material inside the grinding chamber of a sprial jet mill is subjected to two opposing forces. They are the free vortex mass-force and the drag force

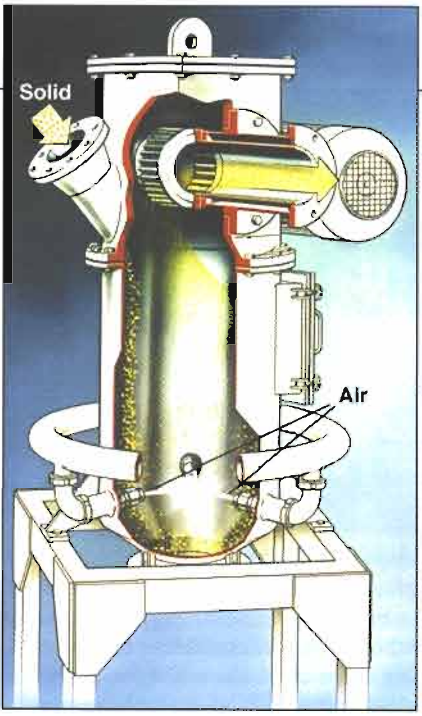

FIGURE 6 (right). The fluidized-bed jet-mill has two distinct segments. The lower section is the actual grinding chamber. The upper section is an air-classifier that controls particle size

Fluid-energy impact mills

As are mechanical impact mills, jet mills are based on the principle of impact size reduction by collision. The fragments are accelerated in a high-velocity gas stream and are reduced by inter-particle collision or impact against a solid surface. There are two common jet mill designs: those that do not have an internal centrifugal forced-vortex air-classifier, and those that do. Examples of jet mills without an internal air-classifier are spiral jet mills (also referred to as pancake mills) and loop mills. Examples of jet mills with internal air-classifiers are fluidized-bed jet-mills (FBJMs) and some varieties of target jet-mills. In reality, all jet mills rely on some type of internal classification to control particle size.

The spiral and loop jet-mills are suitable for fine and ultrafine size reduction of materials up to a hardness of 3 Mohs that also display brittle-crystalline grinding characteristics. Examples include fine chemicals and pharmaceutical materials, including antibiotics, injectable drugs and ascorbic acid. Obviously, this is a limited-use machine.

The spiral jet-mill is simple in design, consisting of a flat, cylindrical, grinding chamber with several nozzles arranged tangentially in the peripheral wall, a pneumatic-feed injector and a feed funnel (Figure 5). Operation is just as simple. The feed is accelerated into the grinding chamber through the feed injector. The material inside the grinding chamber is subjected to two opposing forces. They are the free vortex, created by centrifugal force (mass force), transmitted to the particles by the nozzles, and the drag force created by the airflow as it spirals toward the center.

The larger particles are affected to a greater degree by the mass-force, so they circulate around the periphery of the mill and undergo collisions with other particles. As the particles become finer, the drag-force exerts a greater effect drawing the particles with the air-stream to the central outlet from the mill.

The FBJM is suitable for the fine and ultrafine size-reduction of any material up to a hardness of 10 Mohs that can be fluidized by the expanding compressed gas in the grinding chamber (Figure 6). These mills are typically used in applications not limited by feed size, heat sensitivity of the material, or abrasive characteristics. Examples are: fine chemicals; toners; ceramic materials, including oxides; pharmaceutical powders; carbides; nitrides; mineral powders; abrasives; resins; waxes; pigments; dyes; pesticides; fluorescent powders; phosphors; and rare earth materials. FBJMs use less energy than do spiral jet mills (Figure 7). They are also designed for low wear and build-up in the grinding chamber, steep particle-size distributions and quiet running.

The FBJM can be conceptually divided into two distinct segments. The lower section is the actual grinding chamber, with several nozzles arranged radially in the chamber wall and a gravity feed inlet. The upper section is a centrifugal forced-vortex air-classifier that is responsible for particle size control. The two segments work together to give the FBJM its characteristic steep particle-size distribution and sharp control of the largest particle diameter (top-size).

Operation of the FBJM is simple. Feed falls into the grinding chamber through a large gravity-feed inlet. During normal operation, there is a fluidized bed of material inside the grinding chamber. Material is entrained by the high-velocity gas streams created by the nozzles, and size reduction occurs as a result of particle-to-particle collisions in the gas stream and at the focal point of the nozzles. The expanded gas conveys ground particles upward to the centrifugal air-classifier. The classifier allows material of a given fineness to exit the mill, while rejecting oversized particles back into the grinding chamber, for additional size reduction. An equilibrium is established with this internal recirculation, the rate of introduction of fresh feed, and a constant discharge of ground material.

Air classifiers

The key to maintaining a consistent particle-size distribution is the integral air-classifier. Air-classification is defined as the separation of bulk material according to its settling velocity in a gas. As in the spiral jet mill, the same two opposing forces are acting on the particles — mass-force and drag-force. Mass-force is the force exerted on the particle by acceleration due to gravity, inertia, or centrifugal force. Drag-force is the force exerted on a particle by the surrounding medium as affected by the particle's aerodynamic properties.

In a centrifugal air-classifier the mass-force is exerted on the particle by the peripheral velocity of the classifier wheel. The drag-force is exerted on the particle by the carrying fluid, which in the case of a jet mill, is caused by the expansion of the grinding gas. The cut point is the particle size at which the mass-force and drag-force act equally on the particle.

Similar to the spiral jet mill, the mass-force of an FBJM exerts a greater influence on particles that are coarser than the cut size, and they are returned to the grinding zone. The drag-force acts upon particles that are finer than the cut size, and they are carried through the classifier wheel and recovered as product.

TABLE 4. EFFECT OF CHANGING PARAMETERS ON PARTICLE SIZE DISTRIBUTION IN FBJMs

Nozzle diameter	Grinding pressure	Air volume	Classifier speed	Particle size
Constant	Constant	Constant	Constant	Base line
Constant	Constant	Constant	Higher	Finer
Constant	Constant	Constant	Lower	Coarser
Constant	Higher	Higher	Constant	Coarser
Constant	Lower	Lower	Constant	Finer
Smaller	Constant	Lower	Constant	Finer
Larger	Constant	Higher	Constant	Coarser

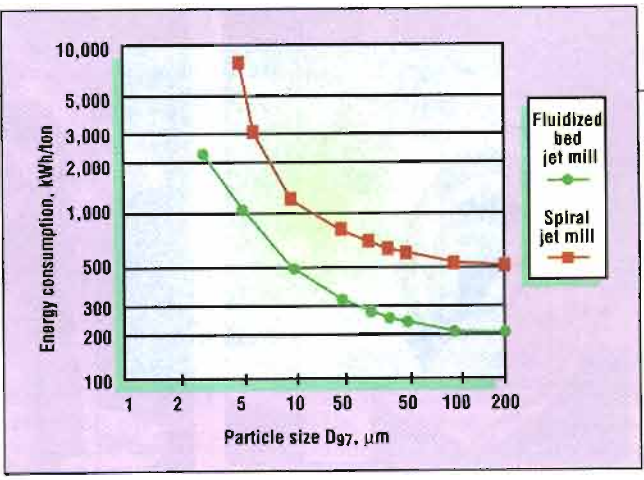

FIGURE 7. A fluidized-bed jet mill is more energy-efficient than a spiral jet mill

An FBJM has fewer limitations than does a spiral jet mill. There is no real limitation on feed size, as gravity-feed inlets from 2 to 10 in. dia. are common. The problems of material build-up and scaling in the mill are virtually non-existent because material does not circulate or impact against the mill walls. The vertical velocity of air and product in the chamber is about 1.5 m/s.

The latest versions of FBJM control the particle size distribution of the product. Adjustments to the integral air-classifier allow tight control of the upper particle-size of the product. A greater mass-force is exerted on the particles by increasing the rotational velocity of the classifier wheel. Smaller particles are rejected and returned to the grinding zone. Conversely, when the classifier speed is reduced, it lets larger particles pass through the classifier wheel, and the result is a coarser particle-size distribution.

A higher airflow through the classifier wheel results in an increased drag-force, and a coarser particle size distribution. With control based on two inputs, an FBJM can produce an infinitely adjustable particle-size distribution. This description of interactions is summed up in Table 4.

Dry-media mills

The horizontal dry-ball mill is commonly applied to mineral powders, refractory materials, and chemicals. In closed circuit operation with a classifier system, the dry-ball mill produces powders with an end fineness in the range D_{97} = 10–40 micrometers. Two or more powder fractions of different fineness can be produced simultaneously by use of one or more classification stages.

Armored cylinders can be used for materials of low-to-medium hardness, (below 4 Mohs), even with those containing a slight amount of abrasive impurities. The armor plates are replaced when they wear out.

For hard-mineral applications, or where iron-contamination-free processing is required, the mill cylinder can be lined with flint or ceramic materials such as hard porcelain or aluminum oxide. The choice of grinding media is steel balls, in non critical applications, and flint, aluminum oxide, steatite, or hard porcelain for iron-contamination-free processing. Grinding media shapes can vary from spherical to cylindrical to irregular, and can be as large as 25 mm in diameter.

The cylindrical ball mill combines a high packing density with a high surface area of the grinding media. This results in high transfer of energy to the material being ground.

While the ball mill is relatively simple technology, the classifier used in the grinding circuit is relatively sophisticated and the main factor in determining product quality. Adjustment of particle size is the same as described in Table 3 although distribution of sizes is not as precise as the jet mills (Figure 8).

A newer version of dry-media mill is the dry vertical pearl-mill (DVPM). This machine is used for the production of powders in the fineness range of D_{97} < 10 micrometers. Some are used for the manufacture of ultrafine fillers at powder fineness values of $D_{80} < 2$ micrometers, with a high specific surface area. Other materials processed in a DVPM are limestone, quartz, zircon sand, talc, ceramics, ceramic pigments, glass, TiO_2, gypsum, alumina, aluminum hydroxide, and wollastonite. Compared to a jet mill, the DVPM discharges a flatter particle-size distribution with a higher fines content at the same maximum size and yet consumes less than one-half the grinding energy. However, in some cases, the DVPM will retain the material structure, such as the high length-to-diameter ratio of talc and wollastonite. The materials need to be preground to a fine feed size before this mill can operate. Even so, the two steps have less of an energy cost than trying to do all in one mill.

The grinding media in a DVPM are smaller than the balls of a ball mill. The pearls can be made from silicon carbide, aluminum oxide, or other suitable hard materials between 200 micrometers and 5 mm dia. The jacketed grinding chamber can be lined with wear-resistant materials, such as aluminum oxide. This ensures iron-free processing and guarantees a high degree of product whiteness in typical products such as calcium carbonate.

Size reduction in a DVPM is a result of shear forces between the rotating grinding media and the product. A finer particle-size distribution and higher specific surface can be achieved because of the smaller grinding media size.

Like the horizontal ball mill, the DVPM is used in a circuit with a high-efficiency, centrifugal, forced-vortex air classifier to control maximum size. But, the DVPM discharges both product and grinding media. This simultaneous discharge prevents blocking of the mill outlet and also helps dissipate heat from the grinding process. The product is separated from the media by a sieve and then conveyed to an air classifier. The oversize from the classifier and the separated grinding media are fed back into the mill, along with fresh feed material, while the fines are transported away as product.

Wet-media mills

Wet-media mills are similar in many respects to dry-media mills, but are usually employed when finer particle-size distributions are required, or when the end product will be used as a wet slurry. Paints and inks are typical ex-

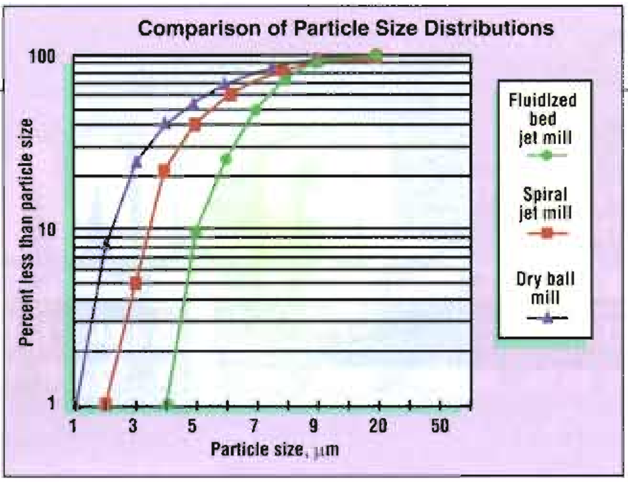

FIGURE 8. The fluidized-bed jet mill has a tighter particle-size distribution than a spiral jet mill or a dry-media mill

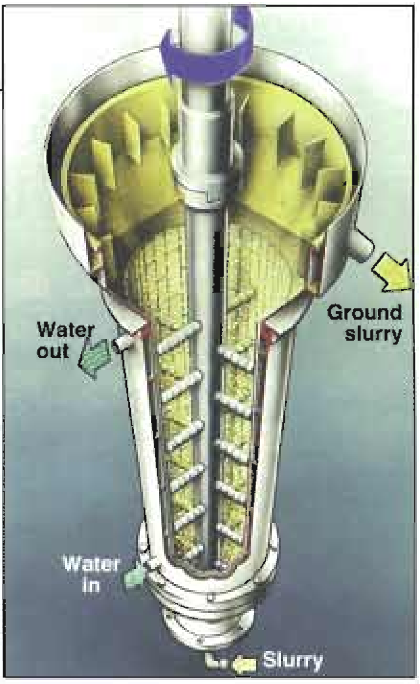

FIGURE 9. In a wet vertical pearl-mill, the feed slurry is pumped into the bottom of the mill and is discharged at the open mill head

amples. Other materials have been successfully manufactured using wet processing technology, including limestone, kaolin, talc, wollastonite, TiO_2, iron oxide, Al_2O_3, SiC, tungsten carbide, various metals, ceramics, food products and colors.

Wet-media mills can produce particle-size distributions that are not possible or not economical in dry processing. Wet-media mills complement dry-powder processing equipment and are of two distinct designs. The first is a wet vertical pearl mill (WVPM) built like a common stirred-attritor with an open top and a vertical shaft. It is similar to the DVPM.

The WVPM is a conventional open-top design with a vertical agitator-shaft and a top-mounted drive (Figure 9). The feed material, at slurry concentrations up to 70%, is pumped into the bottom of the mill and is discharged at the open mill head. It is wear-protected with a ceramic lining, a hardfaced metal or a rubber coating. The grinding pearls can be made of a variety of materials, such as zirconia, silicon carbide, and stainless steel, in sizes ranging from 2 to 4 mm.

The second, more-innovative design is a radial agitated-disc pearl mill (RADPM). This features a disc-shaped grinding zone with internal circulation of the grinding media. To get steep and uniform particle-size distribution with strict top-size control between 2 and 20 micrometers. The RADPM is built in a circuit with a wet, radial-deflector-wheel classifier.

The WVPM is designed for the processing of medium-hard to hard minerals at high production rates. It operates with feeds of no larger than 500 micrometers, product fineness of $D_{97} \approx 1.0$ micrometer can be achieved. The geometry of the mill ensures uniform energy input, therefore uniform grinding and particle size distributions.

The RADPM is a new and innovative design when compared with the WVPM. It is intended to process high-value-added minerals, metals and ceramic materials at medium-high throughput ranges, and high concentrations (usually about 70% solids). The agitator and grinding zones of a RADPM are disc-shaped with a radial-flow pattern. The grinding pearls are recirculated internally and returned to the grinding zone. A slotted screen, well above the grinding zone, prevents the pearls from exiting the grinding zone with the slurry. The grinding pearls are smaller than those used in a WVPM, not exceeding 2.5 mm, resulting in an operating range finer than the WVPM. The feed material is in the 100-micrometer range, with end product fineness (D_{97}) possible in the submicron range.

Some examples will show the advantages of adding a classifier to a RADPM. In one application, the classifier was used as a preliminary separation stage to remove the fines fraction, preventing over-grinding. The more-concentrated coarse fraction was then ground. The end result was a steeper particle-size distribution achieved at reduced specific energy as compared with not removing the fines. In another application, the classifier was used to separate the fines from a slurry after grinding and to return the oversized particles to the feed stream. This is similar to the classifier function in a dry-media mill grinding circuit.

Test before you buy

The chemical engineer tasked with the selection of a suitable grinding system has many options to consider. The properties of the raw material, the required particle size, the need for product purity, and the hazards associated with handling the material, such as dust explosions or toxicity, all have to be evaluated. There is also the cost factor of the process vs. the value added to the material. The installed cost of equipment can be minor when compared with the cost of operation.

This article and consultations with vendors provide a rough screening. However, the best way to determine the most suitable process equipment for a specific application is to conduct technical trials to answer the following questions: Can we process this material at all? Can we process it economically? Can we process it safely? What scale production equipment will we need? How much will it cost? You need answers to all these questions before making a final decision. ■

Edited by Peter M. Silverberg