Reprinted from Powder and Bulk Engineering, June 2002

Universal mill: Grinding versatility in an economical package

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Are you searching for a versatile grinding machine to handle multiple bulk products? One solution may be a universal mill. The mill uses grinding tools that can be interchanged to handle a range of soft to medium-hard materials, providing the advantages of customized grinding in one housing. After outlining the universal mill's components, operation, and maintenance, this article gives information on grinding tools, special applications, and mill selection.

A universal mill is a form of mechanical impact mill that fractures and reduces particles with high-energy impingement. Called *universal* because it can be fitted with interchangeable grinding tools, the mill handles a range of feed characteristics and produces final products that meet various particle size requirements. By combining the capabilities of more than one mill in a single housing, the universal mill provides grinding versatility while conserving capital equipment outlay.

The universal mill can grind feed materials of up to 3.5 Mohs hardness, including pharmaceuticals, chemicals, fertilizers, cosmetics, food products, animal feeds, and mineral powders. The mill accepts feed materials with an average particle size typically up to 2 inches; a larger mill can handle materials up to 4 inches. The resulting final average particle size can range from fairly coarse to as fine as 20 microns. To grind heat-sensitive materials such as resins, the mill can be equipped with a grinding tool that generates high airflow and a wide housing that enlarges the grinding chamber and dissipates the grinding heat. [***Editor's note:*** Also see the later section "Special applications."]

Mill components, operation, and maintenance

The universal mill is available in lab- or pilot-plant sizes, such as for pharmaceutical production, and in full-scale production sizes from about 6 to 27 inches (measured in terms of grinding tool diameter). Grinding capacities can range from a few kilograms to many tons per hour, depending on factors such as the feed characteristics and the desired final particle size. Construction materials for the mill's contact surfaces include carbon steel, hardened steel, cast iron, stainless steel, and sanitary-standard polished stainless steel.

Components. The universal mill, as shown in Figure 1, consists of a vertically oriented housing with a large door. Inside the housing, mounted on a motor-driven rotating shaft, is a grinding tool — a rotating disc (called a *rotor disc*) fitted with pins or teeth or a rotating wheel-like rotor fitted with blades or bars.

When the mill is fitted with a pin rotor disc, a second disc is mounted inside the mill's door so that its pins or teeth intermesh with those on the rotor disc. The door's disc can remain stationary or rotate; in the latter case, the door is fitted with a drive assembly that turns the disc counter to the rotor disc's rotational direction.

When the mill is fitted with a grinding tool other than a disc, the tool fits inside a *stator* (also called a *basket*), as shown in Figure 2, which adjusts the final product's fineness. The stationary, ring-shaped stator can be a screen, grinding track, or combination screen and grinding track. (No stator is required with a pin rotor disc.)

The universal mill's grinding tools can be removed and replaced easily and quickly. The time required to change the tools depends on the mill size: A 6-inch mill's grinding tool can be changed in a matter of a few minutes, and a 12-inch mill's tool takes about 30 minutes. Because handling the tools for larger mills typically requires lifting equipment, tool changes for larger mills can take somewhat longer.

Operation. The feed flows from a volumetric feeder by gravity through the universal mill's inlet, which directs the feed into the grinding chamber's center. The grinding tool (or tools) rotates at high speed, creating centrifugal force that accelerates the feed particles outward. The particles' high-speed outward flow hurls them against the pins, blades, or other elements at the tool's periphery. The particles' impact with these elements and other particles fractures and reduces them.

With disc grinding tools, desired-size particles exit the disc periphery and flow toward the mill's bottom outlet.

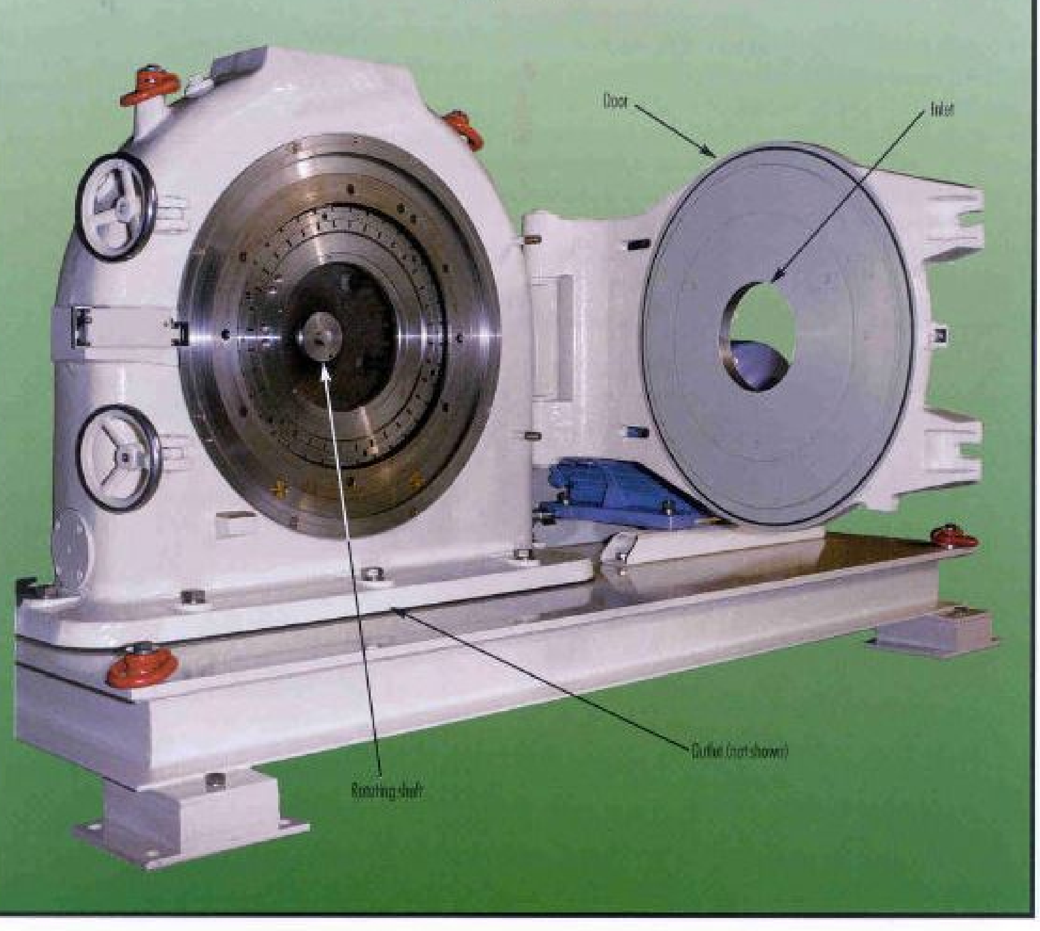
With other grinding tools, the reduced particles pass through the bars or blades to the stator:

- With a screen stator (Figure 2a), the desired-size particles pass through the screen openings (which can be of various shapes) and exit the mill's bottom outlet.

- With a grinding-track stator (Figure 2b), oversize particles impact the track's ribbed surface and bounce back into the grinding chamber for further grinding, and desired-size particles exit through the stator's rear discharge slot.

Figure 1

Universal mill



• With a combination stator (Figure 2c), the screen sections control the final product's upper particle size by allowing desired-size particles to exit the screen openings, and the grinding track sections deflect oversize back into the grinding chamber for further reduction.

Figure 2

Stators

a. Screen

b. Grinding track

c. Combination screen and grinding track

After exiting the mill, the particles fall by gravity or are drawn by a pneumatic conveying system to downstream processing or storage.

Maintenance. Regular preventive maintenance will keep the universal mill running smoothly. A critical maintenance step is inspecting the grinding tools and stators for wear. A screen stator can require more frequent inspection because it's subject to blinding and breakage. Rapid tool or stator wear can indicate a feed problem, such as overfeeding due to an improperly selected feeder.

More about the grinding tools

Your feed's characteristics and the particle size your final product requires are major factors in determining which grinding tool is best suited to your application. Some common grinding tools are shown in Figure 3.

Pin discs. Dry crystalline and brittle feeds, such as sugar, aspirin, sodium bicarbonate, kaolin, and carbon, can be handled by a mill equipped with *pin discs* (Figure 3a). When only one disc rotates, the pin discs can typically achieve a final average particle size of less than 50 microns. Fineness is controlled by the rotor disc's speed (which controls the disc's peripheral speed) and the number and arrangement of pins on the discs. When both discs rotate, the peripheral speed is much higher, and the final average particle size can be less than 30 microns. The higher energy applied during this operation, called *counter-rotation*, generates more heat and can require cryogenic cooling (discussed in the later section "Special applications").

Pin discs are often the best option for drug and food applications because they require no stator, eliminating stator screen-blinding problems and the need for grinding-track cleaning. The pin discs are also easier to access for good manufacturing practice (GMP) clean-in-place applications.

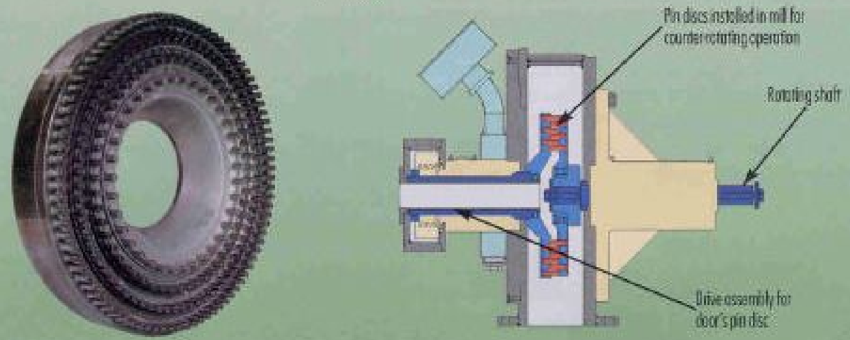
Wing beater. The universal mill can be equipped with a *wing beater* (also called a *blade beater* or *plate beater*), as shown in Figure 3b, to reduce soft, medium-hard, and some fibrous feeds to a final average particle size of less than about 400 microns. Typical soft feeds include coarse talc and lactose; medium-hard feeds (and those with abrasive impurities) include glass fibers, toner pregrind, and polyvinyl chloride; and fibrous feeds include coconut shells, herbs, root drugs, and wood. The wing beater has a series of rigid, replaceable blades around its periphery and is mounted inside a stator. The tool is often used with a screen or combination stator for soft to medium-hard feeds and with a grinding-track stator for medium-hard and fibrous feeds. The final particle size can be controlled by adjusting the tool's peripheral speed and choosing a particular stator.

Blast rotor. A *blast rotor* (also called a *turbine rotor* or *turbo rotor*), as shown in Figure 3c, allows the universal mill to

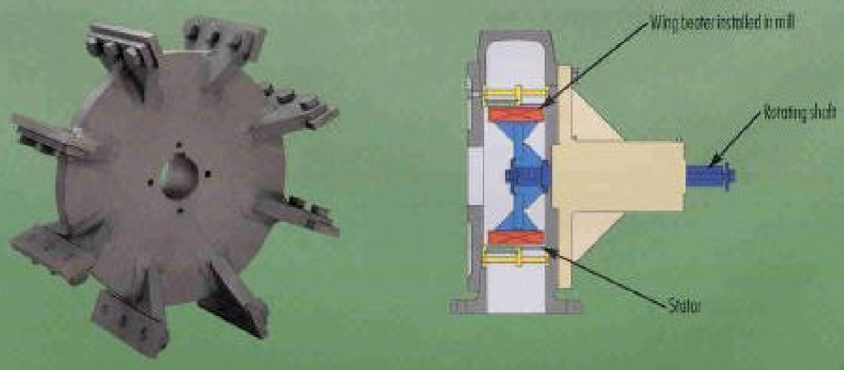
Figure 3

Some common grinding tools

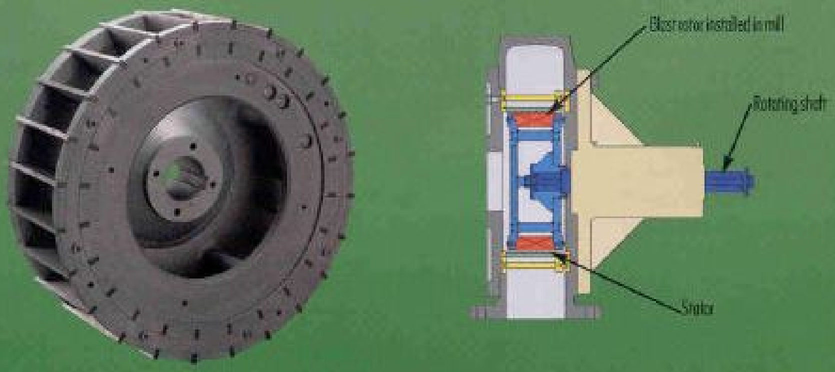
a. Pin discs



b. Wing (also blade or plate) beater



c. Blast (also turbine or turbo) rotor



grind feeds ranging from brittle to elastic, including most of the materials handled by the other grinding tools. The blast rotor also handles feeds that are slightly abrasive (such as limestone containing a minor abrasive component) and feeds that are temperature-sensitive (such as resins and powder paints). The tool can achieve a final average particle size of less than about 40 microns. The blast rotor consists of several rigid, replaceable bars or blades mounted inside a pair of rings. It operates like a turbine, generating a large volume of airflow during grinding and quickly dissipating the grinding heat so the mill can handle temperature-sensitive feeds. The blast rotor is mounted inside a screen or combination stator. As with the wing beater, the final average particle size can be controlled by adjusting the tool's peripheral speed and choosing a particular stator.

Others. Various other grinding tools, many of them proprietary to one mill supplier, are available to grind feeds with particular characteristics, such as high moisture or fat content and extremely soft or fibrous consistency, and to produce a particular final particle size. Depending on its design, a grinding tool can apply impact, shear, or both to reduce the particles. [***Editor's note:*** For more grinding tool information, contact the author and suppliers listed under "Universal" (page 211) in the "Mills" section in *Powder and Bulk Engineering's 2001-2002 Reference & Buyer's Resource* (August 2001).]

Special applications

To handle potentially explosive products, the universal mill can be constructed of components that are pressure-shock-resistant up to 10 bar. The mill's inlet and outlet can also be fitted with pressure-shock-resistant and flame-proof isolation valves (such as rotary and slide-gate valves). For further protection, fire-detection and -suppression systems and similar components can be installed in the mill and related equipment.

Although it's a more complex and costly option, the universal mill can also be installed in a closed-loop inert-gas grinding system to handle potentially explosive products. The system reduces explosion risks by using an inert gas such as nitrogen to reduce the oxygen content of the air in the mill. The closed-loop system can also handle products that tend to oxidize or undergo property changes in contact with oxygen.

The universal mill can be adapted for cryogenic grinding. This allows the mill to handle a product that can't be ground to the desired size at ambient temperatures (such as rubber or thermoplastics, which are too soft at ambient temperatures to be fractured during grinding) or to handle a product that's degraded by heat (such as a spice or flavoring that loses essential oils at high temperatures). In these applications, a cryogenic fluid can be sprayed into an upstream feed trough (or similar unit) to cool and embrittle the feed before it enters the mill. The fluid can also cool the air flowing through the mill during grinding.

Mill selection

Base your selection of the universal mill's components and features, including grinding tools, stators, and construction materials, on your feed and final product requirements. During the selection process, expect to work closely with the universal mill supplier. The supplier will ask you to describe the characteristics of each of your feeds, including the material type, particle size distribution, bulk density, flowability, friability, abrasiveness, temperature sensitivity, moisture or volatile content, and chemical corrosiveness. You'll also need to identify which properties — such as particle size distribution, bulk density, and moisture or volatile content — each of your final products must have.

During the selection process, expect to work closely with the universal mill supplier.

Considering where the mill will be located in your process is also important. The selected mill components will affect which upstream and downstream equipment, such as feeders and dust collectors, will best suit your grinding process. For instance, if your mill discharges by pneumatic conveying and one of the grinding tools you select is a blast rotor, you need to consider the high airflow volume produced by this grinding tool when sizing the dust collector and related ductwork downstream from the mill.

Once these preliminary selection steps are completed, the supplier's test center can run grinding tests with your feeds. The results can help establish which universal mill grinding tools and stators, which rotation speeds and other operating variables, and which mill size will best meet your grinding requirements. **PBE**

For further reading

Find more information on universal mills and other grinding equipment in articles listed under "Size reduction" in *Powder and Bulk Engineering*'s comprehensive "Index to articles" (in the December 2001 issue and at www.powderbulk.com).

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