BASIC JET MILLING AND COSMETIC APPLICATIONS

This article provides basic information on jet mills, how they work, and how they’ve evolved for cosmetic applications.

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Jet mills are particle size reduction equipment that use high-pressure compressed air to direct powdered material into a chamber, grinding the material into single-digit-micron-sized particles. The size reduction results from high-velocity particle-on-particle collisions and the particles colliding with the chamber walls. The grinding chamber’s interior allows the oversized particles to recirculate, enhancing the incidence and the effect of these collisions. As particles are reduced in size and progressively lose mass, they naturally migrate toward the chamber’s central discharge port, which helps make precise classification both automatic and controllable. By creating a one-step milling and classifying process, jet mills have continued to increase their presence in new and varied markets.

Cosmetic applications
Jet mills have been used in the cosmetics industry for nearly a century. According to cosmetics historian James Bennett, in the 1930s the Lady Esther brand of loose face powder became the top-selling brand in the US. The company reached — and maintained — that position, in part, by promoting its loose face powder as the very finest and encouraged customers to conduct a “bite” test. A Lady Esther ad told customers: “Take a pinch of your powder and place it between your front teeth. Bring your teeth down on it and grind firmly. If there is any trace of grit in the powder, it will be as instantly detectable as sand in spinach.”

The promotion was so successful that cosmetics competitors set out to find new processes and equipment that could produce products also capable of passing the bite test. One competitor, Coty, began processing a line of fine powders using air mills and called them “airspun.” In 1937, chemists began researching the necessary particle size required to pass the bite test. Chemist M.S. Smith conducted experiments with volunteers and determined that particles would need to be 12 microns (0.012 mm) or less to pass the test. This was much smaller than the particles being produced by the powder mixing and sifting processing methods that most powder manufacturers used at the time.

Milling evolution
Jet milling technology definitely has evolved in the decades since the bite test, which has benefitted industries beyond cosmetics. When compared with other dry powder particle size reduction methods, jet mills offer advantages including:

- Fine milling and tight particle size distribution
- Low contamination risk due to the absence of media, blades, knives, or screens
- No mill temperature rise due to expanding air creating a cooling effect. (This is especially important for temperature-sensitive materials such as cosmetics.)

A stainless steel jet mill system operating with a dust collector and material receiver.
Jet-milled particles in sizes larger than 10 microns generally are the hard-to-fracture polymers such as toner compounds or hard waxes and some organic materials. Reducing power to the mill or increasing the feedrate permits the grinding of other materials to sizes larger than 10 microns. Running at elevated feedrates with a low grinding pressure, which changes how a material compacts, allows the use of jet mills to polish or remove particles’ sharp edges. While other milling methods might be able to achieve an average particle size of less than 10 microns, the particle size distribution produced by a jet mill might be considered its biggest asset. Figure 1a shows the particle size distribution of a ball-milled material while 1b shows the same material processed in a jet mill. As you can see, the main curve in the graph depicting the jet-milled material moves to the left — showing a decrease in size — but the particle size distribution also narrows. This is particularly important for high-value materials where process yield becomes important. Table I shows the achievable particle size distribution for several materials today with a well-designed jet mill.

Potential disadvantages include:

- High process requirements for compressed-air (or other gas)
- Relatively lower productivity compared to some other size reduction methods
- Need for system equipment additions, such as a dust collector, create a potentially larger equipment footprint

Many different compressed gases can power jet mills, all starting at around 100 psig. Commercially compressed air is by far the most commonly used gas, but super-heated steam (no moisture is present in the super-heated state) is used in very large installations grinding primarily titanium dioxide pigment. Nitrogen is commonly used when a material needs to be ground in an inert atmosphere to protect from oxidation and possible fire or material explosion. Argon also has been used for this purpose when the less expensive nitrogen has been unsuitable. Light gases such as helium also have been experimented with because of the possibility of even higher-velocity impacts, creating more energy and further increasing particle size reduction.

Typically, a well-designed jet mill can grind friable or crystalline materials down to an average 1 to 10 micron particle-size range. Some materials, such as some molybdenum compounds, paint pigments, and similar materials, can be reduced down to particles as small as 200 nanometers. A jet mill’s work in the nanosize range also can involve the deagglomeration of nanosized particles. The expected throughput from a jet mill helps provide for good production scalability. Unit sizes range from a 2-inch mill producing 15 lb/h to a 36-inch mill producing multiple tons per hour, satisfying a range of applications from research and development laboratories and pilot plants to large-scale production facilities.

### References


### Table I

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<tr>
<th>Material</th>
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<tr>
<td>Mica</td>
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<td>Pigments (from oxide)</td>
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<td>Zinc oxide</td>
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<td>Talc</td>
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</table>

### FIGURE 1

Particle size distribution of ball-milled and jet-milled material

a. b.

For further reading

Find more information on this topic in articles listed under “Size reduction” in *Powder and Bulk Engineering*’s comprehensive Article Index in the December 2018 issue or the Article Archive on PBE’s website www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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