Six strategies for combating abrasion in your low-speed blender — Part I

Heinz Feibert and Bill Purse Charles Ross & Son Company

Abrasion problems aren't confined to high-speed mixing equipment: They also affect low-speed blenders — namely, ribbon blenders and vertical cone screw blenders — with equally serious results. This two-part article outlines six strategies for fighting abrasion in your low-speed blender. Part I covers the first two strategies as well as low-speed blender basics and tips for assessing the wear potential of your abrasive materials. Part II, which will appear in the July issue, covers the final four abrasion-fighting strategies.

In a high-speed, high-energy mixer with 7,000-fpm or higher tip speeds, abrasive dry bulk materials can erase an agitator blade's steel edge in no time. But abrasive wear can also seriously damage low-speed blenders — whether a ribbon blender or vertical cone screw blender[1] — with tip speeds of just a few hundred feet per minute. In fact, after only a year or two of mixing abrasive materials, your low-speed blender can end up with paper-thin agitators and a shaft ready for the scrap pile. [*Editor's note:* For basic information on low-speed blender operation, see the sidebar "A quick look at low-speed blenders and how they work" on page 20.]

Consider an abrasive powder's effects on a ribbon blender: Left unchecked, the powder will do much more damage than simply wear the ribbon blender's agitator blades and shaft. The powder will tear apart the blender's seals and stuffing box. Once the powder has invaded the stuffing box, it grinds away the shaft. The grinding increases with every revolution, spreading and deepening the shaft's eroded area and producing more friction. The result? The blender needs more maintenance. Downtime increases. Overall blending efficiency declines.

This abrasive action is essentially the same as that in a high-speed mixer, except that in a low-speed blender the action is in slow motion. Most of the engineering strategies and technologies that work in preventing abrasion in high-speed equipment will also work in a low-speed blender, significantly extending the blender's working life and long-term value.

Balancing engineering and business factors in preventing wear

As you approach the blender manufacturer to specify your low-speed blender for an abrasive application, keep in mind that determining the best strategy for your application isn't just an engineering problem. There are many strategies in the design engineer's playbook for preventing excessive wear in your blender, and the correct solution strikes a balance between blender performance and cost — that is, between the nuts and bolts of engineering and the dollars and cents of doing business.

The questions you should ask at the start of the specification process reveal the relationship of engineering and business factors in the blender's design:

How abrasive are the materials I'm blending? Are the materials mildly abrasive? Or are they extremely abrasive like limestone, tungsten carbide, or ceramic powders? How quickly will they grind down a typical low-speed blender? [***Editor's note:*** Find more information in the sidebar "Assessing the wear potential of your abrasive materials" on page 24.]

A quick look at low-speed blenders and how they work

Figure A

Ribbon blender

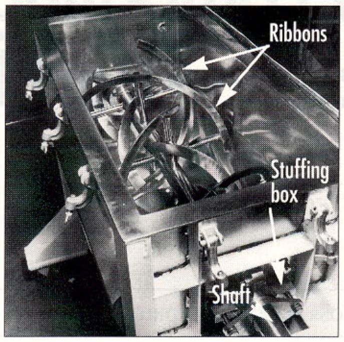
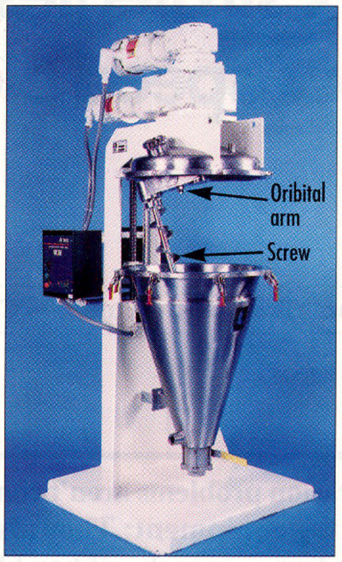


Figure B

Vertical cone screw blender



The low-speed blenders discussed in this article are those equipped with agitators to assist blending. Types include the ribbon blender, often considered the workhorse of solids blending, and the vertical cone screw blender (also called a *vertical orbiting screw mixer* or *conical screw mixer*).

Ribbon blender

A ribbon blender, as shown in Figure A, consists of a long, horizontal, U-shaped trough equipped with a rotating shaft that's fitted with agitators in the shape of narrow helical blades, called *ribbons.* The shaft is powered by a drive motor. Typically, a *stuffing box* at the point where the shaft enters the trough forms a pressure-tight joint around the shaft seal. The stuffing box is stuffed with packing material to prevent materials inside the blender from contacting and wearing the shaft.

In operation, the shaft rotates and the ribbons simultaneously move some material inward toward the blender's center and some outward toward its periphery along the trough's length. This provides a high-energy blending action at low speed. Tip (peripheral) speeds are typically around 300 fpm, depending on the application.

A variation of the blender that has wider, thicker paddles mounted on a shaft rather than narrow ribbons is called a *paddle blender.* Unlike ribbons, the paddles lift the material as they move upward through it. The paddles also displace more of the material on the downward stroke than ribbons do. The blender operates at about 200 fpm. One common application is blending fibrous materials, such as fiberglass or wet shredded paper, that tend to clog the clearance between a ribbon blender's ribbons and the trough wall, stalling the machine.

Vertical cone screw blender

A vertical cone screw blender, as shown in Figure B, consists of a cone-shaped vessel and a screw agitator that rotates while orbiting around the vessel's perimeter. A drive motor with a drive assembly powers the screw's rotation; typically, a smaller drive motor is connected to an orbital arm to provide the screw's orbital movement. The screw can be supported at the bottom by a support bearing or can be suspended from the top by the drive assembly (in which case the screw is called an *unsupported screw*) to facilitate discharge and simplify maintenance and cleaning.

In operation, the rotating screw gently lifts the materials, which then tumble and slide down along the vessel wall as the screw orbits. This provides low-speed blending (typically with a tip speed around 100 to 300 fpm) while applying less energy than the ribbon blender.

—PBE

How valuable will the final product be? If you blend a high-value product, you can justify a high-value blender equipped with wear-resistant features because the final product will pay for the blender within a reasonable time. But if your blend has lower value, this decision will be more difficult.

Will I be blending this final product over a short- or long-term production run? If your final product is well established, you can justify a well-equipped wear-resistant blender because you can expect to operate the blender long enough to recoup its cost. But be prepared to adjust your focus as conditions change. If you're specifying a blender for a pilot project producing an unproven product, you may want to specify a conservative pilot-scale blender design, expecting wear to be severe over a short period. Then, when demand for the product takes off and it's time to scale up your operation, choose a full-scale blender with wear-resistant features for the long haul.

As long as the stuffing box is properly installed and aligned, it will work well in a ribbon blender handling abrasive materials.

Providing answers to these questions is the first point where you and the design engineer must begin to think alike. Instead of withholding some information about your application, you need to provide as much detail as possible so the engineer can recognize the business context in which your blender will operate. In this way, you'll receive the full value of the engineer's experience in designing the blender to meet your needs.

To accept or prevent abrasion?

Abrasive wear to your low-speed blender can be approached in two ways: You can recognize that it's inevitable or try to prevent it.

Many users believe that abrasive wear is as inevitable as taxes or that preventing wear — using exotic steels, engineered composites, and sophisticated coatings — is generally prohibitively expensive. Others believe wear is just another engineering challenge to overcome and that selecting the right wear-prevention technology will effectively meet that challenge.

These two perspectives are combined in the following six strategies for specifying a low-speed blender that can handle abrasive wear. The strategies also offer plenty of flexibility in designing a blender for your application.

Strategy 1: Go with the flow

The simplest strategy, especially when you can't spend much money on wear prevention, is to expect wear in your low-speed blender. In designing a ribbon blender, for example, this would mean specifying a heavier-than-usual gauge of carbon steel for the ribbons and trough. This simply provides more steel in these components, which allows for more erosion loss and extends the working life of the ribbons and trough.

Specifying heavier-gauge steel can also be appropriate for a vertical cone screw blender, but only when the unit handles extremely abrasive materials. This is because the vertical cone screw blender provides gentler blending than the ribbon blender, generating less friction on the agitator and vessel wall.

For most abrasive ribbon blender applications, you can specify a stuffing box for the blender's submerged shaft seal. The stuffing box forms a pressure-tight joint around the shaft seal where the shaft enters the trough and is packed with sealing material to prevent particles inside the blender from contacting and wearing the shaft. Some say that a stuffing box is "old-fashioned" and should be replaced by a mechanical seal. Often this is because they've experienced problems with a misaligned stuffing box that leaks; the blender operator typically responds by over-tightening the stuffing box, which makes the leak worse. However, as long as the stuffing box is properly installed and aligned, it will work well in a ribbon blender handling abrasive materials.

A mechanical seal is seldom needed in a ribbon blender, even when the blender is equipped to operate under vacuum. It typically doesn't seal the shaft better than a properly installed and aligned stuffing box but adds substantial up-front and maintenance costs. Maintenance on a stuffing box is simpler, faster, and less costly.

A vertical cone screw blender typically isn't subject to stuffing box wear problems because the stuffing box isn't submerged in the material inside the blender.

Strategy 2: Slow down!

Another common-sense strategy for reducing wear is to slow the blending process. By slowing the blender, you can substantially reduce wear because the slower speed greatly reduces the friction applied to the agitator and vessel. This solution is more suitable for a ribbon blender because a vertical cone screw blender already operates at a lower speed.

As appealing as this easy solution may be, slowing the blending action has serious limitations: Slower operation lengthens the blending cycle and cuts throughput.

Assessing the wear potential of your abrasive materials

The wear threat posed by some abrasive materials to your blender is obvious. But for others, you must carefully consider the threat based on:

- The materials' particle size and physical properties.
- The action of your blender.
- Process changes during the blending cycle.

For example, a powder blended with a liquid may pose a small abrasive threat while the mixture remains a slurry. But when the liquid is forced off during a later vacuum drying phase in the blender, and the material becomes a fine, lightweight dust, the material's potential for causing abrasive wear to the blender may increase sharply. For this reason, during the blender's design it's important to consider each step in your process and how it can increase or reduce abrasive wear to blender components.

Some common examples of materials likely to cause abrasive wear in a blender include sugar, salt, ceramics, minerals (such as quartz crystals), cement, sand, metal oxides (such as iron oxide and aluminum oxide), silicon carbide, tungsten carbide, pigments, and fillers. Some surprising examples are shredded paper and plastic — both can be extremely abrasive under some circumstances!

—H. Feibert and B. Purse

For a 5-cubic-foot ribbon blender operating at 70 rpm, you can probably reduce the speed to 65 rpm without threatening blending performance. For a 155-cubic-foot unit operating at 24 rpm, you can probably slow it down to 20 to 22 rpm. The ribbon blender's speed can't be reduced much more than 5 to 15 percent because it's limited by a critical threshold in efficiency. A slower speed will cause the material flow's fluid characteristics to drop off abruptly, making proper blending impossible. This critical efficiency threshold varies from one application to another because each material behaves uniquely. Before you purchase your blender, the manufacturer should perform tests to determine the threshold for your application.

Whether you choose a ribbon or paddle blender, verify the blender's optimal blending speed for your materials before you buy the machine.

One way to overcome this efficiency threshold in a ribbon blender is to switch from ribbon agitators to paddles. The paddles in this blender (now called a *paddle blender*) suffer less abrasive wear than ribbons because the paddle blender normally operates at two-thirds of the ribbon blender's speed. The paddles can generally be made thicker to compensate for abrasive wear, and their plowing action makes the paddles less subject to sliding abrasion.

Whether you choose a ribbon or paddle blender, verify the blender's optimal blending speed for your materials before you buy the machine. Also reserve some flexibility for accommodating future process changes by specifying a variable-speed drive for the blender. **PBE**

Next month: The remaining abrasion-fighting strategies will appear in Part II in the July issue.

Reference

1. This article concentrates on low-speed blenders equipped with agitators. For information on other low-speed blenders or general mixing and blending equipment, see the next section, "For further reading."

For further reading

Find more information on blenders in articles listed under "Mixing and blending" in *Powder and Bulk Engineering*'s comprehensive "Index to articles" (in the December 1999 issue and at www.powderbulk.com).

***Heinz Feibert** is product manager for ribbon blenders, vertical cone screw blenders, and custom-built mixers and tanks at Charles Ross & Son Company, Box 12308, Hauppauge, NY 11788; 800/399-4569, fax 631/234-0691 (hfeibert@rossmixing.com). His expertise includes engineering, manufacturing, and pressure vessel design and fabrication, and he's been with the company for 17 years. **Bill Purse** is senior engineer at Ross, specializing in product design and standards, applications, and technical service. He's been with the company for 13 years.*