Selecting a sifter for scalping, removing fines, or grading

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A sifter (also called a screener) is a unique and often misunderstood machine compared with other equipment in the powder and bulk solids handling industries: Only one material goes into a sifter, but two or more materials come out. This article takes the mystery out of the machine by discussing sifter uses, where to install a sifter, sifter types, and selection factors.

Any dry free-flowing material can be handled in a sifter, including pharmaceutical and cosmetic powders; wood chips and wood flour; minerals such as limestone, pumice, and silica; food products such as wheat flour, sugar, and baking soda; plastics and rubber; and pigments such as carbon black. The sifter mechanically separates the material according to individual particle size by moving the material in relation to a screen.

You can use a sifter in a quality assurance program to scalp material, remove fines, or grade material. You can also use a sifter to grade material in a manufacturing process.

- For **scalping**, the sifter’s most common quality assurance application, the sifter removes oversize or foreign materials. These can be agglomerates and lumps in materials such as flour mixes, as well as foreign materials such as insects, bin wall scale and flakes, moldy material, or tramp metal.

- For **removing fines**, the sifter removes undersize and dusts the material to meet final product specs. This is useful for friable materials that give off fines or other materials that release fines in response to excessive or rough handling. Typical applications include removing fines from dried herbs, spices, sugar, and granular pharmaceuticals.

- For **grading**, the sifter controls both oversize and undersize in your material. A common example for quality assurance is grading sugar to simultaneously remove the lumps and fines. In manufacturing, in addition to removing coarse oversize and fines, grading can produce multiple intermediate particle sizes in materials such as wood particles or polystyrene beads.

In each of these uses, sifting provides another benefit: Passing through the screen aerates the material, which gives it a more uniform bulk density for subsequent processing and handling steps.

**Where to install a sifter**

For quality assurance applications, especially for sanitary applications such as food manufacturing, the traditional sifter location is immediately prior to your material’s final point of use. This will provide quality control of the material as close as possible to its use in your final product and your customer’s use of the product. Any problems that come to light after you analyze the sifter tailings can help you pinpoint a problem with the material supplier, the transport company, or your own plant. If you produce a material mixture that has a tendency to agglomerate, you can also sift it after dry blending.

The next most common sifter location for quality assurance is immediately after raw materials are received. When materials are received in bulk, the sifter can be inserted into a pneumatic unloading system to sift the mate-
siffler's quality control and sanitation practices while materials before they reach bulk storage. Sifting at this point allows you to monitor the supplier's and transport company's quality control and sanitation practices while allowing you to remove contaminants before they can enter your bulk storage vessels. When raw materials are received in small bags, the bags are emptied directly into the sifter before the materials are moved to storage or processing. The sifter not only breaks up and removes lumps but separates any torn bag pieces, strings, or other contaminants from the raw materials.

For a manufacturing application such as grading, a common sifter location is just prior to packaging and shipping. This allows you to package different grades of material for shipment to specific customers.

During sifting, each material behaves in a unique way.

Less commonly, a portable truck-mounted sifter can also be stationed outside a plant or shipping container for either quality assurance or manufacturing applications. For instance, the truck-mounted sifter can supply emergency sifting for scalping oversize or contaminants from a shipment of material to your plant. The material can be conveyed from your receiving silo to the truck-mounted sifter, which removes the oversize before the material enters your process. The truck-mounted sifter can also be used to transload material from a train to trucks. For instance, a flour mill in the Midwest can ship flour in a unit train to a central location nearer its bakery customers. Here, the truck-mounted sifter can remove contaminants while transferring the flour to bulk trucks. Each bulk truck can then deliver a contaminant-free load to an individual local bakery.

Sifter types

When classified by their application, sifters are either gravity-flow or in-line units.

In a gravity-flow sifter, shown in Figure 1a, material flows at atmospheric pressure through the sifter by gravity. The material can be fed to and carried away from the sifter by a pneumatic conveying system (shown in the figure) or mechanical conveyors. With a pneumatic conveying system, two blowers are typically required, one for conveying material to the sifter and one for conveying material away from it. However, the machine is designed to sift material without the influence of positive or negative airflow on the sifting motion.

Using the gravity-flow sifter can require auxiliary equipment such as a cyclone or filter receiver, airlocks, a blower package, and associated dust control equipment. However, the gravity-flow sifter itself costs less and is less likely to leak than an in-line sifter. If the flexible connections linking the sifter's inlet and outlet to the conveying equipment fail, less spillage will result because of the sifter's operation at atmospheric pressure. The gravity-flow sifter also allows you to separate your material into multiple fractions and more easily use metal detectors.

In an in-line sifter, shown in Figure 1b, which is installed directly in a pressure or vacuum pneumatic conveying system, the material flows with the conveying air at the conveying line pressure into and then away from the sifter. But because the pressure is equalized above and below each screen in the sifter, no force other than gravity causes the material to pass through the screen. Only one blower (that for the conveying system) is required, thus simplifying the operation and reducing the system's cost by eliminating the need for auxiliary equipment. This limited amount of equipment also reduces the system's installation costs, including those for electrical controls, and reduces maintenance and power costs over the system's life.

Whether used for a gravity-flow or in-line application, the sifter typically provides one of several types of screening motion. Each type of motion results from the differential movement between the screen and particles at a given amplitude and speed. Usually the particles are moved in relation to the screen, but in one case (the centrifugal sifter, described in the next subsection), the particles move while the screen remains static. For best sifting results, the material must be metered uniformly to the sifter and be well distributed over the full screen surface with minimal agitation. The particles naturally stratify, with fine particles migrating to the material bed's bottom and thus having maximum exposure to the screen surface.

The most common types of screening motion are centrifugal, vibratory, gyratory-reciprocal, and gyratory. Each motion typically is suitable for sifting any dry free-flowing material, but has advantages and disadvantages you need to consider before selecting a sifter for your application.

Centrifugal. A typical centrifugal sifter is shown in Figure 2a. In operation, an integral screw feeder meters material into the sifter's stationary screening chamber, which is formed by a cylindrical screen. Rotating beaters or paddles in the chamber impact the material and accelerate its movement through the screen, shown in Figure 2b. This high velocity presents the particles to the screen surface many times, providing many chances for the particles to pass through the screen.

Moving material so quickly requires high energy. Containing this energy causes the screen to deflect and flex, which helps prevent screen blinding without requiring screen cleaners (which are discussed in the next section). Although all screens eventually fail, the centrifugal sifting
motion’s flexing severity reduces the screen life more than other sifting motions.

The centrifugal sifter is compact and typically easy to disassemble and maintain. It doesn’t have flexible connections at the inlet and outlet, eliminating this common source of leaks. According to most centrifugal sifter manufacturers, the sifter can break up soft agglomerates in sticky materials or materials that contain fat, which can be an advantage in some applications.

However, the centrifugal sifter has relatively high power requirements, applies high stresses to the screen, and isn’t typically suited for precise separations of near-sized particles. Current Baking Industry Sanitation Standards Committee guidelines suggest using sifters that “employ no rubbing or physical pressure to facilitate” flow through the screen; the centrifugal sifter’s rotating beaters do apply rubbing or pressure, which can be a concern for food products because the beaters can fracture particles and force them through the screen.
**Vibratory.** A vibratory sifter, shown in Figure 3a, has horizontal screens. Each screen is typically mounted in a round frame; each screen and frame together form a screen deck. (Each screen deck also includes a large-opening wire mesh, called a backwire, that's mounted below the screen to hold a set of screen cleaners, such as rubber or plastic balls or cubes. The cleaners bounce against the screen's bottom surface during sifter operation to prevent screen blinding.) Material is fed into the sifter as a drive mechanism applies both short, back-and-forth linear motion and vertical motion to each screen, shown in Figure 3b.

The vibratory sifter’s benefits include its simple drive mechanism, which makes the sifter inexpensive, and its simple design. However, the vertical motion tends to disturb the particles’ natural stratification on the screen surface, so that material tends to be airborne much of the time rather than in contact with the screen; this, coupled with the sifter’s short linear stroke, reduces the sifter’s efficiency. Because the sifting motion is relatively small, relatively little energy is imparted to the sifter’s screen cleaners, which can lead to screen blinding. The machine also won’t break up lumps or agglomerates, but this may not matter for some applications.

The sifter has an additional disadvantage for grading applications: its inefficient use of screen area. This is because
most vibratory sifters have only one screen per size grade, providing the same screen surface area for each grade, regardless of the quantity of material in each grade. So, for instance, if the sifter separates a material into four grades (greater than 10 mesh, between 10 and 20 mesh, between 20 and 40 mesh, and less than 40 mesh), the sifter’s capacity would, for most applications, be limited by the 40-mesh screen area. As a result, excess screen area would be provided for the 10- and 20-mesh screens.

Gyratory-reciprocal. A gyratory-reciprocal sifter, shown in Figure 4a, has a rectangular, relatively steeply inclined screen and a drive mechanism that imparts a gyratory motion at the sifter inlet end and a reciprocating, linear motion at the outlet. Together, these movements produce a gentle elliptical motion, shown in Figure 4b, that both conveys the material and promotes particle flow through the screen.

The sifter’s benefits include its simple design and gentle sifting motion. The sifter also requires little headroom because, for each mesh size required, only one screen deck is used to provide the application’s required screen area. The screen’s incline and linear motion at the discharge also help it convey bulky material or high volumes of material from the inlet to the outlet.

However, the sifter’s conveying action can limit the particles’ maximum exposure to the screen openings, reducing the sifting efficiency. The screen’s large area results in other disadvantages, including increasing the sifter’s required floor space and making the screen unwieldy and awkward to handle for service or replacement. Like a vibratory sifter, the gyratory-reciprocal machine isn’t usually configured to accurately allocate the screen area required for the application.

Gyratory. A gyratory sifter, shown in Figure 5a, consists of a stack of multiple square, rectangular (Figure 5a), or round (Figure 5b) screen decks. Multiple screens in the stack can have the same mesh size to provide the required screen area for the application. A drive mechanism imparts a circular motion in a horizontal plane to the screens, shown in Figure 5b. The horizontal screens and lack of vertical motion produce the sifter’s gentle sifting motion and maintain the material’s natural stratification — with fine particles adjacent to the screen and coarse particles at the material bed’s top.

In an application producing only two fractions, multiple screens arranged in a series provide the required screen area. The oversize pass from one screen to the next, and each screen removes a portion of the particles that pass through it while the oversize continue to pass from one screen to the next.

In an application producing more than two separations, the gyratory sifter provides a major benefit: Because it uses smaller stacked screen frames, the screens can be accurately allocated to each separation’s requirements. For instance, to handle the grading application previously discussed for the 10-, 20-, and 40-mesh screens, the gyratory sifter’s screen area would be allocated appropriately. Typically, the 10-mesh separation would require a smaller screen area and thus fewer screens than the 20-mesh, and the 20-mesh would require less than the 40-mesh. The result is that no excess screen material, cleaners, or maintenance would be required for underused screens and screen frames.

You should also be aware that a common misconception when the gyratory sifter uses multiple screens with the same mesh size is that the material is sifted repeatedly on each screen. This isn’t the case. Instead, as the material enters the sifter, the gentle motion immediately stratifies the material. Fines are in contact with the screen and begin to pass through. The fines that didn’t pass through the first
screen along with the oversize flow onto the next screen. Separated materials of the same size discharge together from the sifter in individual channels. As long as the sifter is correctly designed for the material and flow rate, only oversize will remain and travel over the last screen to exit the sifter.

Other benefits of the gyratory sifter include both its gentle motion and its lack of vertical motion or incline, which makes the sifting efficient and provides accurate material separation. The screens are typically smaller and easier to handle than those on a vibratory or gyratory-reciprocal sifter with equal screen area. The screen cleaners also work more efficiently than in a vibratory sifter because the gyratory motion imparts more energy to the cleaners.

However, the gyratory sifter has a more complex flow pattern and more complex drive mechanism than other sifters, which can make the unit harder to operate and maintain. The gyratory sifter’s gentle motion won’t break up lumps or agglomerates. The sifter’s stacked-screen design also requires more headroom than other sifters.

Selection factors
To choose a sifter for your application, you need to consider several factors. Begin by analyzing your material characteristics. Then consider factors about the sifter, including the sifting motion, screen, screen tension, screen attachment method, and screen cleaners.

Material characteristics. During sifting, each material behaves in a unique way. For instance, a granular, free-flowing material is easier to sift than a fine, sticky material. The key material characteristics that affect sifting performance by promoting or slowing the material’s flow through the sifter are:

- Particle size distribution (including the distribution for each ingredient in a material mixture).

- Particle shape (spherical, flat, irregular, interlocking, or other).

- Oil and moisture content.

- Temperature (which can be high after processing or pneumatic conveying).

- Bulk density.

- Electrostatic charge (which can increase after grinding or pneumatic conveying).

Work closely with your sifter manufacturer to determine how these factors will affect your sifter choice.

Sifting motion. The amount of energy imparted to your material during sifting greatly affects the process. Choosing the right sifting motion (centrifugal, vibratory, gyratory-reciprocal, or gyratory), the right sifter speed, and the right stroke or amplitude of motion will provide the right amount of energy for distributing your material over the full screen surface with minimal agitation. Applying too little energy can cause a sticky material such as starch to sit in a mass on the screen. But applying too much energy can cause a free-flowing material such as whole grains or pellets to bounce around rather than fall through the screen.
Work with the sifter manufacturer to test your material on various sifters at various speeds. This will help determine which sifting motion and speed are best for meeting your requirements.

**Screen.** Consider screen type, mesh size, and open area to select the screen for your sifter.

**Screen type:** Screen can be synthetic (either nylon or polyester) or wire (stainless steel, magnetic stainless steel, carbon steel, or plated or coated carbon steel).

Nylon screen often lasts longer than polyester, but can absorb moisture and lose screen tension. Either type of synthetic screen resists fatigue better than wire. In sifting, especially in a centrifugal sifter, the screen is constantly flexing. Resistance to fatigue is an important consideration for obtaining long screen life.

Wire can be thinner than synthetic filament, thus producing screen with a greater open area and higher sifting capacity than synthetic screen. Eventually any screen will fail, and fragments that break off the wire screen and fall into the material can be detected by a metal detector, which is important in many applications. However, the wire diameter in some screen can be so small that a detector must be carefully selected and calibrated to detect the tramp metal, particularly since its largest dimension won’t always be oriented toward the detector.

Maintaining proper tension on the screen will keep your material well-stratified.

One option for solving this problem is to use magnetic stainless steel (400 series) wire screen because fragments of this wire can be removed from the sifted material by magnets. However, the wire is more brittle than carbon steel or 300-series stainless steel wire and thus is more likely to fail due to fatigue. The magnets also must be regularly inspected and cleaned to ensure that they effectively remove the tramp metal.

**Mesh size:** Choosing mesh size is critical in selecting a screen for your sifter because the right mesh size allows an efficient sifting rate while ensuring that oversize particles and contaminants are effectively removed from the on-size particles. Mesh size, as shown in Figure 6, is the number of openings in the screen, in each direction, from center to center of parallel filaments or wires per linear inch. For instance, a 30-mesh screen has 30 openings per linear inch. If both mesh measurements $M$ shown in Figure 6a are 1 inch, then the mesh size for the top section is 1 mesh and for the bottom section is 2 mesh.

**Open area:** In addition to specifying the mesh size, also specify the opening size, or open area (measurement $O$ in Figure 6a). In Figure 6b, all the mesh sections have the same mesh size but different mesh opening sizes, with resulting differences in the percentage of open area. The greater the open area, the greater the sifting capacity.

The data in Table I shows how open area can vary among different screen types with matching or very similar mesh sizes. In the table, the filament or wire diameter, mesh opening size, and open area for US Standard 30-mesh screen are compared with those of some commercially available screens.
The 30-mesh US Standard mesh screen is listed only for comparison. This screen is used for particle sizing tests and isn’t suitable for production applications because, besides not being widely commercially available for sifter screens, its filament diameter is so large and the resulting open area is so small that its sifting capacity is extremely limited. The open area in the next four screens (the first two are wire and the last two are nylon) matches the US Standard 30-mesh screen’s open area as closely as possible. For instance, the 3-590/42 screen (3 indicates nylon, 590 indicates the opening size in microns, and 42 indicates percent open area) is equivalent to 28 mesh, and the 3-600/51 screen is equivalent to 30.2 mesh.

In the table, you can see that the open area varies widely for these similar screens. Monitoring this value is a good way to ensure that the screen you choose can provide the capacity you need, because the greater the open area, the greater the opportunity for particles to pass through the screen. But consider more than open area, because in some screens, obtaining a greater open area comes at the cost of reducing the filament or wire diameter. This reduces the screen’s durability. If screen life is important to your application — for instance, if you sift an abrasive material — you may choose to select a smaller open area and, thus, lower capacity in return for larger-diameter filaments or wires that will extend the screen life.

**Screen attachment method.** One factor in achieving the right screen tension is to select an effective method for attaching the screen to the screen deck frame. The attachment method also affects the sifter’s performance and the screen’s sanitation level and maintenance ease. There are two main screen attachment types: mechanical and bonded.

**Mechanical attachment:** Mechanical attachment requires no special tools, equipment, or adhesives, allowing the screen to be removed and replaced on the frames by workers in your plant. The screen can have grommets that are attached to hooks on the frame. Another option is a screen with looped edges into which stainless steel rods are inserted; the edges with the rods are then clamped and tensioned around the screen frame by set screws. Mechanical attachment methods require very accurately fabricated screen edges to maintain good screen tension. Even when properly fabricated, the screen’s resulting tension can be lower than that achieved with a bonded attachment method. Material can also collect between the screen edges and the frame, posing a contamination risk.

**Bonded attachment:** Bonded attachment requires stretching the screen over the frame with mechanical or pneumatic equipment, which develops better tension than mechanical attachment, and then bonding the screen edges to the frame by gluing them in place. The improved tension improves sifter and screen cleaner performance and increases the screen life. The glued edges also eliminate spots for potential material buildup. Stretching equipment and adhesives for replacing bonded screens in your plant are available for some sifters. If you prefer not to invest in the equipment and adhesives, you can send the screen frames back to the manufacturer for rescreening or, when removing the adhesive isn’t possible or practical, discard the frames and buy new ones.

**Screen tension.** Maintaining proper tension on the screen will keep your material well-stratified, ensuring that the fines are in contact with the screen but preventing the material from pooling on the screen. A well-tensioned screen also flexes less, extending its life. The screen will be easier to keep clean, because the screen cleaners can bounce harder against the taut screen. Consult your sifter manufacturer for help determining the right screen tension for your sifter.

**Screen cleaners.** Screen cleaners for vibratory, gyratory-reciprocal, and gyratory sifters are available in many materials (typically rubber or plastic) and types, including balls, cubes, belts, and other molded shapes with studs or brushes.

Ball cleaners are effective for dislodging near-size particles, but they can pack or tamp sticky materials against the screen’s underside. Cube cleaners scrape or scour the screen’s underside and are particularly effective for cleaning oily or sticky materials, but can be hard on the screen. Belt cleaners or molded cleaners with brushes are effec-
tive because they wipe the screen’s underside. However, they tend to disintegrate faster, and the resulting loose threads or bristles can contaminate your material.

Work with your sifter manufacturer to determine which cleaner type and quantity is best for your material and capacity requirements. If your sifter’s capacity or performance eventually drops because of screen blinding, try switching to a different type or quantity of cleaner or use a combination of different cleaners.

Reference

1. More information on portable truck-mounted sifters is available from the author.

For further reading

Find more information on sifters in articles listed under “Screening and classifying” in Powder and Bulk Engineering’s comprehensive “Index to articles” (later in this issue and at www.powderbulk.com).

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