

Selecting and Sizing Process Screening Equipment

by Alex C. Young

Screening is a mechanical process that separates material according to individual particle size. This is accomplished by transmitting a particular motion to a screen medium that is made of wire mesh or perforated plate. The motion causes particles smaller than the screen's openings to pass through as fines and particles larger than the openings to carry over as tailings. See Fig. 1 for additional screening definitions.

Types of Screening Functions

There are basically three types of screening functions: scalping, grading, and fines removal. Scalping removes a small amount of oversize material (5% or less) from a feed that consists predominantly of fines (at least 50% half-size). Scalping capacities are the highest of all screening functions.

Grading separates material by particle size using single or multiple screen surfaces. These separations can be coarse (larger than 4 mesh), medium (4 mesh to 48 mesh), or fine (smaller than 48 mesh). Grading capacities vary and depend on the characteristics of the feed material, the separations to be made, and the product specifications.

Fines removal removes a small amount of fines material (10% or less) from a feed that consists predominantly of oversize particles. Relatively high capacities are attainable, particularly when the amount of fines to be removed is less than 5 % of the original feed.

Material Characteristics

The characteristics of the material to be screened are fundamental to selecting and sizing process screening equipment. Perhaps the most important characteristic is the particle distribution of the feed material, as determined by a sieve analysis. The analysis is expressed in percentages of particle size groupings as retained on testing sieves, which are available for use on a variety of particle size analyzers.

Sieve analysis provides several clues to the expected screening performance. In Table I, the particle distribution of feed material X shows that only 2 % of the feed material is larger than 8 mesh. As a result, a scalping operation can be used to separate the material and a high capacity can be expected. If a 28mesh separation is also required, then a grad- ing operation is necessary. This can significantly reduce the capacity and be the determinant in selecting a two-deck screener.

Test Sieve	Percentage Retained
+ 7	0.4
+ 8	1.6
+ 9	4.3
+24	51.1
+28	15.4
+32	17.6
-32	9.6

Sieve analysis also measures the amount of near-size particles—those particles close in size to the desired separation. The greater the amount of near-size particles, the less the capacity will be for a given efficiency. When a near-size cluster is present in excess of 25%, screen blinding can occur.

Particle Configuration

Particles are described in many ways, such as granular, crystalline, flaky, spherical, fibrous, cylindrical, elongated, sliver-like, and irregular. The configuration of individual particles is a characteristic that distinctly affects the ease of screening a given material.

For instance, uniformly shaped granular particles (with no single, transverse dimensions) screen more readily, producing higher, capacities and efficiencies. Spherical particles also screen well if the separation does not take place in a concentration of near-size particles, which blind easily. Because spherical particles are near-size in every dimension, they can lodge into an opening regardless of the alignment at which they enter the opening. .

By contrast, elongated sliver-like particles (with substantial differences between their maximum and minimum transverse dimensions) screen poorly. Identical sliver-like particles align to the screen openings so that some particles pass over the openings and some pass through them even though the particles are the same size. In effect, this is sizing by length and not a good application for screening. Removal of a single fraction by length is possible., however, with a screen motion that prevents up-ending of elongated particles.

Fig. 1
Glossary of Screening

Accuracy of Separation: The trueness of a separation as measured by the amount of off-size material within a screened grade or cut. Not to be confused with efficiency. Also called *sharpness of separation*.

Amplitude: The distance traveled by the screen surface during one cycle. The definition of distance varies from one manufacturer to another: e.g. for a circular motion some consider the radius as amplitude, others consider the diameter. See **Stroke** for a better description of motion.

Angle of Repose: That angle to the horizontal that material will assume naturally when in a pile.

Aperture: An individual opening in the screening surface.

Ball Deck: A deck or tray beneath the control mesh that retains balls. The machine's motion causes the balls to bounce and impact against the underside of the clothing to reduce screen blinding.

Bed Depth: The thickness of the material layer as it traverses the screen surface.

Blinding: A condition, such as coating or plugging, that reduces the open area of the screen surface. See Fig. 3.

Cable Suspension: A method of screener installation-hung from overhead-that isolates or reduces the transmission of out-of-balance forces.

Capacity: The amount of material that a screener can handle under specified conditions. Capacity statements are meaningless if not related to other parameters such as efficiency, accuracy of separation, and particle distribution.

Cloth: The wire screening surface, woven in square, rectangular, or slotted openings. Also called *wire cloth* or *screen cloth*.

Coating: A condition of blinding where moisture or static causes undersize particles to cling to the screen openings. See Fig. 3.

Deck: The screening surface. Also used to describe the number of surfaces within a machine, such as single deck or double deck (two deck).

Degradation: Material breakage that is caused by handling, sometimes in the screener itself.

Efficiency: The ratio of the material amount passing through the screen surface to the undersize material amount in the feed that is available to pass through. Various formulas are sometimes used to factor in the presence of off-size material in the feed that passes through. Also called *product yield*.

Feed Rate: The amount of material presented to a screener for processing.

Fines: Particles smaller o size than the screen openings. Also called *thrus* or *undersize*.

Frequency: The number of times peak-to-peak amplitude or stroke takes place per unit of time, usually expressed in revolutions per minute or cycles per minute.

Mesh: The number of openings (and fraction thereof) per linear inch of screen cloth, as measured from the center of a wire.

Near-Size: Material that is very close to the size of the screen cloth opening, generally considered within a $\pm 25\%$ range.

Open Area: The ratio of the screen cloth opening area to the total screen surface area. Also called *percent open area*.

Overs: Material that passes over the screen surface. Also called *tailings*.

Plugging: A condition of blinding where near-size particles wedge or jam into the screen openings, preventing the passage of undersize material. See Fig. 3

Rate of Travel: The conveying speed of material over a screen surface, usually expressed in feet per minute.

Rejects: Unwanted material, either oversize or undersize.

Retention Time: The amount of time a particle spends on the screen surface.

Scalping: The removal of a small amount of oversize material (generally less than 5%) from feed that is predominantly fines (at least 50% half-size).

Sieve Analysis: The particle distribution of a representative sample of material. This is expressed in the percentages of a particle size group passing through and retained on standard testing sieves. (Tyler and U.S. Standard are the common standards n the U.S.)

Stratification: The process during screening where larger particles rise to the top of the bed of material and smaller particles sift through the voids to the bottom of the bed.

Stroke: The peak-to-peak distance traveled by the screen during one cycle; the diameter of a circular motion.

Testing Sieve: An instrument that uses stacked cylindrical screens with standardized apertures to determine the particle distribution of a representative sample of material.

Bulk Density

Another important material characteristic is bulk density. Since screening is a volumetric process, the bulk density of the feed material determines the bed depth, which, in turn, determines how easily stratification of fines will occur on the screen surface.

Surface Moisture

The presence of surface moisture adversely affects the screenability of most materials. Surface moisture causes particles to adhere to each other, making stratification difficult. The rate of travel is also reduces increasing the bed depth.

Static

Static charges also adversely affect screening operations. If the charge is sever enough to coat over the screen opening; screen blinding can occur. The use of static eliminating additives or the introduction c humidified air sometimes controls this condntion.

Screening Motion

The type of screening motion employed also affects screening performance. See Fig. 2. There are a variety of terms to describe the array of screening motions, and combinations of motions, that are available to the user. Some common terms include inclined vibratory, horizontal gyratory, and circular vibratory.

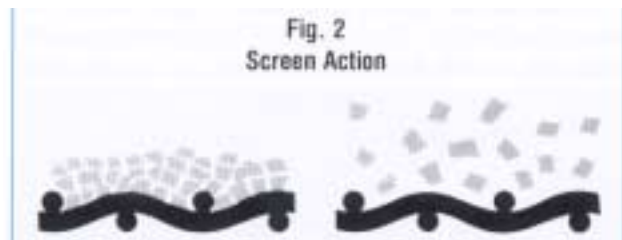


Fig. 2
Screen Action

Inadequate agitation dampens out particle stratification, resulting in inferior separations.

Too much screen action makes particles airborne, reducing the frequency of screen contacts necessary for efficient particle pass-through.

Regardless of name, all screening motions involve a combination of a given amplitude and speed in a particular alignment or plane. The objective is to distribute the material over the full screen surface and simultaneously induce stratification of fines through the bed of material without violent agitation or vertical hop. This permits finer particles to achieve maximum exposure to the screen openings for efficient separation. Equipment that employs a horizontal gyratory motion is generally acknowledged to provide this type of action at high-production rates.

Screen Blinding

Screen blinding is any condition—such as plugging, coating, or bridging—that reduces the open area of the screen surface. See Fig. 3. Blinding can be a cumulative or noncumulative condition. Cumulative blinding eventually leads to total blockage of all screen openings and a complete loss of the screening function. Noncumulative blinding, however, is a stable condition; only a certain percentage of openings are blocked at any given time. As one set of openings are cleared another set become temporarily blocked, and the process continuously repeats itself.

To prevent blinding, it is sometimes possible to use a different size screen opening to shift the separation away from the concentration of near-size particles, but this can produce an unacceptable product spec. The best solution is a screen mesh cleaning system that ensures rated capacities without sacrificing separation accuracy. There are many antiblinding devices that can be used to control or prevent this condition, including bouncing balls, brushes, wiping rings, and screen heaters. The selection of an antiblinding device depends on the type of screen motion and the nature of the blinding to be controlled.

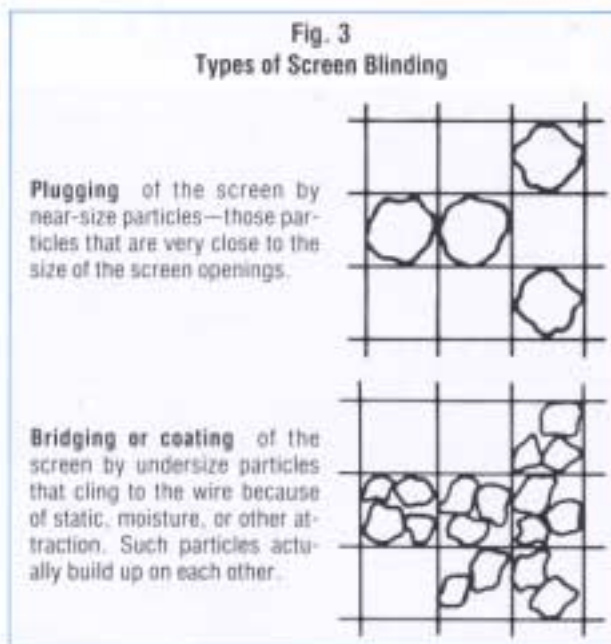


Fig. 3
Types of Screen Blinding

Plugging of the screen by near-size particles—those particles that are very close to the size of the screen openings.

Bridging or coating of the screen by undersize particles that cling to the wire because of static, moisture, or other attraction. Such particles actually build up on each other.

Screen Clothing Selection

For a given screen opening, the diameter of the wire screen can dramatically affect screening performance. The heavy wire screen shown in Fig. 4 lasts longer than a light screen with the same opening. The light wire screen blinds less easily, however, and handles more throughput since it has a greater percentage of open area. In practice, the selection of screen clothing is often a compromise between capacity, durability, and efficiency.

How to Specify Screening Performance

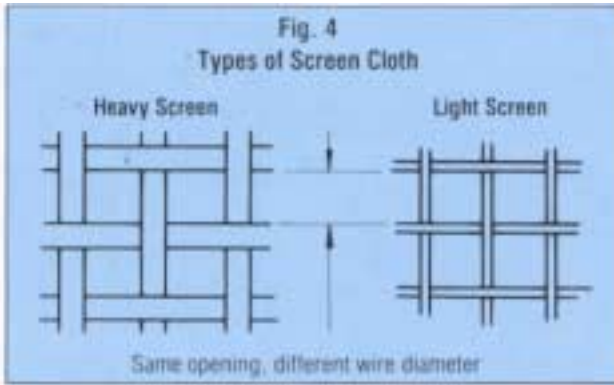
The proper selection of screening equipment begins with an accurate description of the application and the specific performance requirements. In general, there are three considerations: capacity, accuracy of separation, and product yield.

Capacity

Defined simply, capacity is the amount of material that a screener can handle under specified conditions. It is important to distinguish whether capacity is the amount of material fed into the screener or the desired output of a particular product. It is also necessary to account for any amount of material that can be recycled. Screening equipment should be sized to handle the maximum feed rate, even if it occurs for only a short period of time and not continuously. A screener should not be used as a surge-leveling device; it is not intended to handle surges of more than a few seconds in duration.

Product Accuracy and Product Yield

Product accuracy is a statement of the desired particle distribution of the finished product. Using the particle size distribution of feed material X given in Table. I, a product accuracy specification might call for a -9 mesh, + 28 mesh product to contain a maximum 5% + 9 mesh material and a maximum 10% -28 mesh material.



To quantify product yield, it is important to specify the maximum amount of allowable, usable product in the rejects. For instance, using the particle size distribution of feed material X, the rejects can contain a maximum 5% -9 mesh in avers mid a maximum 5% + 28 mesh in fines. In other words, for each screen deck or separation to be made, the accuracy can be defined by the amount of fines permissible in the material passing over the screen and the amount of avers permissible in the material passing through the screen.

A. Particle Size Distribution:			
Test Sieve	Percentage Retained		
+ 7	0.4		
+ 8	1.6		
+ 9	4.3		
+24	51.1		
+28	15.4		
+32	17.6		
-32	9.6		
B. Separation Yields Obtained:			
Overs (+ 9 mesh)	8.5%		
Product (- 9 mesh; + 28 mesh)	64.3%		
Fines (- 28 mesh)	27.2%		
C. Separation Analysis: (Percentage Retained)			
Test Sieve	Overs ^a	Product ^b	Fines ^c
+ 7	6.3	—	—
+ 8	24.9	—	—
+ 9	65.2	2.5	—
+24	3.6	62.0	—
+28	—	27.5	2.1
+32	—	5.9	62.4
-32	—	2.1	35.5
^a + 9 mesh ^b - 9 mesh; + 28 mesh ^c - 28 mesh			

How to Evaluate Performance

Most screener manufacturers offer testing services in their application laboratories. Due to the many variables that affect a final screen area selection, it is advisable to take advantage of these testing services.

The screener manufacturer should provide a test result report (see Table II) that addresses the performance parameters of capacity, product accuracy, and product yield.

In Table II, the separation analysis of the -9 mesh, + 28 mesh product shows the product to be on spec because it contains less than 5% + 9 mesh material and less than 10% -28 mesh material. The rejects (+ 9 mesh avers and -28 mesh fines) are also on spec; only

Test Sieve	Overs ^a	Product ^b	Fines ^c
+ 7	4.5	—	—
+ 8	18.7	—	—
+ 9	61.3	2.5	—
+24	15.4	62.0	—
+28	—	27.5	20.6
+32	—	5.9	52.0
-32	—	2.1	27.4
^a + 9 mesh ^b - 9 mesh; + 28 mesh ^c - 28 mesh			

3.5% -9 mesh material is contained in the avers and 2.1% + 28 mesh material is contained in the fines.

The desired product yield can be obtained by placing specifications on the reject avers and fines. For example, the separation analysis in Table III shows a -9 mesh, + 28 mesh product with the same particle distribution as that in Table II; however, the reject fractions of the avers and fines contain large amounts of good -9 mesh (15.4%) and + 28 mesh (20.6%) product. This represents inefficient screening, perhaps achieved on less screen area but at the expense of lost product.

Conclusion

When specifying and selecting screening equipment, it is important to establish precise specifications for the desired product quality. It is also necessary to define the acceptable limits of good product in the reject material. This translates into an optimum product yield, the proceeds of which will easily pay for the premium of purchasing high-efficiency screening equipment.



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