Metal contaminants in bulk solid materials can damage processing equipment, reduce product quality, and even harm consumers. This article provides a basic understanding of magnetic separators and describes what you should consider when selecting a separator to remove ferrous metal contaminants from your material.

Many bulk solids manufacturing operations use magnetic separators to remove ferrous metal contaminants from material during processing to ensure product quality, protect consumers, and prevent damage to downstream equipment. Ferrous metal contains iron, making it magnetic, and may enter the material stream in a number of ways at any stage during the manufacturing process.

A magnetic separator uses magnets to remove ferrous contaminants from the flowing material stream during processing. The magnets attract and hold contaminants passing over or near the separator. The captured contaminants then accumulate on the separator until they are cleaned off either manually or automatically.

Many factors influence magnetic separator selection. These include the size of the contaminants you’re trying to capture; your material’s characteristics such as bulk density and abrasiveness; and the specifics of your process such as the material flow rate and temperature. These factors can add up quickly and make choosing a magnetic separator confusing and overwhelming.

This article will explain the basics of magnetic separators to help you sort through these factors and select the best separator for your application. To ensure the best results, however, you should always work closely with a magnetic separator supplier with experience and expertise in a wide range of bulk solids handling applications.

**Separator configuration**

Magnetic separators can be configured in a number of ways. Common configurations include tube, grate, or drawer separators, plate separators, pulley separators, and drum separators. A tube, grate, or drawer separator uses one or more magnetic tubes placed directly in the material stream. Because material comes into direct contact with this type of separator, the magnetic field’s strength is concentrated at the magnet surface to hold contaminants once they’ve been captured. A plate separator is a magnetic plate that’s typically mounted within a chute, with the magnetic field’s strength concentrated away from the magnet surface. As material slides down the chute, the magnetic field “reaches out” into the flowing material, attracts ferrous contaminants to the magnet, and collects them on the plate. A pulley separator is a magnetic roll that’s used as the head pulley for a belt conveyor. The pulley attracts ferrous contaminants and separates them from the material during belt discharge. Clean material is thrown forward off the belt to the downstream process, while tramp metal is drawn around the pulley and discharged beneath the conveyor. A drum separator is a rotating magnetic drum that’s placed directly in the path of a falling material stream. As the material passes over the rotating drum, any ferrous contaminants are captured on the drum surface, rotated out of the flow stream, and discharged into a collection container.

The best separator configuration for your application depends on your material’s characteristics and your process. Free-flowing materials will typically flow well through a grate- or drawer-style magnetic separator, but cohesive materials may bridge across the openings between the magnets, stopping flow and causing production delays. With materials that have a high bulk density or processes that have a high flow rate, flowing material can wash off contaminants that have already been captured by the magnets and reintroduce the contaminants to the material stream, so magnetic strength is critical. Abrasive materials can wear through the magnets’ protective steel cover if the steel is too thin, so abrasive applications require a thicker steel layer to avoid having to frequently replace the magnets.

**Magnetic material**

Metal contaminants can range in size from fine particles, such as powders or flakes that wear off of a mill’s grinding components during normal operation, to large pieces of tramp metal, such as nuts and bolts.
that vibrate loose and fall into a raw material either during shipping or in the manufacturing plant. The mass of the ferrous particles in your material stream will help determine which magnetic material your separator’s magnets should be made from. Environmental conditions can also affect magnet performance and longevity. Heat, for example, degrades magnetism, so the temperature range where the magnet will be placed is another important factor to consider.

The most common magnets for magnetic separators are ceramic and rare earth. Ceramic magnets, which are made from iron, strontium or barium, and calcium, offer excellent “reach out” and can withstand temperatures up to 400°F. Reach out is the magnet’s ability to attract contaminants from a distance. Ceramic magnets are well suited for separating large tramp metal, with sufficient mass, and holding it in the magnet’s magnetic field.

Rare earth magnets have far superior holding power than ceramic magnets but are more expensive to manufacture. Rare earth magnets are made using the rare earth elements neodymium and samarium. Neodymium magnets consist of neodymium, iron, and boron and are the strongest type of commercially available magnet, but they’re subject to corrosion and have a limited maximum temperature (between 140°F and 350°F). Samarium cobalt magnets consist of samarium, cobalt, and iron and can handle temperatures up to 600°F but are more expensive to manufacture than neodymium magnets and have a somewhat weaker magnetic field.

Magnet applications
The magnetic separator’s location in the process stream is critical for maximizing contaminant capture and retention. In a typical processing plant, separator locations can be divided into three categories: primary, secondary, and finishing.

Primary. Primary separators are best suited for receiving areas, where the magnets can capture tramp metal in incoming raw materials to prevent damage to your processing equipment. Primary separators are designed to handle high-volume material flows and can retain large volumes of contaminants between magnet cleanings. A primary magnetic separator can also be helpful for monitoring vendor quality by capturing contaminants as raw materials enter your plant.

Secondary. Secondary separators are placed before (upstream from) sensitive process equipment, such as mills, airlocks, sifters, screeners, or pumps, that could be severely damaged by metal contaminants in the material stream. A secondary separator may also help detect failing processing equipment by capturing pieces that have broken off and entered the material stream. This can initiate required maintenance or repairs that may have otherwise gone unnoticed and prevent further damage to downstream equipment.

Finishing. Finishing separators are best suited for packaging and bulk load-out locations to ensure that your end product is contaminant-free when it leaves the plant. This is critical for protecting consumers, maintaining the brand’s reputation for quality, and avoiding product recalls.

Magnetic circuitry
Magnetic circuitry refers to how the separator is designed to attract and retain contaminants. Magnetic circuitry is very important for optimizing contaminant separation for a specific application and can be separated into three basic types:

Type A circuitry. Type A circuitry, as shown in Figure 1a, is used in applications that require the highest level of product purity. This circuitry uses one or more magnetic tubes placed directly in a free-flowing material stream. As material flows over the tubes, metal contaminants come into direct contact with the magnets’ working surface and are captured, resulting in a very high level of contaminant removal and retention.

Type B circuitry. Type B circuitry, as shown in Figure 1b, is designed with more emphasis on reach out and is best suited for larger material streams, where the entire stream doesn’t directly contact the magnet surface. Type B circuits may include features such as steps on a plate magnet, which help tuck contaminants out of the material stream to prevent the flowing material from washing the captured metal off of the magnet between cleaning cycles.
Type C circuitry. Type C circuitry, as shown in Figure 1c, can be used in applications with very high levels of tramp metal or high material flow requirements or where regular magnet cleaning may not be possible. Type C circuitry allows the magnet to continuously self-clean or retain a large amount of contaminant metal, making it ideal for magnet applications that don’t require the removal of fine contaminants.

Magnet cleaning

Regular magnet cleaning is critical to maintain a magnetic separator’s optimal performance. The recommended cleaning frequency will vary depending on the application and the amount of metal in the material. Many magnetic separators are available in quick-clean or self-cleaning designs, which can decrease downtime, prevent damage to the magnets, and improve worker safety. Also, a self-cleaning design may be necessary for separators that are difficult for workers to access or for processes where downtime for manual cleaning isn’t an option.

Magnet testing

Testing your magnets is an important part of separator maintenance and upkeep. You can test the strength of your magnets by using a gauss meter or a pull-test kit. A gauss meter is an electronic device that measures the strength of the magnetic field at a given point on a magnet. The meter can provide extremely accurate measurements in a controlled lab setting but is difficult to use effectively in the field. A pull-test kit is a simpler device that’s more practical and repeatable for regular testing of multiple magnets onsite. The kit uses a digital or spring scale to measure the force required to break the magnet away from a test fixture (a ferrous ball). You should test your magnets at least annually and document the test results. This will provide a record of the magnets’ performance over time so you can see changes that may indicate wear or damage.

Magnetic separator suppliers typically offer pull-test kits, gauss meters, and resources on proper testing procedures. Some suppliers also offer magnet audit services, where certified auditors regularly come to your plant to clean, inspect, test, and photograph your magnetic separators. These audits may also include a comprehensive report that can be used to meet Food Safety Modernization Act (FSMA) requirements for monitoring metal control system effectiveness.

Comparing quotes

Finally, when comparing quotes for magnetic separators, be sure that the quotes are for the same separator configuration and grade of magnetic material. This will ensure that you have an apples-to-apples comparison. A good rule of thumb is that if your quotes from different suppliers vary by more than 5 percent, the magnets being quoted are likely not the same and you should ask further questions to ensure that you’re getting the right piece of equipment for your application.

For further reading

Find more information on this topic in articles listed under “Magnetic separators” or “Metal detection/separation” in Powder and Bulk Engineering’s article index in this 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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