How to Choose and Use the Best Metal Separators and Detectors for Your Food Application

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In the food industry, ferrous metal contamination can damage process equipment and create an impure product that must be scrapped. This metallic contamination may come from a variety of sources; incoming products sometimes contain contaminants from the transportation vessel used to deliver the product, such as a tanker truck or railcar. Contamination can originate within the plant due to material processing, grinding, crushing or general abrasion. In some instances, contamination is introduced from plant staff accidentally dropping metallic objects into a container or stream of food or beverage.

Problems associated with ferrous metal contamination can be reduced or eliminated by using magnetic separation equipment. Magnetic separators are available in a wide variety of designs to remove ferrous material such as nails, rust, scale, bolts, welding rod and other contaminants from dry or liquid products. This article will also briefly discussion detection and separation equipment for nonferrous metals.

Selecting the proper magnetic separator requires an understanding of magnetic properties, the application and environmental elements in each specific installation. Processors are advised to consult with a magnetic separator supplier as early in the decision cycle as possible.

Permanent Magnet Materials

The magnet material specified in a separator product generally refers to the magnetic pressings or castings used to develop the magnetic field within the separator. This material may be cut and arranged in a linear fashion using other materials to create a magnetic circuit. Depending on the desired outcome, circuits may be designed to cast a shallow-wide magnetic field, a deep-narrow field--or anything in between. This is why it is often difficult to compare competing products made of similar materials. Once the circuit is assembled, it is usually encased within stainless steel to protect the magnet material from mechanical damage, wear associated with product flow or from contaminating the feed material. Today, there are a number of ways to compare magnetic strengths. Methods include pull tests, gauss and product simulations.

Since their inception in the early 1940s, there has been substantial change in the materials used to manufacture permanent magnetic separators. The following are the most common magnetic materials used over the past 80 years:

- Alnico: One of the earliest magnet materials used for ferrous separation. Alnico magnets are

castings of aluminum, nickel, cobalt and iron. They are commonly recognized by their horseshoe shape. Although seldom used today because there are more economical magnet sources, alnico may still be used in applications involving temperatures above 400 F (204 C). This material is comparable in strength to ceramic magnets and is used to remove relatively large pieces of ferrous metals, such as nuts or bolts.

- Ceramic: From the 1960s until the early 1980s, ferrite ceramic pressings were the standard for permanent magnetic separators. Ceramic pressings are easy to work with because they can be cut in any direction, assembled into a circuit and then charged as a complete unit. Ceramic-magnet circuits work best when the goal is to remove relatively large pieces of ferrous metal contamination.
- Rare earth: The term “rare earth” is a misnomer. This magnetic material derives its name not because it is rare, nor because it is earth. It is so named because part of its makeup includes at least one of the 14 lanthanide elements of the periodic table between 57 and 71. These are known as the “rare earth elements.” Samarium-cobalt was the first such material used in the early 1980s. The next material on the market was neodymium-iron boron. Today, rare earth magnetic circuits produce a magnetic force more than 10 times that of ceramic magnetic circuits. Today’s rare earth magnetic circuits are 50 to 66 percent more powerful than early versions. They can develop an extremely high surface force to enable the magnetic circuit to remove very fine or weakly magnetic contamination such as rust, scale or even work-hardened stainless steel from a product flow. High-strength rare earth separators are used by food processors requiring the highest levels of purity.

Application Considerations

Below are several factors to consider when choosing a magnetic separator for your food application.

Temperature: Permanent magnetic materials lose strength when exposed to elevated temperatures. Some losses are reversible, so that when the temperature is returned to normal, the magnetic strength returns. Depending on the specific material, permanent magnets heated beyond certain temperatures may also suffer irreversible loss—a reduction in strength that cannot be recovered by cooling. When specifying a magnet application, it is important to note the ambient as well as any clean-in-place (CIP) temperatures to ensure a proper magnet design suitable for long-term separation performance.

- Flow rate: Magnetic separators perform best when the contamination is presented to the surface of the separator. It is best to select a magnetic separator configuration that provides for a thin “burden depth” or thickness of the material layer over or under the magnet to ensure the magnet will have

the best opportunity to capture the ferrous contamination.

- Flow characteristics: Many products exhibit different flow characteristics when damp or moist. Are there large chunks that may plug an opening or gap in the separator? Will the product flow freely through the selected magnetic separator? For example, brown sugar with any significant moisture content will not flow between the tubes in a grate magnet assembly, although they may be positioned only 1 inch apart.
- Process issues: How will the material be presented to the separator? Is the material metered or do you need to handle surge flow? Can the system be stopped for cleaning or is a self-cleaning magnet required? Is access available for cleaning? Is there ferrous material in the area that may create a hazard for magnet handling? How much contamination is to be removed? And finally, what level of product purity is required?

Type of Material Processed

Assessing the material being processed is a key step in selecting the proper magnetic separator. Materials generally fall into three categories: dry, moist or liquid. A wide range of product variation exists within each of these groups, depending on the particle size of solids or viscosity of liquids.

Dry, free-flowing, granular product

If the particles are small and free flowing, a grate magnet may provide the best opportunity for the ferrous contamination to contact a magnet directly. Grates do the best job with vertical product flows, while plate magnets work well if the material is cascading down a chute. These product-cleaning methods require that the product flow be stopped when removing collected ferrous contamination from the magnet.

Pneumatic flows of free-flowing product work best with a magnetic “hump” configuration or radial field cartridge. These separators also require suspension of product flow for cleaning.

Drums, pulleys and suspended magnets can provide for continuous automatic removal of tramp metal without stopping the flow and require little or no cleaning.

Dry product with some bridging tendency

While grate magnets provide very efficient removal of fine metallic contamination, they do not work if the material cannot cascade between the magnetic tubes. Plate magnets do not restrict the flow of material and will not contribute to bridging if installed beneath a sloped chute.

Magnetic humps are recommended for less-than-free-flowing products, as long as the material will cascade down a sloped chute. Suspended magnets and pulleys may also work well if the material is conveyed with a belt conveyor or vibratory feeder.

Liquid or slurry products

Products in a liquid or slurry state require a magnetic trap. Traps are available in either a grate or plate type design. Many traps are built similar to grates in that tube magnets are arranged perpendicular to the flow inside in the body of a casting to “trap” any ferrous materials passing through. A U-Trap employs a flat plate magnet in a shallow body to minimize damage to the product flowing past. They are ideal for chunky-flow applications.

Plate Magnets

Plate magnets are used in the bottom of an inclined chute or suspended above a thin burden of material on a belt conveyor or stainless-steel vibratory feeder to remove occasional pieces of ferrous contamination. Plate magnets are simple and economical to install and are good at removing occasional pieces of tramp metal.

Some ceramic magnet models are effective in removing relatively large ferrous objects such as nuts, bolts, staples and welding rods from a dry product flow. Rare earth models will do a much better job on very fine or weakly magnetic contamination such as rust or scale.

In a typical chute installation, the magnetic contamination adheres to the magnet face while the product material slides across the face of the magnet. The magnetic field attracts and holds ferrous material until the plate is removed for cleaning. The magnet is usually hinged and swung away from the chute and cleaned manually.

Round pipe separators (RPS) are actually plate magnets with a fabricated transition from a round pipe to the rectangular chute that contains the plate magnet. The RPS consists of an inlet transition to match the existing pipe or tubing, a rubber deflector to direct the product against the plate magnet, then transitions back to the chute type magnet. The material flow must be stopped to clean the accumulated tramp metal from the plate magnet.

Hump magnets are like round pipe separators except that the fabricated chute utilizes two plate magnets instead of one. This extra plate effectively doubles the chances of collecting ferrous material. The hump

consists of a “dogleg” chute that allows the product stream to cascade from one magnetic plate to another as material moves through the dogleg. Units are available for pressure, vertical or horizontal pneumatic applications. The material flow must be stopped to clean each plate. Self-cleaning units are also available to cycle the plate magnet away from the flow so that a stripper may automatically remove the accumulated tramp metal from the plates. Deep-reach separators use a plate-magnet-style circuit but incorporates it into a vertical chute. They work well when sticky products do not readily flow down sloped chutes or when headroom is at a minimum. Two large magnet assemblies are often affixed to opposite sides of a stainless-steel chute and attract ferrous contamination as material flows by the chute. The magnetic circuit is designed for an exceptionally deep reach into the product flow, which makes these separators effective at removing large, chunky tramp metal.

Grate Magnets

Grate magnets consist of 1 inch diameter magnetic tubes in a grid formation designed to allow the feed material to cascade through the grate, effectively spreading magnetic protection through the cross-sectional area of a pipe, chute or hopper. As with plate magnets, ceramic models are effective in removing relatively large ferrous contamination such as nuts, bolts, or staples, while rare earth models are better on fine or weakly magnetic material such as rust or scale.

There are a variety of grate magnet designs to match almost every application. The simplest of these incorporate a single-layer magnetic grid for use inside a hopper so raw materials must pass through the grates as material feeds from the hopper. Multiple row units improve separation effectiveness. Some applications will utilize a single row of magnets and incorporate them into a grate housing assembly of the user’s design. Housings can also be fabricated to include one or multiple rows of magnetic grates with staggered magnetic tubes, depending on the level of protection required. These units are common for vertical chutes of free flowing materials.

Grate-housing designs may include a standard grate that is removed from the housing for manual cleaning. An easy-to-clean grate design provides for a push/pull operation to strip accumulated tramp metal from the grates without physically handling the magnet. Rotating magnet designs are available for materials that bridge or do not flow well. Self-cleaning units are also available to automate the cleaning process.

Pneumatic Line Magnets

The radial field (RF) cartridge magnet is ideal for pneumatic flows of any product typically conveyed with air

from a tank truck or railcar.

The assembly is designed to match the existing pipe and is then transitioned to a larger pipe that incorporates an enclosed magnet element.

The material cascades around the magnet and ferrous material collects on the magnet as it is conveyed through the assembly.

Pulley and Drum Magnets

Magnetic pulleys replace standard conveyor head pulleys and effectively convert the conveyor into a self-cleaning magnetic separator. As the conveyed material passes the head pulley and discharges in its natural trajectory, the magnets “scalp” large tramp metal from the burden, then discharge it as the belt pulls away from the backside of the pulley.

Drum magnets are self-cleaning magnet assemblies that continuously remove tramp metal from a product flow. The magnet assembly is enclosed within a stainless-steel drum and fixed in position. The drum rotates around the magnet, conveying material through the magnetic field. Clean or nonferrous material cascades off the drum face while the magnetic material is drawn around the drum and discharged at the bottom. As noted for plate and grate magnets, drum separators use ceramic magnet circuits to remove relatively large ferrous objects from a dry product flow, while rare earth models are better suited to removing very fine or weakly magnetic contamination.

Monitoring from Receiving to Shipping

A number of companies installed a series of liquid line B-Traps or dry pneumatic RF cartridge magnets at the processing door of their plants. When the tanker truck comes to the side of the building and hooks up their hose, the B-Traps or RF cartridges on the other side of building/wall ensure metal is not entering the plant.

When it comes to safety, magnetic separation and metal detection should be used throughout the entire process, especially at the beginning. Often companies are most interested in the end or final package. That may be satisfactory, but consider the added protection from contamination that is possible if the product is monitored from the start of the process.

For example, your plant relies on your suppliers to deliver clean, contaminant-free ingredients. However, once the product enters the plant, you assume responsibility for the ingredients.

There is great value to conducting an annual audit to see what changes are needed to improve product purity and protect equipment. Based on the latest advancements in technology, there are new options that can further improve product quality and protection. Plant-wide audits are also valuable.

Metal Detectors Enhance Purity

Plant operators shouldn't assume that every supplier is sending a perfectly clean product. As has been mentioned, there are many opportunities for contamination to occur before products arrive at the processing plant.

Even with safety regulations in place, many plant workers refuse to check items for contamination upon arrival. Proactive companies never assume complete cleanliness, so they install magnetic separation equipment and metal detectors at the very beginning of their processes.

Here is a good example. A United States company placed a vertical metal detector below their silo, but they didn't want it to reject contaminated product. Rather, they wanted to count the amount of metal in the product coming into their plant from a major supplier. They held their supplier accountable. In this case, one rail car had 10 pieces of metal in the shipment. Of course, this was not acceptable.

Today's metal detection products combine a precision mechanical design with state-of-the-art electronics, multiple frequency range, vibration immunity and complex algorithms to detect the smallest metals in difficult products. Industrial metal detectors are also designed for harsh wash-down environments.

Metal Detector Sensitivities

New metal detection systems have the ability to find smaller metal contaminants than previous metal detectors, even in difficult applications. Today, metal detectors ship with factory presets for various products based on actual testing and the provided application data.

With the software and graphical interface, customers can detect contaminants at levels never before possible. With older metal detection technology, these contaminants went undetected. Be certain to evaluate the software when you compare metal detectors before making a final decision.

Remote Monitoring and Record Keeping

Government guidelines drive companies to create policies, procedures and protocols to ensure safety. New metal detector systems provide reject log monitoring along with remote notifications to processors indicating when a problem exists. Both are critical when it comes to safety and existing food safety regulations.

Today, it is critical to have records as confirmation along with regular reporting. Even 24/7 monitoring from remote locations is possible. It is vital to monitor product purity from the time the product enters the plant until the time it leaves. This continual data logging is imperative for both corrective actions and auditing.

Conclusion

Diligent companies avoid recalls and damaged reputations by using high-powered rare earth magnetic separators and smart manufacturing concepts. They have raised the bar when it comes to food purity and equipment protection. Work closely with manufacturers that offer training, customer service and quality products.