Tramp metal removal

Paul Moore examines how magnetic solutions can protect crushers from costly damage due to metal contaminants

UNWANTED metal contaminants, referred to in the mining industry as 'tramp metal', can cause serious damage to crushers and other processing machinery if not removed. If a primary crusher needs repairs it is not only costly in terms of the repair itself, but worse due to the downtime of a capital and primary piece of equipment.

Many mining operations employ magnetic-separation equipment specifically to extract ferrous contaminants, as well as metal detectors to identify non-ferrous materials.

Many firms produce magnetic solutions for industry, including a large number of Chinese players. However, there are only a handful of global suppliers for heavy-duty mining applications. These include Eriez, headquartered in Erie, Pennsylvania (and with manufacturing affiliates worldwide); Dings Magnets in Milwaukee, Wisconsin; Master Magnets in Redditch, UK; and Steinert Elektromagnetbau in Cologne. All of these firms supply both suspended and magnetic head-pulley solutions for mining operations.

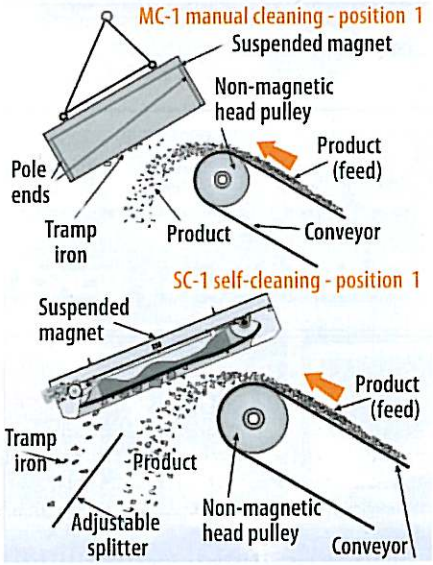
In September, Steinert announced it was merging with RTT Systemtechnik to form RTT Steinert. An important development in Steinert's involvement in the mining market was its acquisition of Sturton-Gill in Australia in 2004, based in Bayswater, Victoria.

TRAMP METAL

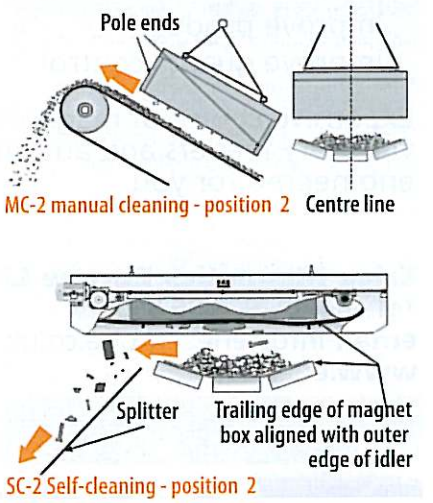
Paul Fears, managing director of Eriez Magnetics Europe, comments: "There are two reasons for removing the tramp metal. Firstly, it is done to protect processing equipment such as crushers, feeders and screens. But, also to ensure mineral product quality – this is usually done just prior to loading, especially at ports."

Large ferrous tramp contaminants can include a wide variety of objects, including excavator teeth, drill rods, drill hammerheads, truck-body fragments, scrap metal, barbed wire, and large cans or drums. Even larger metal objects can sometimes appear, especially those brought up accidentally in skips from mine shafts or in ports; objects that have fallen on to stockpiles.

The removal of larger fragments may not always be the main priority. Paul Fears comments: "It can depend on what will damage the processing equipment. For example, a cone crusher cannot cope with small, metal contaminants like a bolt whereas a jaw crusher can. Every application needs review and careful consideration. Mistakes are made when magnets are recommended on suspension height and belt width alone."



Magnetic configurations (source: Eriez)



Power plant suspended Eriez magnet installation over a coal conveyor

DESIGN AND DELIVERY

The overall design of today's most commonly used magnetic separators does not differ that much between manufacturers, but the magnetic strength required, positioning and overall system size are very much customised and based on the individual project.

Often, the customer is the conveyor designer/engineering contractor, with whom the magnet supplier will work closely to deliver a turnkey solution. Jonathan Millington, marketing manager at Master Magnets, says: "Master Magnets uses computer prediction software when designing magnetic equipment to ascertain which type of magnet will be capable of providing customers with desired results."

A magnet is selected or designed by looking at key variables, including the burden depth of the product, as this will dictate the suspension height of the magnet and the magnetic force required to pull a piece of metal through the material. Another vital factor is the type and size of the tramp metal being encountered. The smaller the metal, the harder it is to attract and separate, thus the magnetic strength (not physical size or kw rating) needs to be maximised. Spheres are the most difficult metal objects to separate.

Product streams may contain relatively small ferrous contaminants and this type of contamination is difficult to remove by a suspended magnet. For applications of this type, a magnetic head pulley can be installed into the end of a customer's conveyor. Mr Millington at Master Magnets says: "Although this type of magnet is very effective at separating small contaminants from shallow burden depths, pulley magnets are not suitable for extracting large pieces of ferrous material."

For extracting much larger contaminants, suspended magnetic separators are specifically designed for installation above conveyors. These are usually electromagnets, where the magnetic field is generated by a coil. If a product stream contains a range of contamination sizes, both suspended and pulley-magnetic systems may be used in conjunction with each other. However, the suspended magnet would need to be installed with a sufficient operating gap to handle the separation of large contaminants prior to a much stronger pulley-magnetic system to ensure a quality separation of the smaller, metallic particles. In some special applications, tramp metal is removed using other specialised equipment such as trommel magnets and, in some cases, magnetic drum separators.

INSTALLATION CONSIDERATIONS

When suspended, the magnet's location is crucial. Mr Fears comments: "The best location for a suspended magnet is over the head pulley, which, itself, must be non-magnetic. Most are suspended across the belt due to space restrictions." The conveyor specifications must also be factored in, including width, speed and toughing angle. He adds: "It also improves a magnet's separation capabilities by installing it in an in-line position. This allows the magnet to extract metals as they begin to free-fall from the end of the conveyor."

The depth of the material being conveyed must also be taken into consideration when trying to determine the magnetic strength required to extract →

certain contaminants. If a piece of ferrous material is embedded beneath 150mm of product, for example, it will be considerably more difficult to extract than a metal that is sitting on top of the product.

Another aspect to consider in the design is the cleaning of the magnet itself. In applications where contaminants do not frequently occur, a manual-cleaning magnetic separator can be used to extract any ferrous materials. For applications with much more frequent ferrous contamination, a self-cleaning magnet system is more suitable as constant cleaning of the magnet is not be required.

Unlike permanent magnet systems, heavy-duty electromagnetic systems will require a power source and these types are most commonly used in mining. For magnetic separators with a self-cleaning belt, an electric or hydraulic motor can be supplied.

The priorities of magnetic separation also vary between industries. Jonathan Millington comments: "The removal of relatively large ferrous materials is the main priority in the mining industry. Removing small contaminants will increase the end product's value, but this is not as important as the protection of valuable processing machinery from large, damaging ferrous objects."

Conversely, at a ship-loading application the removal of small contaminants is vital, especially when shipping metal concentrates, where ferrous contaminants could result in smelter penalties.

CASE STUDY: ERIEZ

In China in 2005, Eriez supplied the strongest suspended magnets ever built, which were superconducting suspended magnets for removing the blasting caps from coal just prior to ship loading. Shenhua Coal Trading Co placed the order, which was for six Eriez Suspended Superconducting Electromagnets (SSEs). Shenhua wanted the magnets to try to achieve "zero impurity" in coal exports.

This order followed the successful installation of the world's first SSE magnet at China National Coal's Qingdao branch a few years earlier. The SSE magnet was installed over a conveyor to attract and remove smaller, less magnetic ferrous-metal contaminants, such as detonating caps, embedded in the coal overburden.

Other important Eriez mining orders in recent years include: two large SE775SC2 Suspended Electro Magnetic Separators for Bulgarian copper miner, Ellatzite Med AD in 2007; and, in 2009, a Trunnion Magnetic Separator to Finnish ferro-chromium producer Outokumpu for its Tornio Works, where it is used to improve chromite concentrate production in its Kemi mine.

The Eriez Trunnion Magnet is a powerful system for the automatic separation and removal of processing balls and ferrous chips from milled ore in ball or SAG mills.

COOLING SYSTEM

An electro-magnet is a coil (usually aluminium) wrapped around a central steel core and placed in a box. When current goes into the coil it generates a magnetic field. Due to resistance in the wire, the coil also generates heat, and as the heat increases so does the coil resistance and this affects the magnetic field, reducing the magnetic force. There are several ways of keeping the coil cool.

The coil can be air-cooled by air circulating around it. However, material can be blown or sucked into the magnet and on to the core, and the magnet box usually needs to be large. The coil may be air-cooled by fans with the box sealed, and metal sheets or fans radiating from the coil to the outside of the box. Heat is transferred down the sheet to the outside where it is cooled by air. Again, the magnet box has to be big.

Then there are two oil-cooling options where the coil is immersed in oil. The first sees the magnet box filled with oil, completely covering the coil, and heat from the coil transfers to the oil. The hot oil rises to the top of the magnet and then recirculates through natural convection currents along the sides of the magnet box to the bottom. The heat is continuously transferred to the steel sides of the magnet box. Special oils can be used for specific applications and the box can also be kept relatively compact in size.

Lastly, the coil may be immersed in oil and force-cooled – the oil is pumped through a radiator fan outside the magnet box. This force cools the oil

Master Magnets suspended magnet installation at a coal-loading terminal, Indonesia

and allows higher magnetic fields to be generated. The size of the magnet box and weight of the magnet can both be reduced. This is the magnet-cooling system used in many larger mining projects.

NON-FERROUS REMOVAL

Companies wishing to identify tramp metal that might not have any ferrous content (or a content that is too low) can install metal-detection equipment. Some magnetic suppliers offer these solutions, but this market also has its own players.

Metal detectors are used in the mining industry for detecting non-ferrous metals such as nickel and zinc, but this also applies to stainless steels and manganic steels, which are more common. Thermo Scientific supplies a range of metal-detector products under its Oretronic brand. In many cases, magnetic and metal-detector solutions are used together, so that all bases are covered. Another member of the Master Magnets group of companies, Metal Detection also supplies such products. Eriez offers the MA3600 Hawk and Eagle products, often supplied with magnetic separators.

Metal detectors can be supplied for the detection of ferrous contaminants in place of magnets as they are cheaper than magnetic solutions for ferrous-material removal. However, the solution chosen will depend on the regularity of the contaminant metal encountered. Some suppliers will offer accessories such as marking devices like paint sprays to mark the location of the tramp metal for easy removal, and clip detectors to allow metallic belt clips and splices in the conveyor to pass without tripping the metal detector.

HOUSING AND CLEANING

Suspended magnets are commonly fixed using wire ropes and turnbuckles off a supporting frame. If they are self-cleaning and have a belt revolving around the magnet block, cleaning is automatic with metal being pulled up to the magnet face, and then moved away and discarded away from the product.

Manual-cleaning magnets are used when the level of tramp metal is very low and these are more uncommon. Then, the magnet is moved away from the conveyor and turned off, allowing the captured metal to be discharged. On a self-cleaning magnet the only key wear item is the belt.

For underground magnetic-removal solutions, as with underground conveyors, there are space issues, but also special underground specifications such as ATEX regulations. In some cases, regulations will require the use of a permanent, suspended magnet and not an electro-magnet for compliance.

CASE STUDY: MASTER MAGNETS

In 2008, Master Magnets received an order from Anglo American's Lisheen zinc mine in Ireland for a 6t Overband Separator air-cooled magnet.

The order from the Lisheen mine was placed after Metal Detection supplied industrial metal detectors for the detection tramp metals in the product stream. The detectors were working well for the mine, but as such a large amount of tramp metal was being conveyed the detector was being activated too frequently. Therefore, it was decided to install a magnet before the detector to reduce downtime. Master Magnets had previously supplied a 14t rectangular-core, air-cooled magnet to the nearby Boliden Tara zinc mine for a similar application.

In 2002, the company supplied two type 125 OCW 40 oil-cooled, suspension electro-magnets to one of the largest coal exporters in Indonesia for a bulk coal terminal in Kalimantan.