Protecting Screening Machines from Products they Process
Protecting Screening Machines from Products they Process

Dry processing techniques, when successful, can reduce and eliminate the energy required for evaporation in wet processing. This has forced manufacturers to use new materials and designs.

Screening machines can be grouped into one of three categories, depending on the type of work they do. The first is the controlling of particle size at the mine or raw material stage. Here we find a variety of heavy-duty inclined and horizontal machines oscillated by a variety of motions to attain the desired particulate separations. Often these units are operated coupled to a crushing circuit. It is important to minimize shutdown due to mechanical failure of the unit itself or for screen replacement.

The second general area where screens are encountered is within the process plants themselves. These units tend to be of lighter mechanical design, screening much finer particulates, often to very exact quality standards, such as in the preparation of pharmaceuticals, processed foods and their ingredients, as well as specialty chemicals, plastics, resins, etc.

The third area where we often see screening equipment playing a significant role is in the handling of waste products, particularly the separation of solids from waste water before final treatment.

Protect from abrasion

The problems in these different areas often lead us to quite different approaches, both to the mechanical machine and the media of separation. The large inclined and horizontal rectangular screens process extremely high tonnages of very abrasive materials. These abrasive ores and rocks would cause premature failure to the mechanical equipment, if not protected. It may be necessary to protect surfaces prone to wear, such as in the feed zone of the unit, along the side plates of the body, and the supports which form the crown of the screen deck. The most usual protection for the feed zone and the side walls of these machines is to attach ¼ or 3/8 in. (6.4 or 9.5 mm) wear plates of abrasion resistant steel. These plates are usually of quenched and tempered martensitic steel.

Figure 1 illustrates a heavy-duty two-deck screening machine for use in mineral processing. Note the replaceable wear plates on the sides of the unit and the heavy-duty abrasion-resistant punched plates for the actual particulate sizing.

In recent years mild, steel plates with iron-chromium carbon alloy have found application in severe abrasive situations. Figure 2 shows relative wear resistance between normal quenched and tempered abrasive-resistant plate and hard surface plate when crushed rock of -3/8 in. + ¼ in. (-9.5 mm + 6.4 mm) in size was dropped from a height of 20 ft (6.1 m) with an impingement angle of 20° under ambient temperature conditions. The darker bars show wear resistance determined by weight loss, and the lighter bars show wear resistance determined by impingement loss.

Figure 3 shows abrasive loss comparisons for different materials and conditions.
There are also a number of different alloys which enhance abrasion resistance. The point to remember when selecting abrasion-resistant wear plates is that with any wear plate one is buying time between shutdowns and therefore the economics of higher initial cost of the wear plate and longer production runs between maintenance shutdowns must be balanced against the cost of the downtime.

Returning to the machine itself, when the screening medium is woven wire, the supports beneath the screen, which usually form a crown to aid in the tensioning of the cloth, are subject to abrasive wear. Protecting these supports with rubber covering accomplishes mechanical protection from abrasive wear, provides a cushioning of the screening wire, thereby reducing wire fatigue, and helps to reduce noise.

The screening media themselves are also subject to abrasive wear. Heavy-duty grizzly bars are often protected or enhanced by the addition of hardened plates on the top surfaces of the grizzly bars, or they can also be capped with abrasion-resistant rubber products. Screening decks are often constructed of heavy punched plate, heat-treated to minimize abrasive wear, Figure 1.

Abrasion-resistant rubber decks, with the apertures molded into the deck itself, are also quite common. Most common for screening are the woven wire decks which are available in opening sizes from 4 in. (102 mm) and smaller, and with wire diameters of up to about 1 in. (25 mm). Note that when the process conditions dictate woven wire screening media for abrasive particulates, the wire weavers supply a broad spectrum of alloys to enhance resistance to abrasion. In addition, special weaves have been developed that eliminate the high points of the wire intersections, which generally wear first. These flat top wires are not always successful, but they are worth trying under difficult service conditions.

Rinsing operations or wet screening on large rectangular units often add complexity of adding a mildly corrosive environment to an already abrasive environment, thereby exacerbating the situation. Figure 3 shows the effect of three environments: dry gravel; gravel and water; and gravel, water and cement on both mild steel and a chromium silicon-manganese abrasion-resistant steel alloy when the test samples are rotated within the medium. It demonstrates how easily the severity of the situation can be increased by slight changes in the environment.

Under wet conditions in mineral processing, we are witnessing increasing utilization of stainless steel profile wire decks. These decks have the apparent advantage of broad, flat surfaces to sustain the mechanical loads, stainless steel construction for enhanced wear and corrosion-resistant properties, and the non-clogging characteristics of the diverging apertures of the profile wire.

**Mechanical problems**

For screening machines used in the processing stages or final quality control steps of finished products, there is concern for the material in contact with the product and its effects on the product. In these applications, stainless steel is the usual material of construction for the components in contact with the process materials. Usually Type 304 stainless steel is more than adequate to meet most dry processing conditions, but I have been involved with some dry
products that have been so corrosive in nature that machinery construction of Hastelloy G was necessary.

It should be recognized by the user of particulate separation machinery that when the more sophisticated alloys are required from a processing point of view, they may be difficult or impossible to work from a mechanical point of view. The metal-forming processes themselves may limit the use of a particular alloy, or the vibratory motion imparted to the welded assembly may cause mechanical problems such as cracking and structural failure. Shop techniques are far more critical than for mild steel or stainless steel construction.

For these reasons, we have seen in recent years many in-process units constructed with nonmetallic coatings. Of these, epoxy coatings and nylon coatings probably lead the list in popularity. Care must be given when making the decision between going to a nonmetallic coating or upgrading the metallurgy. Mechanical consideration of the actual operation of the equipment will influence this decision.

For example, nonmetallic coatings of circular, vibratory screen separators, handling an inorganic material, would probably not be satisfactory because the product movement would wear the coatings away at the frame wall as it moves around the periphery of the screen toward the discharge spout. Figure 4 shows a circular screen with the particulate motion indicated by arrows. It is at the outer periphery of this unit where frames with thin coatings would see the coating abraded away under the process conditions just described.

On the other hand, the static casing of a centrifugal sifter, Figure 5, sees very little sliding abrasion and can be expected to provide a higher potential for success.

In the screening media of the in-process machines, we find woven-wire stainless cloth in the vibro-energy-intensive products such as light-weight rectangular screens and circular, vibratory separators. In the lower speed gyratory separators, which provide motion in a single plane as well as in centrifugal sifters, such nonmetallic mesh as nylon, polyester, and polypropylene has been successfully used.

I would assume the reason that non-metals, such as nylon, polyester and polypropylene cloths, have not made extensive inroads into the intensive vibratory energy equipment is due to their stretch characteristics. When these products stretch, they cease to vibrate at the same frequency and amplitude as the machine they are mounted in, and thus throughput is reduced.

In the centrifugal sifter, Figure 5, the stretching and flexing of the cylindrical screen is actually beneficial in preventing clogging of the openings due to minute dimensional changes in the apertures, which helps to clear the near-size material. These cylindrical nylon screens, which provide accurate high-capacity screening in centrifugal separators, are susceptible to puncture by foreign products such as tramp metal or hard agglomerates formed upstream of the centrifugal sifter. The use of stainless steel woven wire or profile wire may provide adequate mechanical strength but at the cost of lowered throughput, as neither of these substitutes has the ability to flex.

An alternate concept which may be used to allow nylon cylindrical screens to function successfully is to incorporate a mechanical design change which will accomplish the desired protection of the nylon screens. Figure 6 illustrates a centrifugal sifter with an internal cone constructed of perforated plate. The cone traps the agglomerates or tramp material and allows it to work its way
out of the system through normal shutdowns and start-ups. The product to be screened passes through the perforations and is physically screened by the nylon mesh.

Although abrasion is not a common problem at this point in processing, it does occasionally make its presence known. For the most part, good experience has been attained using rubber linings which can be bonded to the affected areas. This technique is ideally suited to the lighter gauge metals employed in this machinery, as it allows flexibility to be maintained. Occasionally, however, it is necessary to screen very abrasive particulates. When this is the case, the screening medium is very vulnerable because of the relatively fine wire used in woven-wire screens with small apertures.

Design changes are often required to attain good screen life when handling severe abrasive materials in the fine screening range. For example, in a circular, vibratory separator operating with substantial amount of material being discharged over the top of the screen, is illustrated in Figure 7. The solids accumulate at the periphery of the deck as they move toward the exit spout. If these solids are abrasive, they will wear the fine wire screen around the periphery quite rapidly.

Figure 8 illustrates a change in the mechanical arrangement of the machine which allows the material to flow off the screen deck at a full 360 degrees. This reduces the mass load of abrasives on the screen, thereby enhancing screen life. The product itself is captured by a circular, inclined vibratory conveyor, which is an integral part of the machine, and is conveyed to the discharge spout. If abrasion is sufficiently severe within the external conveyor, bonded linings can be used for protection with a high degree of reliability.

**Performance-enhancing techniques**

In dealing with dry powders within chemical processes, we often run into the problem of static electricity. Static electricity presents a problem when screening because many small particles clump together and behave as one large particle on the screening surface. As important as the screening problem itself is the hazard of high-voltage static charges accumulating on the surface of the screen within potentially explosive environments. The grounding of the screen wire as well as of the body of the machine is important.

The circular, vibratory screen assembly of frame and screen is shown in Figure 9. The screening deck is insulated from the frames by the rubber gasket which acts to seal the joint. To overcome this problem when handling charged materials, simply insert some metal foil between the metallic tension ring to which the screen cloth is welded and wrap it back around the gasket in a number of locations around the periphery. Figure 9. When the unit is reassembled, the screen wire and the outer frames will be electrically connected. This same technique must be used at all joints where there are clamp rings, including those at the dust cover and motor support table. A grounding strap can now be connected to the live body to drain away surface charge. In some units, where the spring systems are isolated by non-metallics, a separate grounding strap should be used to the base of the machine for additional safety.

The technique just described should not be misconstrued as a panacea for processing problems. I have witnessed some dramatic improvements in screening capacity when it has been used, but for the most part, when static electricity is a process problem, it is in the form of an interparticulate charge. In other words, this technique may assist in draining the surface charge of the
clump but it does not affect the interparticulate attractive forces. Nevertheless, the technique is so simple that it is worth trying whenever static is present.

In the area of waste water clarification, there is a significant interest in higher alloy equipment, particularly for the clarification of acidic waste streams. Such alloys as Monel and Hastelloy are used to handle corrosive environments. Occasionally, in this general area of application, severe abrasion can be present as well as a mildly corrosive environment. These problems can be overcome by the proper combination of mechanical design and selection of materials of construction.

For example, a foundry attempted to remove crystalline slag from a quench water stream by a screening process instead of using a settling pond, because of the excessive costs of digging out the abrasive crystalline slag periodically. The first attempt to clarify the stream by screening was with a circular, vibratory screen. Experience from the field indicated that wire cloth would fail due to abrasion within a few days and that the major components of the machine would fail within a matter of weeks. A successful solution to the problem was attained by changing the basic design of the clarification unit to a Cross-Flo sieve configuration with a special non-settling headbox design.

The operation of a conventional Cross-Flo sieve is illustrated in Figure 10. In this basic unit, the material enters a headbox and overflows a horizontal weir on to a flat ramp which accelerates the fluid to about a 10 ft (3 m)/s linear velocity and uniformly distributes it across the face of the machine. The dewatering deck itself consists of a profile wire panel with the slots running perpendicular to the flow of the fluid. The dewatering action is to deflect the liquid layer closest to the flats of the profile wire through the slots and allow the solids to slide over the top of the deck.

To feed this abrasive slurry, a special non-settling headbox was utilized. Figure 11 illustrates an end cut of the non-settling headbox and the inclined planes which are used to distribute the flow uniformly across the machine. Note the use of nonmetallic abrasion-resistant materials on the inclined ramps and on the vertical surfaces where the cascading slurry changes direction. This installation has been a complete success. The unit has been in operation about six months and has shown no signs of abrasive damage.