Abrasion & Corrosion

HOMEROOM

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Centrifugal and positive-displacement pumps can both pump abrasives and corrosives effectively. Each pump type has its own set of problems when handling these liquids, but this discussion will be limited to general areas concerning PD pumps.

Defining abrasion and corrosion

An abrasive liquid is one that has particles in it. Some, like inks, have very fine particles, while others, like some paints, contain much larger particles. Handling abrasive liquids is a difficult application for any pump, because the abrasive particles promote pump wear. Likewise, corrosive liquids, by nature, attack the materials the pump is constructed of. The strength of a corrosive liquid depends on its concentration and temperature.

The effects of moving both corrosives and abrasives are similar -- pumps wear more quickly. Both corrosion and abrasion remove some of the material the pump is constructed of. Evidence of corrosion is different from indicators of abrasion. Corroded parts show even wear and possibly some pitting (Photo 1). Abrasion, however, causes uneven wear that follows the mechanics of the pump. On the outside diameter of a gear, for example, wear causes a scoring along the path of rotation (Photo 2).

Photo 1. An idler with corrosive wear.

Photo 2. An idler with wear from a large abrasive particulate.

Typical corrosive applications can be found in almost every industry, but they are particularly common in the chemical and paper industries. Typical abrasive applications are found in the paint and coatings industry, the printing industry, magnetic oxide tape coating, and a variety of other processes.

The first consideration when applying a PD pump to any application is to try and determine how abrasive and corrosive the product to be pumped is. For abrasives, finding the type of material, the size of the particles, and how concentrated they are is a good starting point. Some printing inks have minimally abrasive characteristics, with pigments that tend to be softer and finer, while some paints have harder, coarser pigments and extremely abrasive properties.

A quick way to get an idea of the abrasive nature of a product is to put a small amount of the liquid between two glass slides and rub them together. Highly abrasive properties result in a grinding, scratchy sound. Admittedly, this is a very subjective test, but with a little experience it can be related to the potential for pump wear. A test for corrosives is somewhat more straightforward. Wafers of materials under consideration for pump construction can be immersed in a sample of the liquid to be pumped, and weight loss recorded over time.

Combating abrasion and corrosion with pump speed, temperature, and differential pressure.

As mentioned previously, abrasive liquids wear pumps. Wear can be slowed dramatically by slowing the pump down. It is not unusual for pump manufacturers to recommend speeds from one third to one half of rated speed to retard wear. This depends on how abrasive the product is and the economics of using a larger pump and slowing it down, but it sometimes costs less to use a larger, slower pump that lasts longer, rather than replacing a smaller, faster pump (Figure 1).

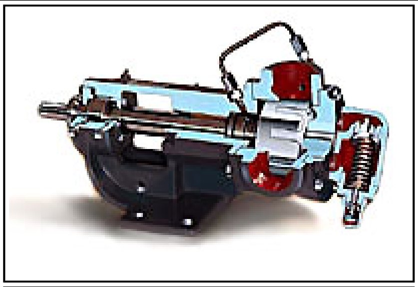

Figure 1. A pump fitted for abrasive liquids.

When pumping corrosives, operating speed is less important than the selection of the right materials. When considering materials, pay particular attention to the temperature of the liquid. Most corrosive materials become more aggressive at higher temperatures, so a lower temperature will help extend the life of the pump.

Another major consideration in successfully applying a pump to corrosive, abrasive liquids is to keep the differential pressure as low as possible. While this is primarily a system consideration, it will go a long way toward extending pump life. Many manufacturers limit the differential pressure for abrasive liquid pumps to about 60% of the pressure allowed for their standard pumps. For corrosive liquids the lower differential pressure will reduce the amount of slippage in the pump, and consequently reduce the related liquid velocities that tend to increase the aggressiveness of many corrosives.

Combating abrasion and corrosion with proper materials of construction.

As mentioned above, careful material selection plays an important role in moving difficult liquids. Materials come in various hardness and have different levels of corrosion resistance. Each pump component should be matched to the nature of the liquid being pumped.

Bushings

The materials of construction of bushings exposed to the pumpage is one area of concern. One common option is carbon graphite, which is modestly priced and has excellent corrosion resistant properties, but its softness does not work well with abrasives. Bronze is harder and less expensive, but it has limited corrosion resistance and needs a lubricating liquid to prevent wear, again a drawback for use with abrasives. Cast iron generally has a modest cost and can be easily handled for field replacement. For mild abrasives, some users have found that a cast iron bushing works well; but with corrosives it has very limited value.

All of these bushing materials are common to many manufacturers and, at best, offer only a minimal resistance to abrasives; and, other than carbon graphite, they are not normally considered for use with corrosives.

There are alternative hard bushings available that can serve to improve the life of a pump in abrasive service. The least costly option is to use hardened cast iron. This material offers a significant improvement in life span over normal cast iron in abrasive service; however, it has no advantage in corrosive applications.

One note of caution: make sure that all cast iron bushings have an initial start-up lubricant in the pump. These bushings are subject to rapid initial wear without lubrication, and some manufacturers pre-lube these bushings to assist in start-up. Be sure to check your pump's start-up requirements. After the initial run-in, cast iron bushings give a very long and reliable life.

The next option in cost and life expectancy are coated bushings. There are many of these available, one example being Colomony-coated bushings. Colomony is a hard coating that resists abrasive wear and has excellent corrosion resistance, provided that the material the coating is applied to can resist the chemical attack.

Unlike the materials mentioned above, a Colomony-coated bushing cannot be used with a non-hardened shaft. The bushing would rapidly wear into a standard unhardened shaft, causing an immediate reduction in service life of the pump. The coated bushing can be run with a coated shaft, giving an excellent life span and a high degree of abrasion resistance.

Again, the coating material is only as good as the base material when it comes to resisting corrosion, so coated parts are not commonly used in corrosive applications, except where a harder part is needed for wear resistance. Colomony coatings also need surface lubrication supplied by the liquid being pumped, so they are seldom used for low-viscosity applications.

Another option is the ceramic bushing. This material, while able to resist abrasion and corrosion, is a good heat sink, and care must be taken to ensure that the bushing is properly cooled. As with coated bushings, a hard shaft must be used to prevent premature shaft wear. Ceramic bushings also tend to be a poor choice for thin liquids, which limits their use with corrosives. Another consideration with this type of bushing is that its coefficient of thermal expansion is quite low, so it often requires a heat-shrink fit when temperatures are elevated.

One of the most superior abrasion-resistant materials is tungsten carbide, but its properties come at a higher cost. Again, as with coated bushings, tungsten carbide bushings must be used with a hard shaft material. A tungsten carbide-coated shaft is one option.

Tungsten carbide running against tungsten carbide has been used successfully with thin liquids, and would certainly be a prime choice for thin, abrasive liquid applications, especially if more than modest differential pressure was required. Tungsten carbide does well in liquids with a pH higher than 4, while liquids below that attack the binders and cause the tungsten to "come apart".

Shaft sealing

A major wearing point in any pump is the area of shaft sealing. This is even more critical in abrasive or corrosive liquid applications. Standard shaft packing needs a liquid film to lubricate the shaft, and if the pumpage contains abrasives this film will cause additional wear, not lessen it. Corrosive materials, while able to provide some lubrication for the packing, are not the sort of material that should be allowed to exit the packing gland while providing that lubrication. As a result, packed pumps are usually shunned for corrosive applications. For packed pumps in abrasive service, special packing and hardened shafts are often used. The other option, that of a mechanical seal, is frequently used for abrasives and almost always for corrosives.

The material of the face seal is an important consideration, and selection follows the guidelines for other pump materials discussed earlier. The harder the face, the more it will resist damage by abrasives. An area of the seal that deserves special attention related to corrosive applications is the type of elastomer used. Viton® is good for many applications and is relatively inexpensive. PTFE is better in many cases and somewhat more costly, while Kalrez® provides excellent corrosion resistance at a high price.

Rotating elements and casing

In addition to the bushings, shaft material, and seals, consideration must also be given to materials used in the rotating elements and housing. Cast iron is the least expensive option. As mentioned, it has a degree of abrasion resistance, but little corrosion resistance. It has the added benefit of being a low-cost replacement part if the application is temporary.

The next step up in abrasion resistance and cost is hardened cast iron or steel. While they have little value for use with corrosives, they can better resist abrasives and can be selectively applied to various pump components.

As these harder components are incorporated into the pump, the cost goes up dramatically. The harder the parts become, the more resistant they are to abrasives; but at the same time, they also become more difficult for manufacturers to machine.

This trade-off has given rise to coating materials for pump gears and casings. Work has been done on adding an even layer of tungsten carbide to the surfaces of these components, with good success. There are also other coatings that have proven their worth in resisting abrasion, and new coatings are being developed and tested.

Corrosives, on the other hand, call for different materials, and hardness is not normally a factor. 316 stainless steel is the most universally selected material for use with corrosives. It has a wide resistance to corrosion, and because many manufacturers have made this a standard material, it is available at a reasonable cost (Figure 2).

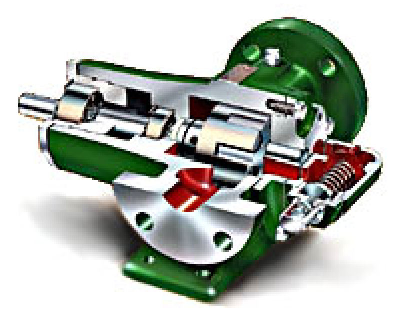

Figure 2. A corrosion-resistant 316 stainless steel pump.

Beyond stainless steel for corrosion resistance, things get a little more difficult. The most serious concern is that cost goes up dramatically. PD pumps constructed of Alloy 20, titanium, and Hastelloy are available. Hastelloy is the most universally corrosion resistant material, but the cost is considerable. Also, do not overlook the composite materials, which generally cost less than even 316SS.

Most of these materials have corrosion resistance that is best restricted to particular types of pumpage. Talking to pump manufacturers and experts on the material being pumped is a good way to find a material that will stand up to a specific service.

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