Handling Corrosive or Abrasive Liquids

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, directly attack the pump materials. 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 material from the pump parts, however, evidence of corrosion is different from indicators of abrasion. Corroded parts show even wear and possibly some pitting (Figure 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 (Figure 2).

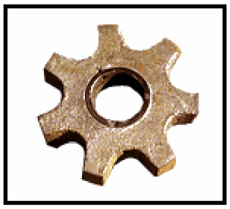

Figure 1
An idler with corrosive wear

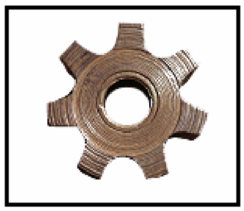

Figure 2
An idler with wear from large abrasive particulate

Typical corrosive applications can be found in almost every industry, but they are particularly common in the chemical and paper industries.

Typical abrasive applications include:

- Paints and Coatings
- Inks
- Filled Roofing Asphalt
- Waste Oils
- Magnetic Oxide Tape Coatings
- Titanium Dioxide Slurries

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. Some questions to consider when selecting a pump for handling an abrasive liquid:

- What is the liquid and what is the particulate?
- How large are the abrasive particles?
- How concentrated are the particles?

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. Liquids with 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.

Some questions to consider when selecting a pump for handling a corrosive liquid:

- What is the liquid?
- If this is a mixture or proprietary name, what is the corrosive?
- What is the concentration of the corrosive?
- What will be the highest pumping temperature?

A test for corrosives is somewhat more straightforward; samples of the materials under consideration for pump construction can be immersed in a sample of the liquid to be pumped, and weight loss of these samples 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 impede 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. PD pumps designed for handling abrasive liquids are not only cataloged to lower speeds and pressures, but feature hardened parts to further prevent wear (Figure 3).

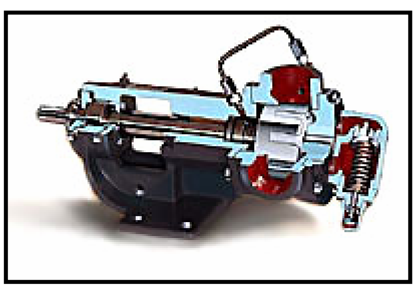

Figure 3
A pump fitted for handling abrasive liquids

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 liquids that are either abrasive or corrosive 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.

<u>Bushings</u>

Bushing selection can hinge on several factors. In addition to hardness and corrosion resistance, you must also consider the pumped liquid's lubricating properties, the temperature range of the application, the material that the bushing will be running against, and the loading (pump speed and pressure). The following table provides a brief description about several common bushing options, but be sure to not to overlook these other factors when selecting a bushing for an abrasive or corrosive application.

Material	Hardness	Corrosion Resistance	Notes
Carbon Graphite	Soft	Excellent	Excellent bushing for corrosive and non-lubricating liquids, but not for abrasives
Bronze	Soft	Poor	Not for abrasive or corrosive liquids. Good general bushing option for lubricating liquids.
Hardened Iron	Medium	Poor	Provides better abrasive resistance than iron alone, but no additional corrosion resistance
Composites	Soft	Excellent	Many material options available to cover broad range of corrosive applications
Coated Bushings	High	Good	Liquid pumped must be lubricating and bushing must be run on coated shafts. Corrosion resistance will depend on the coating as well as the base material. Colmonoy or Chrome Oxide on a stainless steel base is the most common.
Ceramic	High	Excellent	Liquid pumped must be lubricating and bushing must be run on hard shaft
Silicon Carbide	Very High	Excellent	Must be run on hard shaft
Tungsten Carbide	Very High	Good	Excellent abrasion resistance. Good corrosion resistance to caustics, but not acids. Must be run on hard surface, typically tungsten carbide or tungsten carbide coated.

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.

Shaft Seal	For Abrasive Liquids…	For Corrosive Liquids…
Packing	Abrasive particulate tends to embed itself in the packing which can accelerate shaft wear. For this reason, packing is usually not recommended. When it is used, special packing and hardened shafts are usually recommended.	Packing requires a liquid film to lubricate the shaft and cool the packing. This means packing must weep slightly. This external exposure of the corrosive liquid is typically unacceptable so packing is rarely used for corrosive liquids.
Single Mechanical Seals	Commonly used, but require hardened faces such as carbides. Flushing the seal faces helps to cool the seal and insure that particulate doesn't build up.	Commonly used, but material selection is critical, especially elastomer selection. PTFE, Viton®, and Kalrez® are commonly used due to their wide compatibility range.
Double Mechanical Seals	Double seals are more expensive than single seals, but pressurized barrier fluid insures that particulate does not get between the seal faces.	Double seals insure that corrosive liquids do not escape to the external environment. Similar to the single seal, material selection will depend on the liquid pumped.
Magnetically Driven	Not commonly used. Can use a barrier fluid in the coupling to prevent the pumped liquid from reaching the magnets.	Magnetic couplings provide the maximum assurance that the corrosive liquid will not leak out. Offered in stainless steel, high alloy, and composite versions, they've become very common for handling corrosive liquids.

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 4).

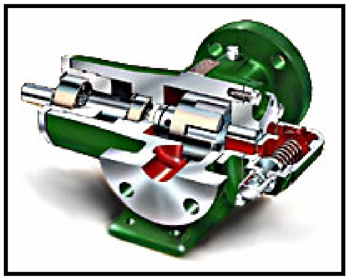

Figure 4
A corrosion resistant
316 stainless steel pump

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 liquids. 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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