Got difficult LIQUIDS?

To select the right pump for abrasive and corrosive liquid applications, the pump user must understand both the liquid's characteristics and the materials available for pump construction

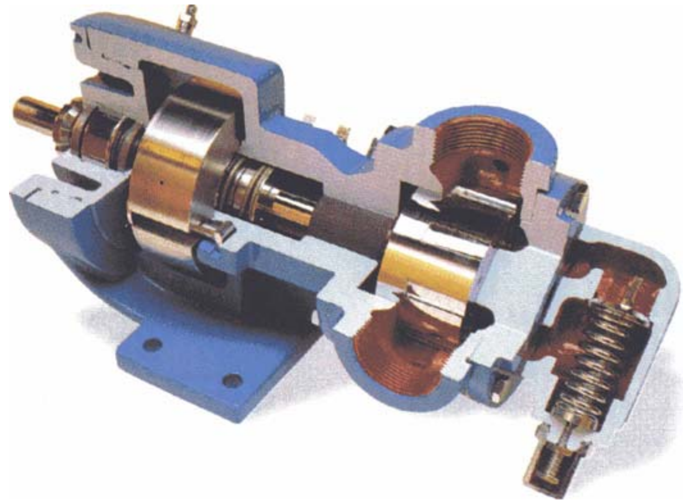
Mr. John Petersen

A very large part of a pump installation's success has to do with selection of the proper pump for the application. Improper selection leads to a shortened pump life span, increased repair costs, unnecessary downtime and higher production costs.

Knowledge and understanding of liquid properties are key to making the right pump selection. This article focuses on two of the more detrimental liquid characteristics - abrasion and corrosion - and discusses common ways to deal with each. Both centrifugal and positive-displacement-type pumps typically handle abrasive and/or corrosive liquids, and each has its own set of solutions. However, this discussion is limited to rotary positive displacement pumps such as internal gear, external gear, lobe, circumferential piston and vane designs.

Operation basics

Rotary positive-displacement pumps are characterized by close-tolerance rotating elements that move liquid through expansion and contraction of the liquid. Unlike centrifugal pumps, which move liquid by imparting kinetic energy, positive-displacement pumps try to move the same amount of liquid for each shaft revolution. Because the pump has only a small amount of clearance, some liquid flows from discharge back to suction.



Shown here is a *pump designed for corrosive service.*

This phenomenon is called slip and is common to all rotary positive-displacement pumps.

These clearances act like small orifices within the pump, meaning slip is like orifice flow. Clearance, liquid viscosity and differential pressure all have an effect on the extent of slip. Both abrasion and corrosion can result in the removal of material from the pump; therefore, pump performance ultimately is affected by these problems. As slip increases as a result of material loss, the pump experiences decreases in developed pressure, capacity or both.

Corrosion

Corrosion is defined as the process in which a material is destroyed through oxidation or chemical reaction. Corrosion shows up in a variety of ways - perhaps in a rusted ferrous part, or possibly in a stainless steel part that has been eaten away slowly by an aggressive acid. Applications involving corrosive liquids are found throughout industry, but are particularly common in the chemical processing and pulp and paper industries.

Determining the corrosive properties of a liquid can be difficult. For more common liquids, several sources for corrosion data exist, including the National Association of Corrosion Engineers (NACE) and Compass Publications. NACE has a number of

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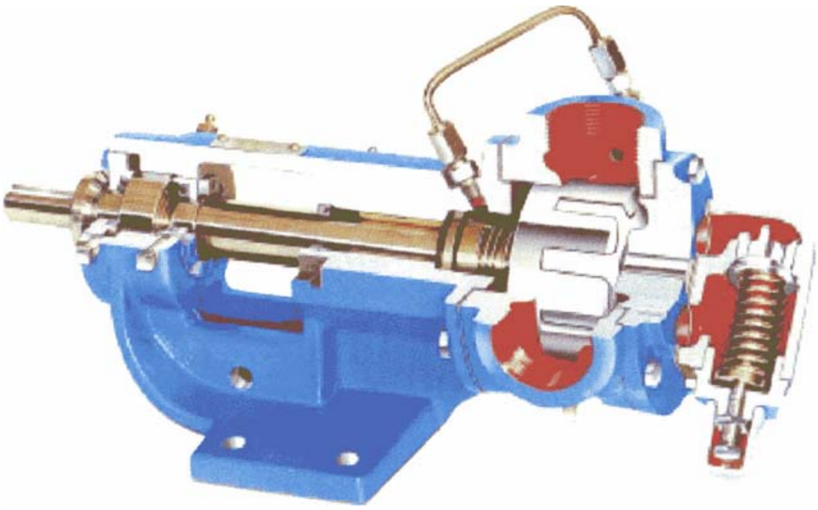

The pump shown her is *specially fitted* for *abrasive* service.

publications, and Compass publishes corrosion guides for both metals and nonmetals. Corrosion data normally are expressed as a rate (inches per year) and often are categorized by level (A, B, C, etc.). Note that corrosion rates nearly always are affected by temperature (a higher temperature can mean a greater corrosion rate), so it is very important to factor in temperatures during ı material selection.

Fewer corrosion data exist for less common liquids, mixes of liquids and unique concentrations. In these cases, historical data and the experience of others can be helpful.

Often, liquid manufacturers can provide useful information. Some pump manufacturers can perform corrosion testing, provided they have the means to handle the liquid safely. This process normally involves a simple immersion test of a proposed material in which weight loss is measured over a given period of time. From that, the manufacturer can calculate a corrosion rate.

Once the corrosion rate is known, the pump user can begin the pump and pump material selection process. External materials (housing) and pumping elements must be "reasonably" compatible with the liquid pumped. Most manufacturers provide materials of construction ranging - at the very least - from cast iron to stainless steel. Many of them also provide materials such as Alloy 20,Monel and Hastalloy for use with more difficult applications.

Material choice often is an economic issue because higher-end alloys always cost more than traditional pump materials. In some cases, a small amount of corrosion can be tolerated, provided the pump still offers adequate performance and an acceptable life. For example, for applications handling concentrated sulphuric acid, cast iron might provide a lower life-cycle cost than another material such as stainless steel featuring minimal corrosion. Cast iron has a "B" rating at ambient temperature, whereas stainless steel has an "A" rating.

Bear in mind, however, that safety comes first. Fluids that are corrosive to pump materials are often hazardous to human health as well. Any corrosion that compromises structural integrity or impairs product safety should not be tolerated. Most pump manufacturers will provide assistance in this area.

Many rotary positive-displacement pumps use bushings lubricated by the product to support the pumping elements. Corrosion factors must be considered here as well.

Improper selection can lead to a quick drop off in performance, as well as seal leakage. Again, most suppliers provide a wide range of bushing materials. Carbon graphite is a nearly universal cost-effective choice, but it does not fit all applications. Silicon carbide is an excellent choice for highly corrosive liquids, but it is also very expensive. If the application warrants, other materials such as Colomonoy, tungsten carbide and a variety of composites are available.

Polyphenlyene sulfide (PPS) and poly ether ketone (PEEK) are two materials

Under heavy corrosion, severe *pitting* of *stainless steel parts* can occur.

Under graphitic corrosion, *cast* iron *parts* are *scratched easily with* a *metal straightedge.*

Large abrasive particles tend to leave score marks such as those shown here.

Fine abrasive particles can result in a fine matte finish such as that shown here.

commonly used as a base for composite-type bushing materials. Again, pump suppliers can help you select the best choice for the application.

Shaft sealing is also extremely critical in corrosive- liquid applications. The selection process is much as for the pump, once again the same starting with liquid characteristics. Numerous , designs, styles and mounting configurations are able, and suppliers can be of help in available and suppliers can be of help in selecting the right combination.

Sealless pumps have gained acceptance in a number of corrosive applications as well; however, the corrosion rate is of utmost importance for these pumps. Sealless pumps often use thin shells to contain liquid; they cannot tolerate much material loss. (This topic is quite complex and could warrant a whole article itself.) Shaft sealing choice can make or break an installation, so be particularly careful in this area.

Ideally, the best material for the application is selected before the pump is applied; however, even in such cases, corrosion still can be a problem. This problem usually shows up in the form of diminished pump performance or leakage. A detailed failure analysis can determine the exact cause(s) of the problem.
For example, a pump user was having difficulty handling an adhesive that would· not normally be considered corrosive. Pump performance on his cast iron pump had dropped off, and it became apparent that pump components were wearing. A detailed failure analysis showed the wear was the result of corrosion specifically, graphitic corrosion.

The base adhesive was not corrosive to cast iron, but small percentages of adhesive additives were causing corrosion. An upgrade to stainless steel subsequently was required to obtain satisfactory life.

Several different kinds of corrosion exist, and the pump user must understand the particular mode of failure before a solution can be put forth.

Abrasion

As with corrosion, the pump user must determine the extent of the liquid's abrasiveness before selecting a pump. However, this determination is not always easy to make. Standard tests are keyed to specific industries, but no one test seems to be accepted universally as a way to measure abrasiveness.
By definition, an abrasive liquid is one that contains some hard solids. The solids' concentration, size, shape and hardness all determine how much damage the particles can do to a pump.
In most cases, the size and concentration are known. Shape and hardness, however, are not always known. Therefore, abrasiveness characterization is more subjective than that of corrosion. Experience - either the pump user's own with other equipment or that of the liquid manufacturer or the pump supplier is often the best guide here. Even a very simple test in which a sample of the liquid is rubbed between two glass slides can give some idea of how rough the liquid will be to handle.

Abrasion has an effect on pump performance that is similar to corrosion in that material is removed. Abrasion caused by finer particles tends to leave more of a matte finish.

Pump users should take a slightly different approach when selecting a pump for an abrasive application than they would for a corrosive one. Because abrasives wear away pump parts over time, one of the best ways to retard this process is to slow the pump down. Many manufacturers, therefore, recommend speeds of one-third to one-half the normal pump rated speed. The speed reduction necessitates the selection of a larger pump, but the longer life attained usually far outweighs the increased cost.

It is also advantageous to keep the differential pressure as low as possible. Here again, higher pressure translates into higher wear. A good look at the system might indicate that a larger pipe size to reduce friction loss will make more sense than operating the pump at higher pressures.

Pumps suitable for abrasive service generally use harder parts. Rotating parts and supporting bushings are the first candidates. Hardened steel, tungsten carbide and Colomonoy are commonly used materials.

It is a little unusual to find an abrasive application also plagued by corrosion, but it does occur. With the exception of hardened steel, all of the previous materials can be used. In addition, a chrome oxide coating provides a very good wear solution, particularly for shafts or pins.

Shaft sealing on abrasive applications also is critical. Mechanical seals designed specifically for abrasive service are avail- able and need to be used. Hard faces (usually silicon carbide or tungsten car- bide) are a must, and a positive drive is recommended.

Bellows-type seals are driven by friction between the bellows and the shaft. Abrasives and/or higher-viscosity liquids can require too much face torque, causing the bellows to slip on the shaft. A positive drive seal overcomes this problem, using pins or set screws to positively drive the seal. Some pump manufacturers also provide a flush that supplies a fresh stream of liquid over the seal faces to extend life. Some manufacturers provide pump models already fitted for abrasive service.

Conclusion

To successfully handle corrosive or abrasive liquids, the pump user must understand the unique characteristics of the liquid. Once they are known, he or she can select the pump that uses the best materials available to provide the lowest life-cycle cost. Pump suppliers are more than willing to help in this process and should be consulted as early as possible.

About the Author

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Bibliography

1. Compass Publications, www.com-passpublications/com, La Mesa, Calif.
2. NACE, http://nace.org/nace, Houston, Texas.

Acknowledgment

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A Typical Difficult Liquid Handled By Viking Pump

ASPHALT MARKET DEFINITION

Asphalt is a dark brown to black cementitious material in which the predominating constituents are bitumens, which occur in nature or are obtained in petroleum processing. Asphalt is a constituent in varying proportions of most crude petroleum and is used for paving, roofing and other special purposes.

The total market for asphalt would include the production, transportation, consumption and recycling of asphalt. More specifically the market includes:

- Refining of crude oil bottoms into liquid asphalt (at the Refinery)
- Processing/blending of liquid asphalt into various finished grades (typically at the Refinery)
- Transportation of liquid asphalt (by Pipeline, Barge, Rail or Truck)
- Storage of finished grades of asphalt (at Terminal Facilities)
- Processing of asphalt into asphalt pavement (at Hot Mix Plants) or roofing materials (at Shingle Manufacturers)
- Reprocessing of asphalt into new asphalt (in Mobile Equipment or at a Hot Mix Plant)

MARKET ISSUES AND TRENDS

The largest environmental issues surrounding asphalt are odour, Volatile Organic Chemical emissions (VOC's) and noise. The number of regulations affecting these parameters will increase.

Barges carry their own asphalt pumps. Good suction performance is very important. Asphalt transported by heated railcars is loaded and unloaded by pumps at the shipping and receiving points. Asphalt is unloaded from the top of the railcars so self-priming performance is important. Asphalt transported by truck is 3000 F or higher. It is rarely transported more than four hours distance due to heat loss and the resulting solidification. Speed of loading and unloading is as an issue due to the cost of operating a tractor/trailer.

More asphalt blending is likely to occur at asphalt terminals and hot mix producers as the number of asphalt grades expands to meet a wider variety of performance standards. This includes asphalt emulsions and polymer-modified asphalts. There is a trend towards drum-type hot-mix plants that are run continuously. This may result in increasingly popularity of smaller size pumps.

Viking 4224A Pump (Heavy Duty)

Viking 434 Pump (General Purpose)

Viking Jacketed Pumps

APPLICATION DETAILS

The types of asphalt encountered vary somewhat in each market segment. This section outlines the major issues in selecting and applying pumps to the types of asphalt encountered in the different market segments.

- Heating the pump at start-up is required to ensure that any residual asphalt is in liquid form in the pump gear mesh area and in the packing or seal area. On initial start-up of new pumps with mechanical seals, venting of the seal chamber is recommended to ensure liquid reaches the seal faces.
- Pump heating options include steam, hot oil, and electric heat tracing. Steam and hot oil can be applied directly in integral jacketed components of the pump (Bracket, head, and relief valve) or indirectly with stainless steel tubing wrapped around the pump.
- Packing, lip seals, and mechanical seals are options for shaft sealing. All seal types have start-up pre-heating requirements to ensure that the seal and shaft are not damaged by cold, solid asphalt. Seal quenches or barrier fluids are recommended with any lip seal or mechanical seal options.
- Limit pump speed to 25% of the maximum rated speed listed in the catalog. Emulsified asphalt is sensitive to shearing.
- Steel fitted construction and extra clearances are required beyond viscosity clearance requirements.
- Bronze bushings can be utilized for temperatures up to 4500F. Carbon graphite is required for temperatures above 4500F
- A drilled idler will be required for added bushing lubrication.
- Acceptable shaft seals include:
  - Packing
  - Cartridge lip seal with quench
  - Single metal bellows mechanical seal with hard faces and quench
  - Double metal bellows mechanical seal with hard faces (inboard) and a pressurized barrier fluid.

COMPETITIVE ADVANTAGE

Viking's competitive advantage is their ability to provide customers with a pump that produces far less leakage than other pump manufacturers. The benefits to the pump user are less clean-up, less site contamination, less employee exposure to a hot product, less maintenance associated with tightening and changing packing and less loss of product. Viking's biggest strengths are their ability to provide multiple options to match each customer's situation (different sources of heat), years of experience in learning what works and what doesn't, and the option of a higher pressure, heavy-duty product for more difficult applications.