Plastic-lined mag-drives

Pumps increase their presence in severe-service applications

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Severe-service pumping in its broadest sense can be found in applications involving the transfer of extreme temperature, highly corrosive, toxic, abrasive, explosive and highly volatile liquids. Transfer of these liquids demands robust pump designs and careful material selection to optimize mean time between failure (MTBF) and protect life and environment.

The 1990 Clean Air Act, which covers 189 volatile organic compounds (VOCs), contains Phase III emissions limits as low as 1,000 ppm for pumps and 500 ppm for valves and connectors (flanges). Phase III requirements for the chemical industry, currently scheduled to begin implementation in April 1997, severely restrict fugitive emissions from the initial Phase I leakage limits of 10,000 ppm.

Even more stringent requirements have been legislated on the state or local levels (e.g. California). From a user's perspective, the pump requirements are loud and clear: safety, reliability and simplicity.

These highly problematic applications are a natural fit for magnetic-drive pumps. Other possible approaches include canned motor pumps (CMPs) and conventional pumps fitted with double, tandem, or double gas lubricated seals.

Plastic-lined mag-drives

Plastic-lined magnetic-drive pumps are becoming more prevalent in severe-service applications. Among the advantages of plastic-lined mag-drives are:

■ **Improved corrosion resistance.** High-performance, plastic-lined magnetic-drive pumps consist of a pressure-containing metal outer shell covered internally by an 1/8-in to 3/16-in plastic coating.

The metal outer shell, normally ductile iron, provides the structural rigidity to handle the pump internal pressure and external nozzle loads, while the lining provides the necessary corrosion resistance. All wetted internal parts are either covered by a plastic lining (usually fiber reinforced), or are made of engineered ceramics such as silicon carbide (SiC) for the product-lubricated bearings.

An increasingly popular arrangement is the close-coupled pump design, in which the outer magnet carrier is mounted directly onto the motor shaft; there is no separate pump-bearing frame required.

Of the variety of plastic lining materials available, there are several key properties that must be considered during selection. They include degree of corrosion protection, temperature capability, resistance to permeation and abrasion resistance. Table 1 compares typical properties for common lining materials available.

■ **Lower initial cost.** Plastic-lined pumps can become economically important when their cost is compared to pumps with metallurgies such as 316 stainless steel and Alloy 20. A favorable cost benefit especially can be realized when comparing these pumps with Hastelloys and metals such as titanium and tantalum. These exotic metals can cost up to eight times as much as 316 stainless steel.

■ **Availability.** Another advantage of plastics is reduced delivery cycles; unless the supplier specializes in these higher alloys it becomes cost-prohibitive to stock these materials. Typical deliveries for standard plastic-lined pumps are three to six weeks; special non-stock alloys can require 14 weeks or more.

■ **Zero eddy-current losses.** Inherent in a plastic-lined magnetic-drive pump is a non-metallic containment shell. Typically, the containment shell consists of a liner material with a fiber-reinforced backing. Better yet, dual can systems are available which can be monitored for leakage between the inner and outer shells, thereby providing secondary containment in the unlikely event leakage occurs. Because the containment shell is non-conductive, eddy currents are not produced.

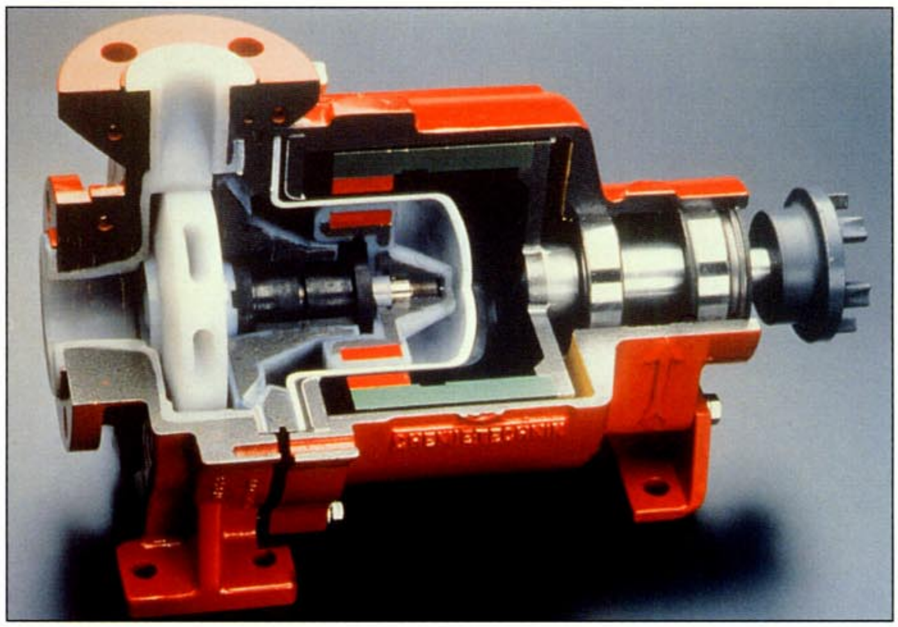
Eddy-current losses are power losses due to electrical currents produced by the rotating lines of magnetic flux cutting through a stationary conductor. In metal shells, such losses can range from 10% to 20% of the magnetic-drive rating for a pump operating at 3,550 rpm. For example, a magnet drive rated at 75 hp at 3,550 rpm can have up to 15 hp in losses due to eddy currents.

These power losses manifest themselves as heat, which is transferred to the pumped liquid. The resulting temperature rise can be critical for liquids with steep vapor-pressure temperature curves or liquids that may polymerize and deposit locally at increased temperature. For non-conductive shells this is a non-issue, as no eddy currents are generated. Consequently, a simpler pump selection process can be used. Some manufacturers also offer non-metallic shells in metal magnetic-drive pumps.

Bottom: Typical plastic-lined mag-drive pump.

Top left: Close-coupled magnetic-drive pump.

Top right: Dual-containment shell.



■ **Enhanced dry-running performance.** Because the only heat added to the liquid in pumps with non-metallic containment shells is due to the compression and viscous shearing of the pumped liquid, plus small power losses in the product-lubricated bearings, short-term dry running is possible in transfer or tank car unloading services. This type of dry running, referred to as "broken prime" dry running, occurs when there is still enough liquid in the pump to lubricate the product-lubricated bearings. Because the heat input is low, dry running can be sustained for short periods.

Some manufacturers provide carbon bearings to extend dry running further but these bearings have the disadvantages of reduced chemical compatibility compared to sintered SiC, increased wear rate, decreased load capability and an intolerance for solids.

One manufacturer has been able to significantly extend dry-running performance by the use of controlled-porosity SiC and polytetrafluoroethylene (PTFE) lubricating strips. This configuration has been tested under broken prime dry-running conditions with a non-conductive containment shell for more than 4$^1/_2$ hr without overheating, failure or damage. Friction-reducing "Safeglide" coatings, comparable in hardness and chemical inertness to the base ceramic, have also been successfully applied to SiC bearings to obtain extended dry-running performance.

■ **Solids-handling capability.** Due to the inherently larger clearances which are used in plastic-lined pumps to accommodate the growth of parts, there is a certain degree of solids clearance built in. The typical radial clearance between the inner magnet carrier and inner containment shell is 0.060-0.080 in. The larger clearances mentioned are typically found in heavy-duty plastic-lined pumps.

Table 1. Comparison of typical plastic lining materials.

Material	Corrosion resistance	Temperature limit (°F)	Thermal shock resistance	Impact resistance	Abrasion resistance
Polytetrafluoro-ethylene (PTFE)	Nearly universal	350	Good	Good	Limited
Perfluoroalkoxy-tetrafluoroethylene (Teflon® PFA)/PTFE	Nearly universal	350	Good	Good	Limited
Polyvinylidene fluoride (PVDF)	Good	250	Good	Good	Fair
Ethylene tetrafluoro-ethylene (ETFE)	Good	250	Good	Good	Fair
Polyethylene—ultra-high molecular weight (PE—UHMW)	Fair	195	Good	Good	Very good

Metallic pumps can have radial clearances as low as 0.030 in. Canned motor pumps have a relatively thin stator liner plus close stator-rotor radial clearances which require a clean, compatible liquid to cool and lubricate the internal bearings when solids are present. Because typical product-lubricated bearing clearances are 0.002-0.006 in (diametrical), the stationary bearing should contain one or more radial and longitudinal lubrication grooves to allow for solids passage.

Certain plastic liners, such as ultra-high molecular weight (UHMW) polyethylene, have very good abrasion resistance. This is the preferred liner material for abrasive applications provided there is chemical and temperature compatibility with the pumped liquid.

The maximum particle size admitted to the drive lubrication circuit should be 0.012 in; the allowable solids concentration will vary depending on the hardness and shape of solids. In addition to premature wear of the liner, excessive solids in suspension could settle during prolonged idle periods and accumulate at the bottom of the containment shell and potentially cause decoupling upon start-up due to the increased torque required.

The design should be robust yet simple enough to enable the user to quickly repair the pump at the plant—offering minimal risk of improper assembly by unskilled workers.

For solids properties exceeding those stated, a filtered flush is recommended. This provides a clean source of liquid from the pump discharge through to a connection in the drive lubrication circuit.

Close-coupled or frame-mounted?

An increasingly popular arrangement is the close-coupled pump design, in which the outer magnet carrier is mounted directly onto the motor shaft; there is no separate pump-bearing frame required.

This arrangement offers several advantages, including no coupling alignment to worry about and a lower space requirement, which allows a much shorter overall length than a separately coupled unit. There is a lower first cost and fewer parts to inventory. There is also no coupling, coupling guard or pump-bearing frame. The baseplate is also significantly shorter.

Typically, motors have a more favorable bearing span for supporting the outer magnet carrier than do separately coupled pump units, which normally have their overall pump length restricted to ASME B73.1 dimensions. Because wet-end radial and axial thrust loads are carried by the product-lubricated bearings, the only loads transmitted to the motor bearings are the outer magnet carrier weight and residual dynamic unbalance plus any magnetic unbalance.

Of particular importance to users is that suction and discharge nozzle locations conform to ASME B73.1 dimensions, since very often the system piping is designed well ahead of the purchase of the pump. This enables users the flexibility of not being locked into one supplier. Close-coupled pumps are available with the same ASME B73.1 nozzle locations as frame-mounted pumps and as such are suitable for retrofit applications.

Life cycle costs

Life cycle costs include not only first cost but the total lifetime cost of ownership. In addition to energy costs, these include parts and labor for overhauling the pump, lost production due to downtime and any costs associated with environmental cleanup and disposal of contaminants.

Life cycle costs are influenced by material compatibility, robustness and simplicity of design, and the ability of the unit to tolerate system upsets and occasional operator error. The design should be robust yet simple enough to enable the user to quickly repair the pump at the plant—offering minimal risk of improper assembly by unskilled workers.

In particular, short-term dry-running situations are commonly encountered in the field during tank transfer or unloading operations. The elimination of a metal containment shell from the design avoids the high increase in temperature due to eddy-current losses and helps improve short-term dry-running life.

Plastic lining materials such as perfluoroalkoxytetrafluoroethylene (Teflon® PFA)/PTFE are virtually inert to chemical attack and have the flexibility to allow the pump to be used in a wide variety of services up to 350°F. Teflon PFA/PTFE offers a high degree of confidence in a liner material and is effective in both corrosion resistance and temperature capability.

■ Reprints of two technical papers for further reading are available: 1) Naasner, G., "Managing Extreme Requirements with Plastic Magnetic Coupling Pumps," and 2) Stavale, A.E., "Dry Running Tests Utilizing Silicon Carbide Bearings and Polymer Lubricating Strips with Conductive and Nonconductive Containment Shells in an ANSI Magnetic Drive Pump"—ITT A-C Pump, Cincinnati, OH.

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