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When to Consider Plastic Pumps

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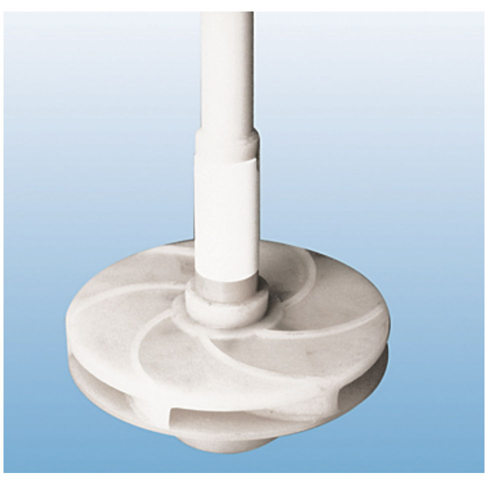
When to Consider Plastic Pumps

They come in a broad range of materials, each offering its own attractions.

Reprinted from CHEMICAL ENGINEERING
Edward Margus - Vanton Pump & Equipment Corp.

Polypropylene sump pump is 20 ft. long



Shaft-and-impeller assembly is of polyvinylidene fluoride except for ceramic bearing

A process engineer considering the use of a plastic pump faces two basic questions: Is a plastic pump better than a metal one for my situation? If so, what plastics and elastomers should I specify?

Plastic pumps have become the choice in more and more process situations as their qualities and capabilities have risen. However, the typical engineer remains far less familiar with plastic pumps than with metal ones.

Pumps made of thermosetting resins are available. However, those made of thermoplastics are of special interest in the process industries because of their wide-ranging inertness, as discussed in the next section.

Why consider plastics?

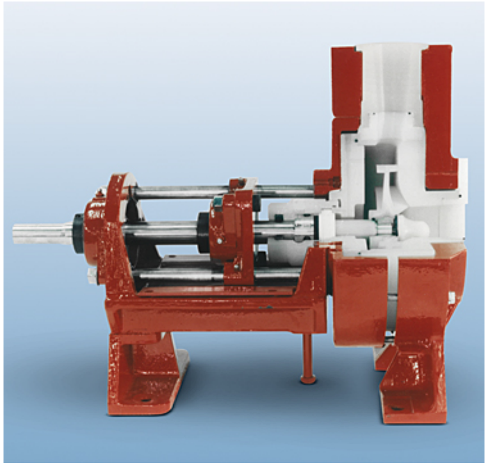
Originally, plastic pumps came on the scene to handle fluids, such as blood or hydrofluoric acid, that could not tolerate metals. That inertness is still a key attraction. The materials are not corroded by the process fluids, and conversely they do not contaminate the fluid. The latter advantage is important in many fields, such as pharmaceuticals, foods and electronic components.

Apart from resisting particular fluids, a given thermoplastic is likely to be inert to a broader range of them than is true for metals. This provides versatility.

Plastic pumps cost little to maintain. Their inertness makes for a very long operating life. Plastic parts do not gall. Nuts and bolts are easy to remove, threaded plastic components can be unscrewed readily, and components of a disassembled pump can be reused. Thus, spare-parts inventories can be kept to a minimum.

Also contributing to low maintenance is plastics' resistance to the atmosphere. Since they don't corrode, plastic pumps need not necessarily be painted.

As regards purchase price, the picture is mixed. Highly engineered thermoplastic pumps cost less than equivalent pumps of expensive metals or alloys (e.g., titanium or nickel). They are about on a par with pumps made of Type 304 or 316 stainless steel. But they are likely to be more expensive than equivalent ones of brass, bronze, aluminum or cast iron.



Centrifugal pump has parts of ethylene chlorotrifluoroethylene

Vertical cantilever bearingless pump with dry run capability

Automated dual pump/tank system for collection and transfer of laboratory wastes.

A look at the limitations

The most obvious limitation of thermoplastic pumps concerns the operating temperatures they can accommodate. Although a few thermoplastics, particularly the fluoropolymers, can retain their properties at temperatures as high as 550°F, commercially available thermoplastic pumps are generally not recommended for continuous service above 275°F. At higher temperatures, loss of mechanical properties and stress-cracking corrosion may hinder performance. In practice, this is not a widely relevant disadvantage, because corrosive fluids are generally handled at moderate temperatures.

Pumps that employ flexible liners incur an additional temperature limitation on the liner material. For instance, although a fluoropolymer casing or body block may be suitable for high temperatures as indicated above, the upper limit of the elastomeric materials is usually about 275°F.

As regards capacity, the upper limit for thermoplastic centrifugal pumps on the market today is about 1,000 gal/min, with heads to 240 ft. The largest rotary pumps cannot exceed 40 gal/min. The largest thermoplastic magnetic-drive chemical pumps are limited to approximately 400 gal/min against a total dynamic head of 40 ft.

Impact resistance and strength of thermoplastic pumps may also pose a problem. They must be protected against falling objects and similar impact dangers, because of possible deformation if the operating temperature is high. Furthermore, thermoplastic material tends to elongate under sustained load (creep) as temperatures rise.

For these reasons, thermoplastic pumps must generally be armored, by surrounding the plastic with a metal sheath. This is particularly true of horizontal centrifugal pumps that are exposed in normal plant operations. Accordingly, these plastics' light weight cannot be considered an advantage in those pumps (except to the extent that the lightness of the plastic components within the armor eases maintenance).

Light weight is, however, an advantage with respect to vertical centrifugal pumps, particularly the larger ones. The same is true of portable hand-held pumps.

Spotlight on materials

The selection of materials for a thermoplastic pump is highly relevant for at least two reasons. One is the very broad range of polymers available. The other is that, unlike the situation with pumps made of metal, the engineer does not consult corrosion tables to help make the choice — a particular plastic either works for a given situation or it doesn't, and that information is readily available.

In spite of the breadth of the field, most thermoplastics used for pumps fall into four basic categories: vinyl, polypropylene, polyethylene and fluoroplastic.

When one considers use of those polymer families, a key parameter is the service temperature. Some of the temperatures cited here may

Mobile unit can store and pump corrosive liquids at various locations within plant

Sump pump set in skid mounted double wall tank to collect hazardous waste.


Polypropylene centrifugal pumps move 50/gal/min of sodium hexametaphosphate

seem conservative. That is because plastic components in pumps must retain not only their shape but also adequate mechanical strength.

Vinyl
The ones most commonly used in pumps are polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC). PVC has good chemical resistance and is an excellent choice for service temperatures to 140°F. CPVC withstands temperatures to 210°F.

These materials are widely used throughout the chemical process industries because they offer relatively low cost, good physical properties, and resistance to attack by acids, alkalies, salt solutions and many other chemicals. They are not generally suitable for use with ketones, esters, chlorinated hydrocarbons, or aromatics.

Polypropylene
These increasingly popular low-cost polymers offer a good strength-to-weight ratio, because of their relatively high stiffness and their specific gravity of only around 0.90. Maximum service temperature is 185°F.

They resist a broad range of acids, bases and solvents. But they are generally not recommended for strong oxidizing acids, or for chlorinated hydrocarbons and aromatics.

Despite that limitation, polypropylene pumps (and other equipment) are widely used in the petroleum industry because the polymer resists sulfur-bearing compounds. They are also attractive for water handling and for waste treatment, and for laboratory service.

Polyethylene
This high-molecular weight material is impermeable to water and generally resistant to organic solvents, acids and alkalies. It is among the lightest of the thermoplastics, and retains good physical properties even at low temperature. Polyethylene is attacked by strong oxidizing acids and chlorinated or aromatic solvents. Maximum recommended service temperature is 200°F.

Fluoropolymer
The three major fluoroplastics widely used in pumps for structural parts are: polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), and ethylene chlorotrifluoroethylene (ECTFE). Each offers particular attractions.

PTFE is perhaps the most inert compound known, so it can be exposed to a extremely broad range of fluids. Its maximum service temperature, 500°F, is significantly higher than that of the other two.

PVDF is stronger, stiffer and less subject to creep than PTFE. It retains strength well throughout its service temperature range. Its maximum recommended service temperature is 300°F. It is chemically resistant to most acids, alkalies (except sodium hydroxide) and organic solvents, and is equally suited for handling wet or dry chlorine, bromine and the other halogens.

ECTFE has high tensile strength and impact resistance. It is inert to a broad range of acids, including the oxidizing types. It also can handle alkalies, organic solvents (and combinations of them), most other corrosive liquids, and abrasive mixtures, even when used as a coating over metals. Maximum service temperature is 300°F.

All three of these fluoropolymers are suitable for applications requiring extreme purity and freedom from contamination. Examples include electronics manufacture and the handling of ultrapure water.

Elastomeric components

Thermoplastic pumps require elastomeric materials as well. These are primarily used where corrosion resistance and impact resistance must be combined with flexibility, as in gaskets, O-rings and other flexible parts.

Natural rubber
It offers good resistance to weak and strong acids and alkalies as well as to oxygenated solvents. It stands up well against abrasion and has good low-temperature characteristics. But it is attacked by oxidizing acids, and tends to swell in vegetable, mineral and animal oils.

Butyl rubber
Formed by the polymerization of butylene and butadiene, this synthetic elastomer has good resistance to corrosive chemicals in general, including outstanding resistance to dilute mineral acids. It also resists vegetable and mineral oils. It stands up very well under heat, and offers low gas permeation. It is not recommended for use with petroleum solvents or aromatic hydrocarbons.

Buna-N (nitrile rubber)
This copolymer of butadiene and acrylonitrile has good resistance to weak and strong acids as well as alkalies, and is highly inert to aliphatic hydrocarbons, petroleum, and mineral and vegetable oils. It has excellent water-swell resistance, and its mechanical properties actually improve at higher temperatures. Buna-N is not recommended for use with highly polar solvents such as acetone, methyl ethyl ketone, and chlorinated hydrocarbons.

Neoprene
It offers excellent resistance to dilute acids and weak and strong alkalies, and good resistance to petroleum, oils and concentrated acids. It is not recommended for strong oxidizing acids, esters, ketones or chlorinated aromatic hydrocarbons.

Ethylene-propylene-diene monomer (EPDM) rubber
This synthetic elastomer affords excellent low- and high-temperature characteristics. It resists attack by a wide range of acids and alkalies, detergents, phosphates, ketones, alcohols and glycols. EPDM does not tend to absorb fluid, or to swell. It is not recommended for use with aromatic hydrocarbons.

Chlorosulfonated polyethylene
It offers good resistance to dilute and concentrated acids, and alkaline solutions regardless of their pH. Resistance to strong oxidizing acids is excellent.

Other elastomers
Copolymers of vinylidene fluoride and hexafluoropropylene have

excellent resistance to oils, fuels, lubricants and most mineral acids, and stand up against many aliphatic and aromatic hydrocarbons that attack other rubbers. They are not recommended for low molecular weight esters or ethers, or for ketones or certain amines, or for hot anhydrous hydrofluoric or chlorosulfonic acids. Copolymers of perfluoromethyl vinyl ether and tetrafluoroethylene offer virtually unmatched resistance to all classes of chemicals, except fluorinated solvents. Continued use at temperatures to 550°F is possible, and intermittent use to 600°F. The material neither creeps nor flows, and it becomes more elastic rather than embrittled with heat aging. The major disadvantage is extremely high cost.

In addition to the structural thermoplastics and the elastomers, thermoplastic-pump manufacturers sometime employ ceramics in seal components. Two of the most common are a ceramic-graphite composite with a silicon carbide surface that stands up well against abrasion and heat, and a sintered silicon carbide that offers extremely high corrosion resistance to aggressive liquids and solutions, such as bromine.

Assuring quality and reliability

The engineer should insist that the supplier test every pump before shipment, rather than relying on random sampling. Testing should in all cases include output flowrate, head pressure, and energy input. Centrifugal pumps should also be hydrostatically checked for leaks up to the rated seal pressure. Hydraulic Institute (Cleveland, Ohio) guidelines should be followed for all testing.

Routine vibration testing can be carried out by sound and touch, but the findings should be checked with a vibration meter if they appear to be borderline. Shaft straightness and runout should be examined, and runout of impellers and similar circular parts should be assessed by an indicator on a motorized fixture.

Be sure to specify that the pump impellers be dynamically balanced. Forestalling shaft vibrations not only makes for accurate flowrates and long seal life but also can help the pump meet workplace-noise limitations, such as those of the U.S. Occupational Safety and Health Administration. Pump buyers' concerns about erosion stemming from surface grinding or hole drilling required for balancing are unwarranted.

Edited by Nicholas P. Chopey

PLASTIC PUMPS' PROGRESS

Plastic pumps came into prominence because of their early use as a mechanism for transferring human blood without contamination or destruction of the cells. The original pump used as an artificial heart was of the flexible-liner design, having a pure-gum-rubber liner and a transparent polymethyl methacrylate housing.

Like the industrial versions that have since grown out of it, this rotary heart pump operates by means of an eccentric shaft within the liner. A rotating eccentric lobe pushing against the liner creates a progressive, compressive force that propels the liquid between the wetted side of the liner and the inert pump casing. Some 150,000 industrial plastic pumps of the flexible-liner design are in service today in the U.S. alone. They can handle gases or liquids, including viscous fluids up to 8,000 SSU.

These pumps are often mistakenly confused with two types of progressive cavity pumps, each also available in plastic. One is the progressive-cavity screw pump, employed mainly to handle highly viscous materials such as toothpaste, glues, grease or sludge. The other is a peristaltic pump of flexible tubing design, often used for corrosive or flammable fluids. Gear pumps are available in plastic. And the use of plastic diaphragm pumps has risen recently.

Horizontal centrifugal pumps employing plastics were already appearing on the industrial scene 30 years ago. At first, pump manufacturers merely re-created the design and configuration of the standard metal pump, using plastic components where possible for fluid contact areas. But as the market grew, pump designers started to take advantage of the superior chemical inertness, abrasion resistance, low weight and precision moldability of the newly emerging engineered plastics. This led to nonmetallic pumps with many design components that were radically different from their metal counterparts.

It was only natural that the vertical centrifugal or sump pump would not be far behind. Stimulated by the tremendous growth in the municipal and industrial water- and waste-treatment fields, engineers have been designing sump pumps with unique characteristics. For example, as waste-gathering sumps have become deeper, vertical centrifugal pumps have been redesigned to be suitable for depths of 20 ft. and more.

Magnetic pumps with plastic components have also been undergoing much development. State-of-the-art versions make wide use of fluoropolymers for housing linings, are of rugged construction, and offer almost universal chemical resistance, in some cases to temperatures of 300°F. The housing linings may be of thick-walled PTFE or PVDF, and are supported by shells of ductile iron.

COMPARATIVE PROPERTIES OF RIGID PLASTICS

Name	Polyvinyl chloride (normal Impact)	Chlorinated polyvinyl chloride	Polyethylene (high density)	Polypropylene	Polytetra-fluoroethylene	Polyvinylidene fluoride	Ethylene chlorotrl-fluoroethylene
Pump components	Casings, impellers, bolts, nuts, shaft sleeves, columns, mounting plates	Impellers, bolts, nuts, shaft, sleeves, casings, mounting plates, columns	Body blocks, casings, impellers, nuts, bolts	Body blocks, bolts, nuts, shaft sleeves, casings, impellers, columns, mounting plates	Body blocks	Casings, impellers, bolts, nuts, shaft sleeves, columns, mounting plates	Casings, impellers, bolts, nuts, shaft sleeves
Specific gravity	1.30-1.58	1.49-1.58	0.926-0.940	0.902-0.910	2.14-2.20	1.75-1.78	1.68-1.8
Tensile strength, psi	6,000- 7,500	7,500-11,000	3,500-4,500	4,300-5,500	2,000-5,000	5,500-8,250	6,500-7,500
Compressive strength, psi	10,000	9,000-16,000	---	5,500-8,000	1,700	8,680	---
Impact strength, ft./lb./in. notch (Izod test)	0.4-2.0	0.61	1.5-12	0.5-2.2 at 73° F. (1/8-by-1/2-in. bars)	3.0	3.6-4.0	No break at 73° F
Hardness, Rockwell (R) Shore (D)	R113	R121	D65 R35-40	R80-110	D50-55	D80	D75, R93
Thermal expansion, 10 ^ 5 in./in./°F	2.8	4.4	6	5.8-10.2	10.0	8.5	4.4
Heat resistance, °F (continuous)	130-140	210	200	185	500	300	300

CHEMICAL RESISTANCE

Name	Polyvinyl chloride (normal Impact)	Chlorinated polyvinyl chloride	Polyethylene (high density)	Polypropylene	Polytetra-fluoroethylene	Polyvinylidene fluoride	Ethylene chlorotrl-fluoroethylene
Effect of weak acids	None	None	None	None	None	None	None
Effect of strong acids	None to slight	None to slight	Attacked by oxidizing acids	Attacked slowly by oxidizing acids. Avoid chromic acid	None	Attacked by hot conc. sulfuric acid	None
Effect of weak alkalies	None	None	None	None	None	None	None
Effect ot strong alkalies	None	None	None	Very resistant	None to slight	Attacked by sodium hydroxide	None
Effect of organic solvents	Resists alcohols, aliphatic hydrocarbons, oils; swells in ketones, esters, or aromatic hydrocarbons.	Resists alcohols, aliphatic hydrocarbons, oils; swells in ketones, esters, or aromatic hydrocarbons.	Resistant below 60° C. except to chlorinated or aromatic solvents.	Resistant below 80° C. except to chlorinated or aromatic solvents.	None	Resists most solvents.	None, except hot amines

(Tables represent general properties. Properties of pump components may vary to suit specific mechanical and chemical requirements.)
Source: Vanton Pump & Equipment Corp.