TECHNICAL
ARTICLE
SERIES

Non-metallic pumps withstand a wide range of severe service applications

ARTICLE # TL-123

INDUSTRY: General

ENTITY: Various

SOLUTION(S) PUMPED: Various

PUMP TYPE(S): CHEM-GARD Horizontal Centrifugal Pump, FLEX-I-LINER Sealless Self-Priming Peristaltic Pumps, Nonmetallic Tank Pump Systems, SUMP-GARD Thermoplastic Vertical Pump

Vanton Pump & Equipment Corp.
201 Sweetland Avenue
Hillside, NJ 07205 USA
Telephone: 908-688-4216
Fax: 908-686-9314
E-Mail: mkt@vanton.com
www.vanton.com

Vanton Pumps (Europe) Ltd
Unit 4, Royle Park
Royle Street
Congleton, Cheshire, UK CW12 1JJ
Telephone: 01260 277040
Fax: 01260 280605
www.vantonpump.com

Overhead view of four thermoplastic centrifugal pumps handling discharges from the production area of a major silicon wafer facility in the U.K.. The process fluids include hydrochloric, nitric, sulfuric, hydrofluoric and phosphoric acids as well as hydrogen peroxide, caustic soda and other chemicals in unknown quantities.

Gaylord H_2SO_4 fume scrubbers usethermoplastic pumps and thermoset tanks to resist corrosives. Teflon rotary pump with Hypalon flexible liner transfers 50% NaOH to the fiberglass tank. The caustic in the tank is circulated by a polypropylene sump pump with cantilevered integral pump/motor shaft sleeved in plastic.

Spotlight on Plastics

Reprinted from PUMPS AND SYSTEMS
By Dan Besic

Non-metallic pumps withstand a wide range of severe service applications

A recent research program conducted jointly by Pollution Engineering magazine and the customer service division of Vanton Pump & Equipment Corporation queried pump specifiers for the factors contributing to their selection of non-metallic pumps.

Although many advantages of non-metallic pumps were indicated, corrosion resistance was clearly the number one factor – receiving 58% of the responses. This chemical inertness permits the safe application of a single pump for the complete pH range from 1-14 as well as for salts, halogens, solvents and other troublesome chemicals.

Abrasion resistance, particularly when coupled with resistance to corrosion, was also frequently cited as grounds for selecting a non-metallic pump. Lower maintenance, longer service life, prevention of metallic contamination, lighter weight, and lower cost when related to high alloy and exotic metal pumps were also mentioned.

When specifying a non-metallic material for the wet-end of the pump or other fluid contact components, and following factors should be considered:

1. specific chemical(s) to be pumped and the possible range of process fluids
2. degree of abrasiveness
3. temperature range
4. pH range
5. importance of metal contamination avoidance
6. field experience with similar installations

The non-metallic materials most often specified are listed below:

Thermoplastics
- Polyvinyl chloride (PVC)
- Chlorinated polyvinyl chloride (CPVC)
- Polyethylene (PE)
- Polypropylene (PP)
- Polyvinylidene fluoride (PVDF)
- Ethylene chlorotrifluoroethylene (ECTFE)
- Polytetrafluoroethylene (PTFE)

Thermosets
- Fiber reinforced plastics (FRP/GRP)

To select the most cost effective construction material for a given application, it is also important to understand the basic characteristics of thermosetting and thermoplastic materials.

Thermosets cannot be remelted or reshaped once they have been cured by heat or chemical means. The thermoset materials most commonly specified for pump components consist of vinyl or epoxy resins reinforced by glass fiber. This composite structure provides relatively high mechanical properties, but lessens resistance to corrosive and abrasive chemicals.

Thermoplastics, on the other hand, are homogeneous polymers which can be remelted, remolded and reshaped. Their uniform structure provides increased chemical resistance over a broad pH range, freedom from product contamination and excellent abrasion resistance.

CLOSE-UP ON THERMOSETS

The glass fibers employed to reinforce the plastic resins are inert to most chemicals and the resistance of the composite is generally limited by the specific resistance of the initial and/or added polymers, as well as by the characteristics of the composite construction.

Pumps manufactured with thermoset structural components have strengths similar to metal pumps. These pumps do not usually require metal armor unless they are installed in an area subject to falling metal objects. Although high nozzle loads do not generally result in nozzle failure of thermoset pumps, they can cause shaft misalignment. And these pumps should only be exposed to nozzle leads at 1/2-2/3 that of a metal pump of corresponding size. With respect to corrosion, thermoset pumps can successfully handle a wide range of acids, caustics, solvents and salts at operating temperatures to 250°F.

Horizontal centrifugal FRP/GRP pumps are available for flows to 5000 gpm and heads to 400 ft. Vertical sump pump designs are available for flows to 4500 gpm and heads to 275 ft.

The vinyl ester resin composite pumps are generally recommended for their corrosion resistance, whereas the epoxy resin materials offer superior resistance to solvents. Special composite formulations are available for handling mildly abrasive solutions.

Since the fiber reinforced composite material is non-conductive, no electrochemical corrosion can occur. But the resin, fiber and other components in the composite can degrade. Such degradation, if it occurs, will tend to occur rapidly. An exception to this rule is the reaction with chlorine and oxidizing chemicals, which can slowly attack resin fiber composites in a manner similar to metal.

The interface between the fiber and the resin may be a source of trouble. If the process fluid is absorbed into the interstices by capillary action, the interface resin material may subsequently bleed out and contaminate the fluid being pumped. The wicking or bleeding action is particularly significant when a single pump is employed for a variety of fluids. The leaching out of the resin by corrosive attacks, which occurs when thermosets have been misapplied, may also cause impeller imbalance.

Another concern with thermoset composites is the softening of the surface by alkaline salt slurries. This condition, which has been referred to as "cor-brasion," tends to limit the use of composite to non-abrasive applications and also limits their use with caustics.

CLOSE-UP ON THERMOPLASTICS

Choosing the specific thermoplastic for a given pump application begins with consideration of the operating temperature range. Thermoplastic pumps are generally recommended for service over a range from -20°F to 275°F. These pumps can handle flows to 1450 gpm and heads to 280 ft. Even though some of the materials can be exposed to temperatures from cryogenic to 500°F, the various elastomeric components employed as seals for centrifugal pumps and flexible liners for rotary (peristaltic) pumps limit the pump application to the indicated range. Table 1 gives physical property data, including maximum service temperatures, for the thermoplastics most frequently used in pumps.

- **Vinyls**

Vinyls, such as PVC and CPVC, are widely used for their relative low cost, good physical properties and broad chemical resistance. For temperatures to 140°F, the low cost PVC gets the nod. If temperatures to 210°F are anticipated, CPVC should be specified. Both materials resist acids, alkalis, salt solutions, aliphatic hydrocarbons and oils, but they tend to swell in ketones, esters and aromatic hydrocarbons. CPVC offers greater impact strength and abrasion resistance and is often recommended when higher mechanical strength is required at elevated temperatures.

- **Polypropylene**

Polypropylene is the lightest of the thermoplastics in general use for pump components. Its specific gravity of 0.91 is significantly less than the densities of the vinyl polymers as shown in Table 1. Its tensile strength is slightly lower than the vinyls, and its heat resistance falls in between, with a maximum operating temperature of 185°F. Because of its low cost, high strength-to-weight ratio and good resistance to a broad range of solvents, acids, alkalis and salts, polypropylene has become the industry standard for general corrosion service. It is not, however, recommended for use with strong acids, chlorinated hydrocarbons or aromatics. Polypropylene is especially suited to handling wastewater effluents and waste treatment chemicals used by industrial and municipal plants and laboratories. The petroleum industry is also a large user of polypropylene pumps because the polymer resists sulfur-bearing compounds. Since unpigmented, natural polypropylene is affected by UV light, it is frequently pigmented or otherwise stabilized when specified for outdoor use.

- **Polyethylene**

Although polyethylene is widely employed for industrial applications in Europe, it is used on a limited basis in the U.S. because the ultra high molecular weight (UHMW) formulation cannot be processed by conventional injection molding methods. Polyethylene has properties very similar to polypropylene. The specific gravity is slightly higher, and the tensile strength is slightly lower (Table 1). Its heat resistance is suitable for applications to 200°F. However, polyethylene is more readily attacked by oxidizing acids. Thick-sectioned, machined pump bodies, such as those used in rotary pumps, are frequently furnished in polyethylene because the material is relatively low in cost and offers excellent abrasion resistance.

• **Polyvinylidene fluoride**

When higher corrosion, abrasion and heat resistance are required, the material of choice is polyvinylidene fluoride (PVDF). Although this fluoropolymer has a melt point of 352°F, the commercial product known as Kynar® is most generally recommended for pump components that will see continuous service in the range from -40°F to 275°F. PVFD is a strong, tough, relatively heavy material with a specific gravity of 1.75 and tensile and compressive strengths similar to CPVC. Its high density enables it to resist distortion and retain its strength at relatively high temperatures. PVDF offers superior resistance to abrasion and is frequently employed for pump impellers even when the casings are specified in polypropylene. It is chemically inert to most acids, alkalis (except sodium hydroxide), organic solvents, wet or dry chlorine, bromine and other halogens. PVDF cannot be used with fuming acids, polar solvents, amines, ketones or esters. Kynar PVDF pumps are widely applied in electronic product manufacturing and laboratories where pumps are required to handle ultrapure water or reagent grade chemicals that cannot tolerate contamination of any sort.

• **Ethylene Chlorotrifluoroethylene**

A similar fluoropolymer, ethylene chlorotrifluoroethylene (ECTFE), offers equal density, slightly higher strength and temperature resistance, along with broader resistance to strong oxidizing acids, chlorides, alkalis and organic solvents. The commercial grade of ECTFE, Halar®, is recommended for use at temperatures as low as -105°F and for continuous service to 300°F.

• **Polytetrafluoroethylene**

Polytetrafluoroethylene (PTFE) is the most inert plastic material currently in commercial use. Commonly referred to as Teflon®, it has extremely high density and is resistant to weak and strong acids, alkalis, salts and organic solvents. Although its impact strength is high, its coefficient of friction is exceptionally low. As a result, its abrasion resistance is much poorer than polyethylene, PVDF, the vinyls or polypropylene. It can be employed, however, for sliding surfaces.

DESIGN CONSIDERATIONS

To offset the lower impact resistance of the thermoplastics, the designs of the thermoplastic horizontal centrifugal pumps incorporate metal armor, which provides protection from falling objects or careless plant operation. Recent ANSI designs completely reinforce the flange so that the thermoplastic pumps can accommodate the nozzle loading levels of the steel pumps these plastics units replace. In terms of unit cost, the average thermoplastic pump for corrosive/abrasive service is about the same price as a quality 316 stainless steel pump and appreciably lower than pumps of high alloy or exotic material construction. Thermoset and thermoplastic pumps are available in conventional and magnetically coupled horizontal centrifugal configurations, in standard and cantilevered shaft vertical pumps designs, and in numerous rotary pumps involving gears, vanes or flexible liners.

Table 1. Thermoplastic Physical Property Data

Thermoplastic Material	Specific Gravity	Tensile Strength (psi)	Max. Operating Temp. (°F)
PVC	1.30	6,000 - 7,000	140
CPVC	1.49	7,550 - 9,000	210
PP	.91	4,500 - 6,000	185
PE	.92 - .94	1,200 - 4,550	200
PVDF (KYNAR®)	1.75	8,000	275
ECTFE (HALAR®)	1.75	7,000	300
PTFE (TEFLON®)	2.14 - 2.20	2,500 - 6,000	500