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What's New with Thermoplastic Centrifugal Pumps?

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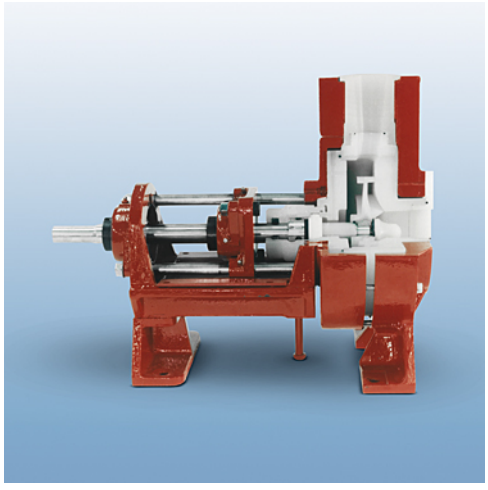
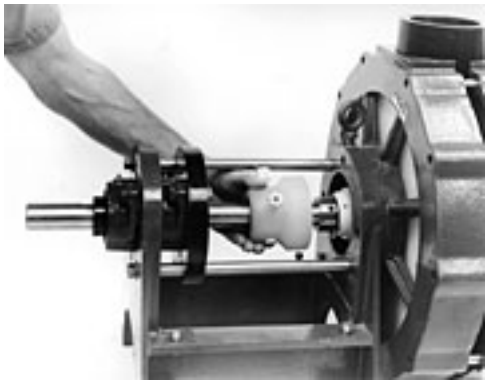
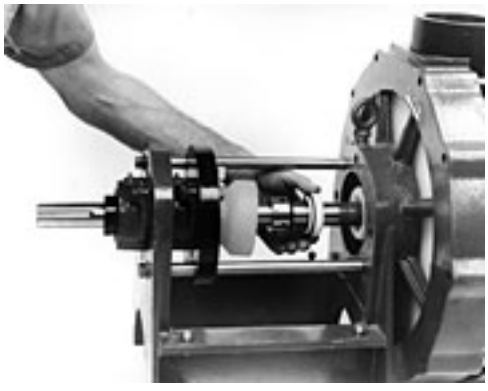


Photo 1. Cut-a-way view of an ANSI thermoplastic end suction centrifugal pump for flows to 1450 gpm (5,488 lpm), heads to 400 feet (122 m) and temperatures to 275°F (135°C). These pumps, which meet ANSI B73.1 process pump standards, incorporate the wide open seal area and retractable front bearings to simplify maintenance and provide ample room for most types of commercially available single and double mechanical seals.





Photos 2a and 2b. The sliding bar design lets users pull the bearing back for easy inspection and maintenance.

What's New with Thermoplastic Centrifugal Pumps?

Reprinted from Pumps and Processes
By George Black, Materials Engineering Consultant, Vanton Pump & Equipment Corp.

A fresh look at recent design developments

Every research study on pump usage clearly indicates that horizontal centrifugal pumps are the most widely used pump type for industrial, chemical and municipal processing, and waste treatment operations. Many years ago, the oft-quoted professor Harold Woodhouse of Stevens Institute of Technology, made this statement in his mechanical engineer's Guide to Selecting Centrifugal Pumps: "There is probably no other piece of mechanical equipment so deceptively simple in construction and yet so complicated in application... perhaps, no other piece of equipment is made in so many styles and designs, a number of which are the result of evolutionary experience which has caused a departure from theoretical design rules. Still misapplications occur. Systems fail to operate as expected, and as required."

There appear to be two major reasons for the misapplications referred to by Professor Woodhouse. The first, and perhaps the most significant, is the tendency to automatically replace a failed pump with a new one of the same design. This is the easiest approach because it requires the lowest level of expenditure approval. Unless the service rendered by the failed pump is economically intolerable, companies learn to live with "acceptable" repetitive maintenance costs. In most manufacturing operations, it is much easier to get authorization for a direct product replacement than an OK to install something new, particularly if the reason for the change might embarrass the individual responsible for the original pump selection, or if the suggested change requires an unbudgeted capital expenditure.

The second reason is tied to a number of causes such as the limited awareness of product upgrades in terms of design, and more recently, adequate knowledge about the availability and potential use of new and modified materials of construction (Table 1). Unfortunately, both of these get short shrift in the engineering curriculum at most universities, and to some extent, even in trade magazine editorial coverage. When I was young and twenty, we couldn't wait for the next issue of Product Engineering or Materials and Methods — two publications that concentrated on design changes to secure higher and more cost effective productivity. Unfortunately, both of these magazines are no longer being published, and the Internet has not begun to fill the void.

THE LATEST DEVELOPMENTS

Horizontal centrifugal pumps have been around for a long time, but design and variations in configuration and material selection have not stood still. Let's take a look at some of the developments in thermoplastic pump design that have grown out of "evolutionary

Photo 3. Open pump showing solid molded thermoplastic casing and impeller.

Photo 4. Metal armor provides structural protection and permits this ANSI mag drive pump to withstand the same nozzle loadings as metal pumps.

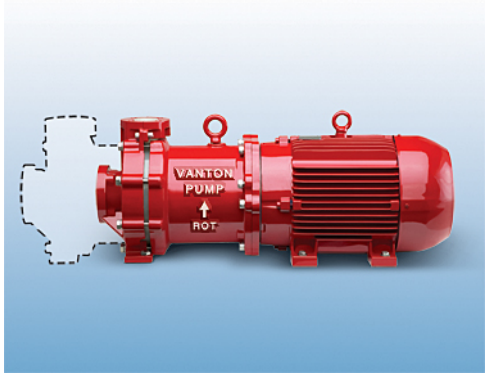


Photo 5. The comparative size difference between standard and close-coupled designs.

experience," and which directly affect performance and maintenance, and the ability to minimize what Professor Woodhouse referred to as "misapplications."

SEALING OPTIONS

One area that has had and continues to have extensive coverage in both advertising and editorial is the subject of fluid leakage and related seal maintenance. The obvious answer has been the move to sealless horizontal centrifugal pumps. These designs automatically prevent fluid leakage and reduce maintenance because they eliminate the use of shaft seals. Magnetically coupled end suction centrifugal thermoplastic pumps, for example, are now readily available from many dependable manufacturers in a broad range of chemically-inert thermoplastics. These should be thoroughly explored and carefully considered in terms of conditions of service and cost. But let us not ignore or overlook the availability of improved seal materials, creative seal construction and placement, as well as back pull-out thermoplastic pump designs. All of these have helped to significantly reduce the cost of seal maintenance in conventional centrifugal pumps and deserve close attention.

NEW MATERIALS

Higher purity of chemically-inert thermoplastics suitable for use at elevated temperatures and offering superior resistance to corrosion and abrasion than the stainless steels have recently become available. These have greatly extended the suitability of thermoplastic pumps for applications not previously considered feasible. Consider the recent studies in the semiconductor and pharmaceutical industries, which indicate quite strongly that the thermoplastics, when supplied in their homogeneous, natural state, ensure greater electronic product reliability so vital to the former, and higher degrees of chemical and water purity demanded by the latter. This relatively new knowledge has opened many new avenues for consideration by system designers and should be high on the "what's new" list for pump users and specifiers. Unfortunately, the hesitancy to accept change continues to be a difficult hurdle to jump.

The leaching differences between stainless steel and PVDF, for example, illustrate why semiconductor plants have opted to use PVDF and why even a biotech facility concerned about producing the highest purity water possible would opt for PVDF or other fluoropolymer materials.

Companies that process or utilize high purity acids in the semiconductor industry have settled upon fluoropolymers as a material of construction because they can be manufactured in such a manner that no foreign additives, that later could become extractables, are needed.

Pharmaceutical plants need piping and other fluid-handling components that can also withstand exposure to hot water or steam used in sterilization. It is important that pipes, pumps, valves and other wetted surfaces not promote microbial activity. An equally strong concern is that these components not contain extractable substances that will leach into and contaminate high purity water. The leaching differences between stainless steel and PVDF are shown in nanograms per milliliter in Table 2.

PEDESTAL POWER FRAMES

More than 20 years ago, in response to customer demands for longer seal life and lower seal maintenance, pump engineers created a pedestal power frame construction design that simplified seal inspection in the field (Photo 1). This design simultaneously permits seal inspection and repositioning of the inboard shaft bearing closer to the impeller, keeping shaft overhang and deflection at a minimum. This inspection and adjustment is accomplished without removing the pump and without affecting shaft alignment. It is made possible by a series of rigid bars parallel to the axis of the shaft, on which the flanged ball bearing assembly can easily be moved, repositioned and locked to the shaft. It also permits the bearing assembly to "float" parallel to the axis of the shaft as it automatically compensates for the differential in thermal expansion between the stainless or other alloy steel shaft and the cast iron pedestal (Photos 2a and 2b).

This unique sliding bar bearing assembly construction received the coveted Vaaler design award on its announcement, but it took many years before it became an accepted standard on conventional end suction horizontal thermoplastic pumps. If your centrifugals are giving you excessive seal maintenance problems, check to see if they incorporate the sliding bar pedestal or something similar. As centrifugal pump designs with back pull-out construction became popular, the sliding bar pedestal design was even incorporated into the ANSI line of thermoplastic pumps because this construction also provides for a much larger, more open seal area than conventional power frame designs. It also permits pumps with this design to accept most commercially available single and double mechanical seals. This attribute enables you to select from a greater selection of suitable mechanical seals and opens an additional approach to reducing seal leakage as well as maintenance costs.

MOUNTING THE SEALS

Another simple concept made feasible by the sliding bar design is directly related to reducing initial seal costs and repetitive maintenance. This is the "reverse mounting" of seals so that the nonmetallic seal component — rather than the metal one — is in contact with the corrosive fluid. Since the nonmetallic materials tend to have greater chemical resistance, seal life is automatically extended. In addition, seal reversal also makes it unnecessary to utilize high cost exotic metal seals.

Since the literature is replete with competitive information about seal selection and design, no attempt will be made here to duplicated the recommendations so readily available. I would suggest, however, that time spent with a seal specialist is well worth the investment. Maintaining accurate records on seal maintenance and discussing the data with your pump supplier can be very rewarding. In selecting centrifugal pumps, don't overlook design differences that provide you with the greatest variety of seal choices and arrangements, and base your decision on construction arrangements that permit seal selection that best fits your own application. Consider your choices among single seal with water jacket, single seal with water flushface for fluids that

leave crystal deposits, single seal with direct product or water flush, double mechanical seal with water jacket, and balanced mechanical seals.

If your application calls for a sealless thermoplastic centrifugal pump, consider available offerings of magnetically-driven designs conforming to ANSI B73.1 end suction process pump specifications and Hydraulic Institute standards. Most of these design factors are critical for all pumps handling corrosive, abrasive and other aggressive fluids. A few specifically pertain to magnetically-driven designs.

1. All fluid-contact components of conventional or mag drive pumps should be furnished in solid, nonmetallic materials inert to the specific chemicals. (Photo 3).

2. The high performance rare earth inner magnet rotor assembly should be encapsulated in thermoplastics and isolated from the fluid to avoid troublesome eddy currents that reduce pump efficiency by loss of magnetic force.

3. The stainless or other alloy steel shaft should be sleeved and the inner magnet rotor assembly completely encapsulated in the appropriate thermoplastic to isolate it from the fluid.

4. Metal armor provides structural protection to the thermoplastic molded casings. ANSI-conforming designs should permit pumps to withstand the same nozzle loadings as ANSI metal pumps (Photo 4).

5. The pump design should incorporate fresh water flushing capability and wide open fluid passages to enable continuous cooling and capability for handling slurries and viscous fluids (Fig. 1).

CLOSE-COUPLED PUMPS

Europe appears to have led the move toward extensive use of close-coupled thermoplastic centrifugal pumps. Recently, however the interest has grown in the United States because of the demand by system designers and OEMs for space saving and unit cost reduction. As a result, pump specifiers and users now have a choice of high quality, end suction nonmetallic pumps with footprints approximately 20% shorter than standard foot-mounted designs (Photo 5).

Pumps with this compact configuration are now available in polypropylene and polyvinylidene fluoride (PVDF), and in a choice of tangential as well as centerline discharge. Both designs offer easy access for seal maintenance, and for removal without disturbing existing piping.

Where space is critical and cost savings important — and where dependable transfer of aggressive or ultrapure fluids is a must, these close-coupled designs should be looked at. They are designed to accommodate standard C-face motors and most commercial mechanical seals.

Table 1. Comparative material characteristics

	MATERIALS	MAXIMUM TEMP °F/°C	SPECIFIC GRAVITY	WEIGHT LOSS (MILLIGRAMS) TABOR, 1000 CYCLES
PVC	Polyvinyl chloride	140°F/60°C	1.30	12 - 20
CPVC	Chlorinated polyvinyl chloride	210°F/99°C	1.49	20
PE	Polyethylene	200°F/93°C	0.92 - 0.94	5
PP	Polypropylene	185°F/85°C	0.94	15 - 20
PVDF	Polyvinylidene fluoride	275°F/135°C	1.75	5 - 10
ECTFE	Ethylene chlorotrifluorethylene	300°F/149°C	1.75	5 - 10
PTFE	Polytetrafluorethylene	500°F/260°C	2.14 - 2.20	500 - 1000
FRP	Fiberglass reinforced plastic	250°F/121°C	3.4 - 5.0	388 - 520
SS	Stainless steel type 304/316	N/A / N/A	7.9	50

Table 2. Leaching comparison between PVDF and 316LSS (ng./mL)

SUBSTANCE	PVDF FITTINGS	STAINLESS STEEL TUBING BENT	STAINLESS STEEL TUBING WELDED
Na	0.676	3.587	3.273
Ca	3.667	<10	122.000
Fe	1.007	63.260	64.260
Zn	0.335	4.548	1.897
Mo	<0.010	2.922	3.039
F	97	<5	<5
Cl	38	54	111

Source: Burkhart, M.; Wermelinger, J.; Setz, W.; Mü, D. "Suitability of Polyvinylidene Fluoride (PVDF) Piping in Pharmaceutical Ultrapure Water Applications", Table 1, PDA Journal of Pharmaceutical Science & Technology 50(4), pp. 247 (July/August 1996).

(Marty Burkhart, Gunter Wagner, and Felix Klaiber, George Fischer Piping Systems, UTLRAPURE WATER May/June 1997)

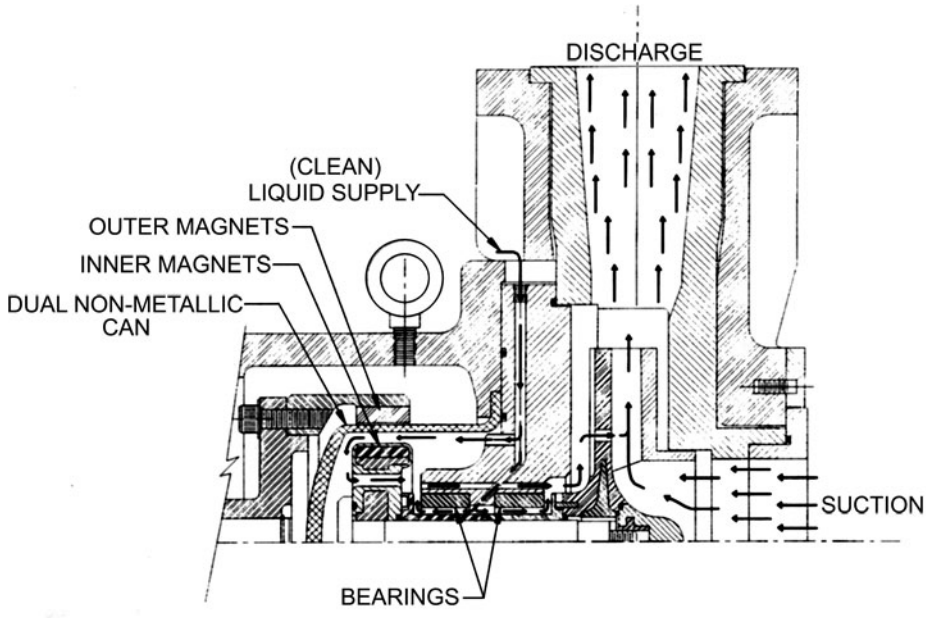


Fig 1. This pump design has a fresh water flushing capability and wide open fluid passage for continuous cooling and capability for handling slurries and viscous fluids.