



Consider Positive Displacement Pumps

Such units offer advantages over centrifugal pumps in some services

By Sean McCandless and Richard Meighan, Colfax Fluid Handling

MOST ENGINEERS are more familiar with centrifugal pumps than positive displacement pumps. In many cases, however, positive displacement pumps, particularly rotary variants, can provide the most cost-effective and efficient fluid handling. That's because, unlike centrifugal pumps, which create pressure, positive displacement pumps create flow.

In a centrifugal pump, an impeller rotates to move liquid through the process. The impeller's velocity imparts energy on the fluid. The resulting rise in pressure, or head, is proportional to the velocity of the liquid.

In contrast, a positive displacement pump moves a set volume of liquid. Pressure is created as the liquid is forced through the pump discharge into the system. The pump converts energy into pressure. This is achieved as an increasing volume within the pumping chamber is opened to suction and then is

filled, closed, moved to discharge and displaced. The delivered capacity is nearly constant throughout the discharge pressure range. This constant capacity or flow will intersect a system curve at a defined point, allowing a high degree of control (Figure 1).

Some flow variation may occur due to internal slip or pump wear. Slip stems from the fluid's viscosity and the system pressure — with lower viscosity or higher discharge pressure creating more internal slip. Pump wear also results in increased slip. Many factors contribute to wear, including the nature and abrasiveness of the liquid pumped, pressure and age.

It's important to note that a rotary unit will continue to pump if there's a downstream blockage. So, rotary systems require some type of safety pressure-relief valve at or immediately downstream of the pump to protect against over-pressure.

ATTRIBUTES OF ROTARY PUMPS

Type	Method of Operation	Advantages	Limiting Factors
Vane	Consists of vanes mounted to a rotor, which rotates inside a cavity. The simplest vane pump is a circular rotor rotating inside of a larger circular cavity. The centers of these two circles are offset.	<ul style="list-style-type: none"> • Reliability • Dry priming • Easy maintenance • Good suction characteristics 	<ul style="list-style-type: none"> • Not suitable for high pressures or viscosities • Not suitable for abrasives • Two loaded bearings • Speed reduction normally required • Can have two stuffing boxes
Piston	Fluid is drawn in and forced out by multiple pistons, which reciprocate within cylinders.	<ul style="list-style-type: none"> • High pressure capabilities • Good for low flow • Good for low viscosity fluids • Fixed or variable displacement 	<ul style="list-style-type: none"> • Pulsation • Suction stroke can be difficult when pumping • Not good with viscous liquids • Potential mechanical wear can be high, leading to maintenance concerns
Flexible Member	Fluid is held within a flexible member, which may be a vane or a tube. Pumping action is accomplished as the fluid is squeezed into the discharge chamber.	<ul style="list-style-type: none"> • Self priming • Low cost • Can run dry without damage (peristaltic type) • Good for high viscosity fluids • Seal not required in some designs 	<ul style="list-style-type: none"> • Temperature limited • Pulsation • Limited tube life • Speed reduction required • Not good for high flow rates
Lobe	Uses lobes to direct flow through the pump case. The rotation of the lobe opens the inlet cavity, allowing the liquid to fill the pumping chamber.	<ul style="list-style-type: none"> • Low shear • Self priming • Multiphase capability • Little or no pulsation • Capable of pumping large solids and slurry-laden medias 	<ul style="list-style-type: none"> • Requires timing gear • Requires two seals • Reduced lift with thin liquids • Two-to-four loaded bearings, which potentially limit the life of pump and speed on larger sizes
Gear (internal)	Uses the meshing of gears (large exterior and small interior) to pump fluid by displacement. The gear-within-a-gear creates a void that is filled with fluid.	<ul style="list-style-type: none"> • Low pulsation • Good for high viscosity fluids • Adjustable end clearance • Operates in either direction 	<ul style="list-style-type: none"> • Operates at moderate speeds • Provides only medium pressure capability • One bearing runs in the fluid • Overhung load on shaft
Gear (external)	Uses the meshing of gears to pump fluid by displacement. As the gears rotate, they separate on the inlet side of the pump, creating a void that is filled with fluid.	<ul style="list-style-type: none"> • Can handle a wide viscosity range • Good for high pressure • Tight clearances • Good abrasives' handling • Low pulsation • Simple, cost-effective • Operates in either direction 	<ul style="list-style-type: none"> • Four bushings in liquid area, which potentially increase wear rate and tolerance • Not recommended for solids • Fixed end clearances
Circumferential Piston	Uses counter-rotating rotors driven by external timing gears.	<ul style="list-style-type: none"> • Low inlet pressure required • Two moving parts • Low shear sensitivity at low speeds • Good for high viscosity fluids • Good for high temperature • Can operate under high vacuum 	<ul style="list-style-type: none"> • Requires timing gear • Requires two seals • Reduced lift with thin liquids • Two-to-four loaded bearings
Single-Screw (progressing cavity)	Helical rotor rotates within an elastomeric stator.	<ul style="list-style-type: none"> • Good for pumping thick, lumpy and stringy fluids as well as sludge cake. 	<ul style="list-style-type: none"> • May require higher torque at startup • Not suited for dry running • Typically operates at lower than motor speeds
Timed Multiple-Screw (two screws)	Uses a set of intermeshing screws. The rotating screws form transfer chambers, trapping and conveying the fluid axially to the discharge.	<ul style="list-style-type: none"> • No internal metal-to-metal contact • Dry running capability • Can handle wide swings in viscosity • Available in a wide range of materials of construction • Low shear rate 	<ul style="list-style-type: none"> • Requires timing gears • Requires four seals
Untimed Multiple-Screw (three screws)	Has only three moving parts: power rotor and two symmetrically opposed idler rotors with no wearing contact.	<ul style="list-style-type: none"> • Very low fluid pulsation • Operates at synchronous motor speeds • Balanced both radially and axially • Requires only one lightly loaded bearing • High pressure capability • Quiet operation • Special designs available for multiphase service 	<ul style="list-style-type: none"> • Not suited for dry running • Not suitable for abrasives or solids • Generally not available in corrosion-resistant metallurgy

Table 1. Each variant has particular advantages and limitations.

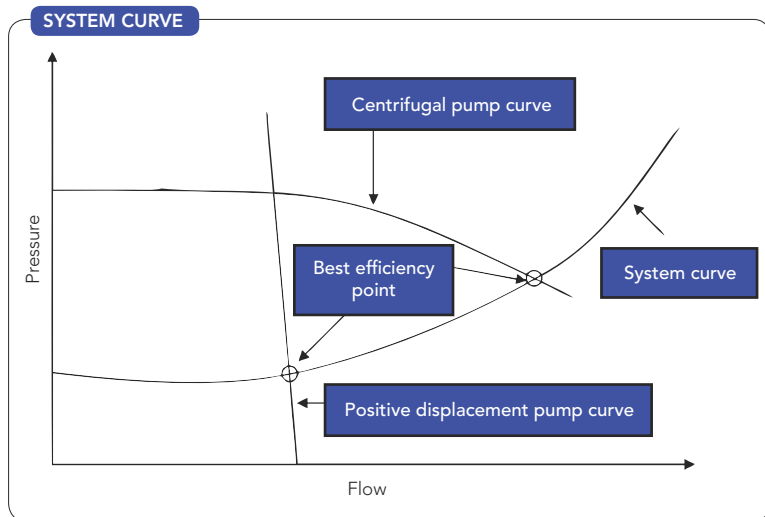


Figure 1. A positive displacement pump provides relatively constant flow.

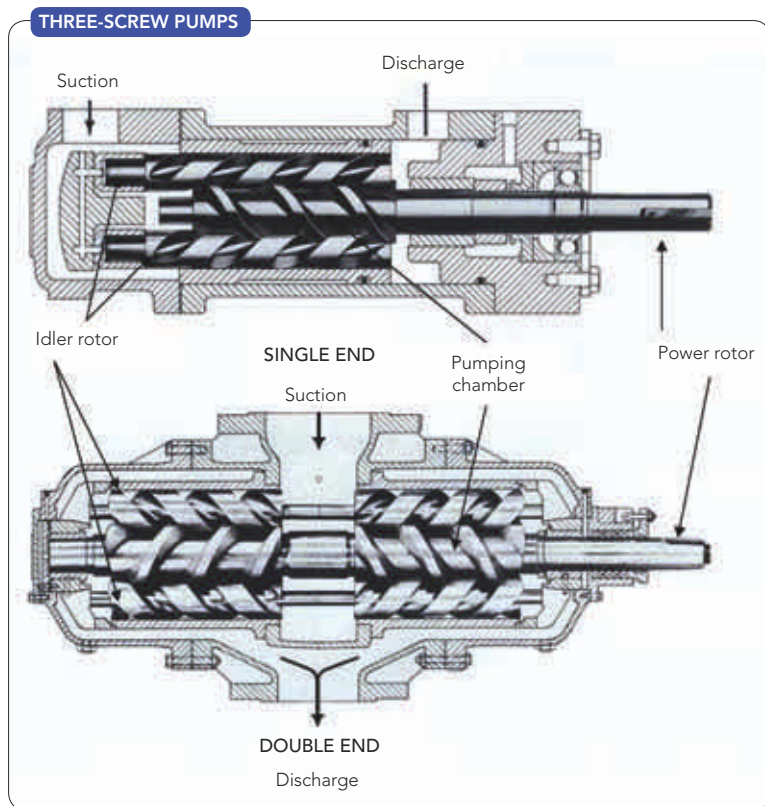


Figure 2. Pumping chamber volume determines the amount of liquid pumped.

ROTARY PUMPS

Positive displacement pumps come in many different types. Here, we'll focus on rotary pumps. The Hydraulic Institute categorizes rotary units in seven primary segments — vane, piston, flexible member, lobe, gear, circumferential piston and screw; this breakdown helps in understanding the various nuances of pump design and operation. (The Hydraulic Institute also provides family trees for kinetic (such as centrifugal), vertical (submersible), sealless

centrifugal (canned motor), reciprocating power (horizontal or vertical) and direct acting (horizontal or vertical) pumps.)

Rotary pump types differ in internal components but all operate on similar principles to create flow, as typified by the single- and doubled-ended three-screw pumps shown in Figure 2: liquid enters at suction and moves axially through the pump to discharge; the volume of each pumping chamber determines the amount of liquid delivered.

Table 1 summarizes the method of operation, advantages and limitations of each type. Treat the comments in the table as a rough guide; direct specific questions or comments to vendors being considered.

Figure 3 depicts the pressure-versus-flow capabilities of types of rotary pumps. The ranges and the maximum values shown aren't absolute; custom designs with alternate speeds, clearances or special materials may exceed these values. To learn more, visit the Hydraulic Institute at www.pumps.org.

SCREW PUMPS

These devices are further divided into two segments: single-screw (progressing cavity) and multiple-screw. Multiple-screw pumps, in turn, are classified as timed or untimed. Each of these variants offers distinct advantages and limitations (Table 2).

Let's look at each type in a bit more detail:

Single-screw (progressing cavity). This design most commonly is fitted with a rigid threaded rotor that rotates within an elastomeric stator with internal threads (Figure 4). Although capable of pumping water, it's most effective in handling contaminated and viscous fluids. So, this pump finds wide use in wastewater service and typically is the unit of choice for sludge, as well as abrasive or stringy fluids where the constant flow characteristics of a positive displacement pump are preferred. Sanitary 3A-rated stainless steel versions handle a wide range of food products from meat to dairy, molasses to concentrated juices.

A unique feature of this pump to keep in mind is the option of an auger feeder fit into a hopper-style inlet. This allows the pump to handle up to 45% solids' content. Not many types of pumps can deal with non-fluids such as recycled tires — but a progressing cavity pump can.

The benefits of the progressing cavity pump include:

- suitability for abrasive fluids;
- ability to handle solids and stringy material;
- metering capability;
- availability of sanitary-service designs; and
- low shear.

TYPICAL CAPABILITIES OF SCREW PUMPS

Parameter	Type of Pump		
	Progressing Cavity	Timed Multiple-Screw	Untimed Multiple-Screw
Flow, gpm	3,750	12,000	5,300
Pressure, psi	1,500	1,500	4,500
Viscosity, million SSU	2.0	4.5	1.0
Solids, diameter in.	3.5	1/32	No solids
Temperature, °F	400	700	500
Self Prime Dry	Yes	No	No
Self Prime Wet	Yes	Yes	Yes
Dry Running	No	Yes	No
Reversible	Yes	Yes	Yes (with special designs)
Abrasives' Handling	Excellent	Good	Good
Shear Sensitive Materials	Excellent	Good	Good
Pulseless	Excellent	Excellent	Excellent
Horsepower Range, bhp	0.1–200	5–2,000	1–1,000

Table 2. Special designs may exceed the values shown. Courtesy of Hydraulic Institute, www.pumps.org, Parsippany, N.J.

Timed multiple-screw. The two- or twin-screw pump (Figure 5) typifies this design. Unlike in a single-screw unit, the twin-screw pump's rotor doesn't contact the casing. In fact, there's no metal-to-metal contact between the rotors themselves or the rotors and casing. Rotors are precision machined and supported by bearings synchronized by oil-lubricated timing gears on one end of the rotors. This sophisticated design means the twin-screw pump isn't a low cost option but enables it to handle difficult applications when other designs fail. It truly can be the pump of last resort.

Advantages of the timed twin-screw pump include:

- ability to handle extremely high to water-thin viscosities (such as required for some flushing cycles);
- capability (of some designs) to cope with multi-phase feeds (fluid, gas and contaminants);
- ability to provide high flow rates;
- extremely low NPSH_R (net positive suction head required), well suiting it for difficult vapor pressure fluid applications;
- high temperature capability;
- extremely low pressure pulse;
- contamination tolerance;
- producible in any metal that can be machined;

and

- typically run at full motor speeds even for high flow rates.

This is the design to consider for difficult applications, particularly when two or more of the above factors are important.

Untimed multiple-screw. This technology most often comes with three screws — one power rotor

and two idlers (Figure 6). It also is available in two-, four- and five-rotor versions. All designs operate with the same principle — that is, with the rotor and idler(s) run in a close-fitting housing. The epicycloidal geometry of the rotor set assures a rolling contact; the rotor set runs inside the bore of the casing much like a journal bearing. A film of the liquid being pumped prevents contact of the rotating elements and the bore. Most designs feature axial and radial balancing. Thrust bearings aren't required. When applied and operated properly, such pumps provide a very long service life between maintenance cycles. Units typically are made of iron and steel, and so shouldn't be used in corrosive applications. Also, except for some special designs, this technology only suits contaminant-free fluids.

Unlike the other screw designs, the untimed multiple-screw can accommodate a magnetic coupling for guaranteed leak-free performance. Such pumps handle applications such as machinery lubrication, fluid power hydraulics, fuel injection and compressor seal systems; some special designs are used for high-pressure water-based applications.

Advantages of untimed multiple-screw pumps include:

- very low noise and pulsation;
- high efficiency;
- operation at full motor speed even at high flow rates (allowing application of a smaller pump without gear reducer);
- self priming;
- high reliability (balanced design); and
- ability to be applied on rotating equipment

PRESSURE VERSUS FLOW CAPABILITIES

Rotary pump consolidated range chart (US customary units)

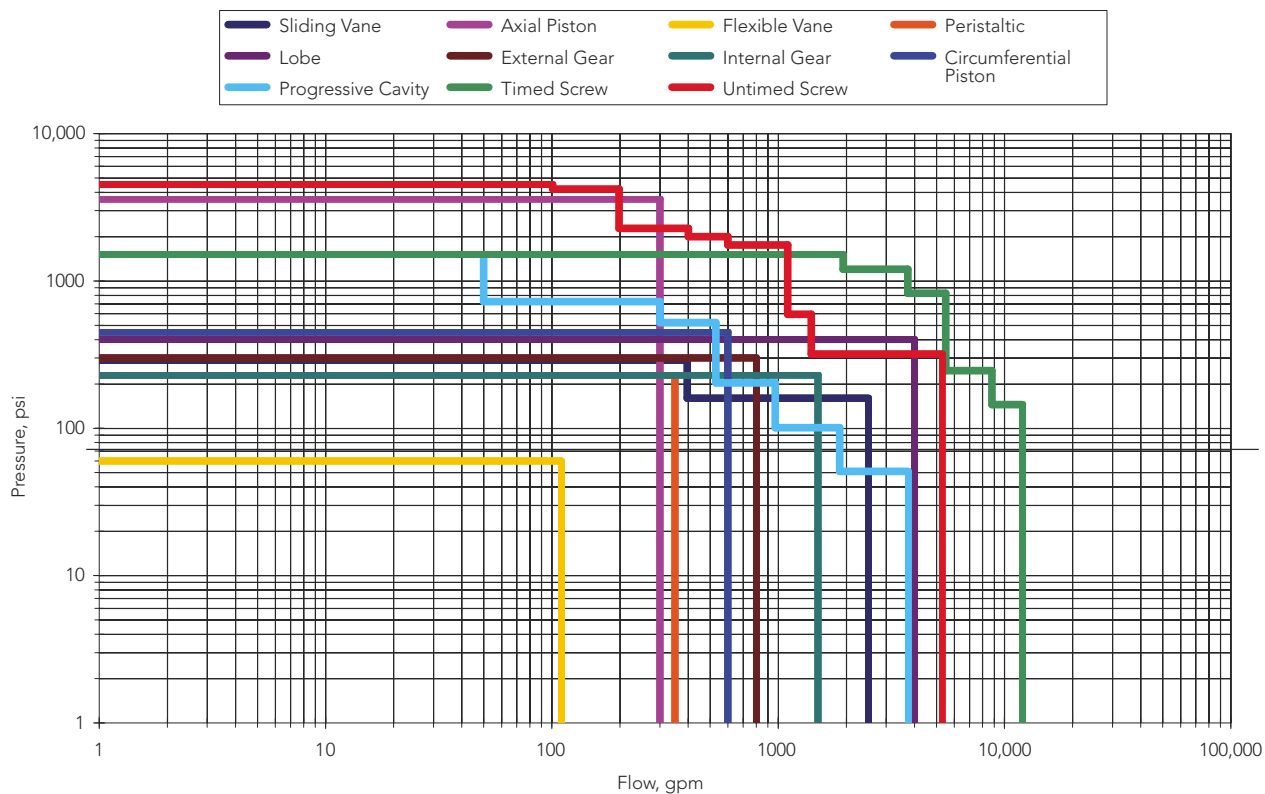


Figure 3. Values given are only general estimates.

PROGRESSING CAVITY PUMP

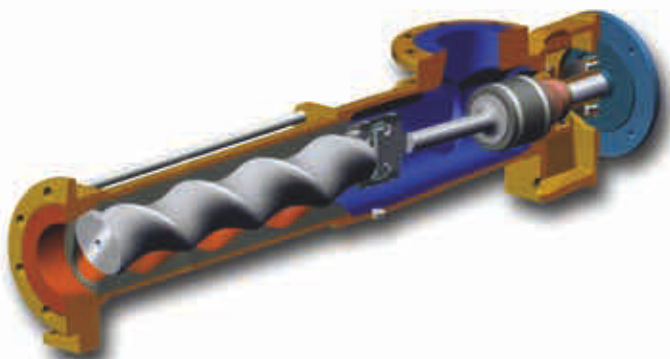


Figure 4. Such a unit is particularly good at handling abrasive fluids.

driven by auxiliary shaft at speeds above two-pole motor speeds.

SELECTION GUIDELINES

When evaluating the pump type for your fluid handling system, focus on four key aspects, namely, fluid, discharge, supply and operating objectives. The following general guidelines indi-

cate when a positive displacement pump may be a good choice:

Fluid. Will your pump see liquid viscosities of greater than 20 centistokes, entrained gas or deal with a shear-sensitive liquid? If so, consider a positive displacement pump for its ability to handle high viscosity liquids more efficiently, i.e., with lower annual energy costs, than centrifugal pumps.

Discharge. Will pressure vary in your system? If so, consider a positive displacement pump for its ability to deliver a nearly constant volume of liquid over the pressure range.

Supply. Will supply conditions vary in your system? If so, consider a positive displacement pump for its versatility in handling a wide range of NPSH_A (net positive suction head available), fluid characteristics and ability to adjust speed efficiently.

Operating. Will your flow or pressure demands change occasionally or even frequently? If so, consider a positive displacement pump because of its ability to respond immediately and efficiently to pressure changes and varied speed.

Selecting the right pump type is important —

TIMED MULTIPLE-SCREW PUMP

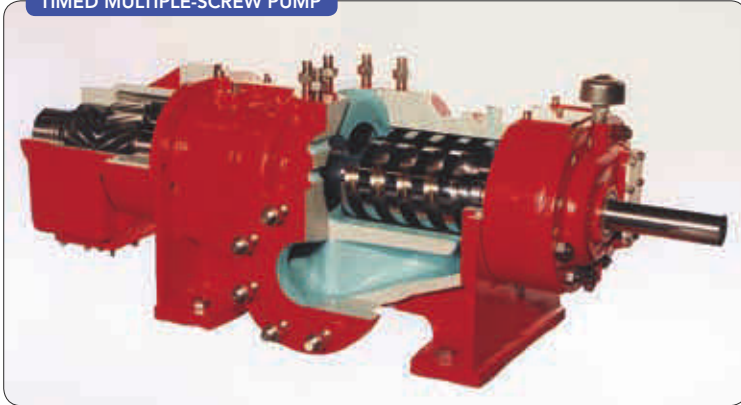


Figure 5. No metal-to-metal contact occurs between the rotors or rotors and casing.

UNTIMED MULTIPLE-SCREW PUMP

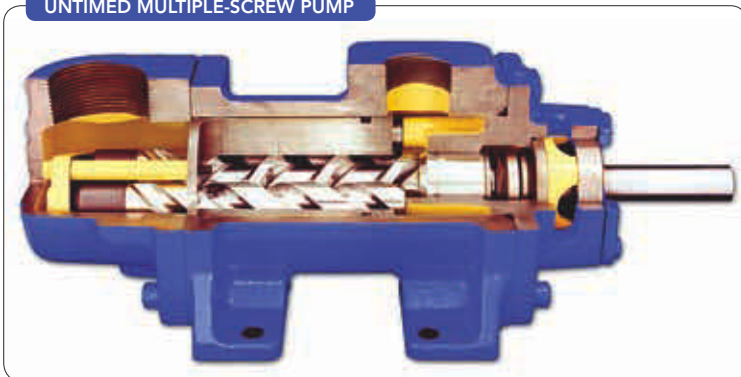


Figure 6. Unlike other pumps, this design can be fitted with a magnetic coupling.

RELATED CONTENT ON CHEMICALPROCESSING.COM

"Ask The Experts — Pumps," www.Chemical-Processing.com/experts/pumps.html

"Keep Lobes in Mind," www.ChemicalProcessing.com/articles/2006/002.html

but so too is properly sizing the pump. Many engineers don't appreciate the importance of sizing a pump only to meet the application's requirements. It's common to oversize a pump, for example, in anticipation of future planned expansions. This leads to higher initial and energy costs.

In making a decision on the best pump for the job, take the time to consider suitability, efficiency, reliability, and, perhaps most importantly, the total cost of ownership. A pump's original price may not amount to much compared to the cost of energy and maintenance over its life. ●

SEAN MCCANDLESS is oil and gas market manager for Colfax Fluid Handling, Monroe, N.C. **RICHARD MEIGHAN** is director, product sales, power generation and industrial markets, for Colfax in Monroe. E-mail them at sean.mccandleless@colfaxcorp.com and richard.meighan@colfaxcorp.com.



San Antonio Riverwalk

International Water Conference®

-The 73rd Annual-

November 4-8, 2012 ♦ San Antonio, TX USA

The IWC is dedicated to advancing new developments in the treatment, use, and reuse of water and wastewater for industrial and engineering purposes. For the past 72 years, the IWC has provided training of best practice principles to those new and experienced in water treatment. Plan now to attend the 2012 IWC to:

Earn
more
than 20
PDH's!

- Learn about the latest developments in water treatment technologies
- Network with manufacturers, suppliers and industry experts
- Gain exposure, knowledge and a multitude of new ideas that can be put to practical use in your facility—large or small—to solve your water treatment problems

www.eswp.com/water

