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PUMP CLINIC 27

POSITIVE DISPLACEMENT PUMPS

This article has been developed from a variety of sources including manufacturers, industry trade organisations, internet articles and common PD industry knowledge.

By definition, positive-displacement (PD) pumps displace a known quantity of liquid with each revolution of the pumping elements. This is done by trapping liquid between the pumping elements and a stationary casing. Pumping element designs include gears, lobes, rotary pistons, vanes, screws and hoses.

PD pumps are found in a wide range of applications -- chemical-processing; liquid delivery; marine; biotechnology; pharmaceutical; as well as food, dairy, and beverage processing. Their versatility and popularity is due in part to their relatively compact design, high-viscosity performance, continuous flow regardless of differential pressure, and ability to handle high differential pressure.

Positive displacement (PD) pumps are divided into two broad classifications, reciprocating and rotary (Figure 1). This article covers rotary pumping principles.

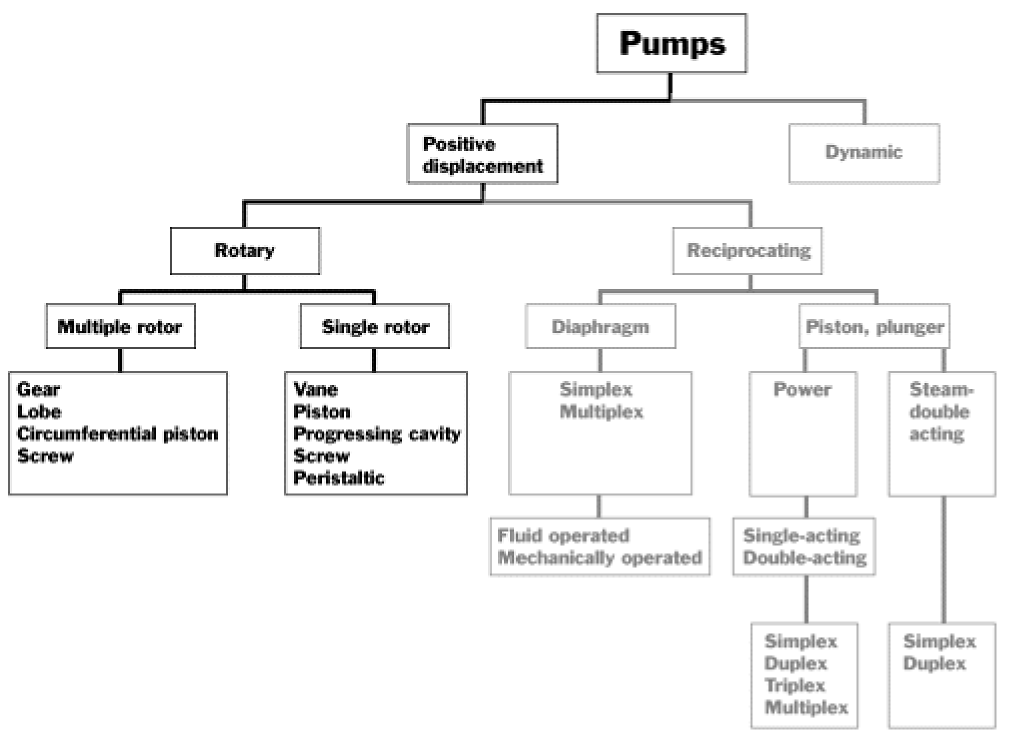


Figure 1

By definition, PD pumps displace a known quantity of liquid with each revolution of the pumping elements (i.e., gears, rotors, screws, vanes). PD pumps displace liquid by creating a space between the pumping elements and trapping liquid in the space. The rotation of the pumping elements then reduces the size of the space and moves the liquid out of the pump. The broad category of PD pumps is able to handle fluids of all viscosities up to 1,320,000 cSt / 6,000,000 SSU, capacities up to 1,150 M^3/Hr (delete) and pressures up to 700 BAR (delete). Rotary pumps are self-priming and deliver a constant, (delete) flowrate, regardless of pressure variations.

Selection of a positive displacement (PD) rotary pump is not always an easy choice. There are many types of PD pumps available. In this article, we cover the more common ones: internal gear, external gear, timed lobe, vane, screw and peristaltic. Most PD pumps can be adapted to handle a wide range of applications, but some types are better suited than others for a given set of circumstances.

The first consideration in any application is pumping conditions. Usually the need for a PD pump is already determined, such as a requirement for a given amount of flow regardless of differential pressure, viscosity too high for a centrifugal pump, need for high differential pressure, or other factors.

Inlet conditions, required flow rate, differential pressure, temperature, particle size in the liquid, abrasive characteristics, and corrosiveness of the liquid must be determined before a pump selection is made.

A pump needs proper suction conditions to work well. PD pumps are often self-priming, and it is often assumed that suction conditions are not important. But they are. Each PD pump has a minimum inlet pressure requirement to fill individual pump cavities. If these cavities are not completely filled, total pump flow is diminished. Pump manufacturers supply information on minimum inlet conditions required. If high lift or high vacuum inlet conditions exist, special attention must be paid to the suction side of the pump.

INTERNAL GEAR PUMP OVERVIEW

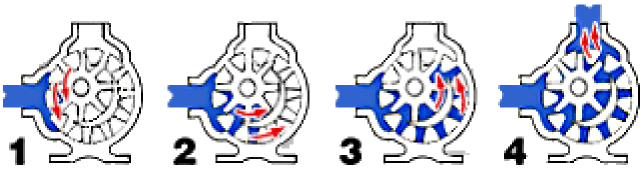
Internal gear pumps are exceptionally versatile. While they are often used on thin liquids such as solvents and fuel oil, they excel at efficiently pumping highly viscous liquids such as asphalt, chocolate, and adhesives. The useful viscosity range of an internal gear pump is from 1cPs to over 1,000,000cP.

In addition to their wide viscosity range, internal gear pumps have a wide temperature range as well, handling liquids up to (delete) 400°C. This is due to the single point of end clearance (the distance between the ends of the rotor gear teeth and the head of the pump). This clearance is adjustable to accommodate high temperature, maximize efficiency for handling high viscosity liquids, and to accommodate for wear.

The internal gear pump is non-pulsing, has some self-priming capability, and can run dry for short periods. They're also usually bi-rotational, meaning that the same pump can be used to load and unload vessels. Because internal gear pumps have only two moving parts, they are reliable, simple to operate, and easy to maintain.

How Internal Gear Pumps Work

1. Liquid enters the suction port between the rotor (large exterior gear) and idler (small interior gear) teeth. The arrows indicate the direction of the pump and liquid.



2. Liquid travels through the pump between the teeth of the "gear-within-a-gear" principle. The crescent shape divides the liquid and acts as a seal between the suction and discharge ports.

3. The pump head is now nearly flooded, just prior to forcing the liquid out of the discharge port. Intermeshing gears of the idler and rotor form locked pockets for the liquid which assures volume control.

4. Rotor and idler teeth mesh completely to form a seal equidistant from the discharge and suction ports. This seal forces the liquid out of the discharge port.

The crescent internal gear pump has an outer or rotor gear that is generally used to drive the inner or idler gear (Figure 1).

The idler gear, which is smaller than the rotor gear, rotates on a stationary pin and operates inside the rotor gear. The gears create voids as they come out of mesh and liquid flows into the pump. As the gears come back into mesh, volumes are reduced and liquid is forced out the discharge port. Liquid can enter the expanding cavities through the rotor teeth or recessed areas on the head, alongside the teeth. The crescent is integral with the pump head and prevents liquids from flowing to the suction port from the discharge port.

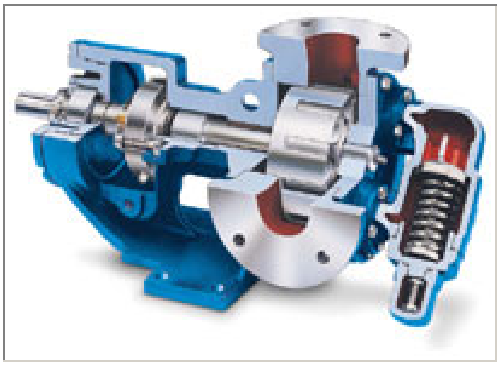


Figure 1. Internal gear pumps are ideal for high-viscosity liquids, but they are damaged when pumping large solids.

The rotor gear is driven by a shaft supported by journal or antifriction bearings. The idler gear contains a journal bearing rotating on a stationary pin in the pumped liquid. Depending on shaft sealing arrangements, the rotor shaft support bearings may run in pumped liquid. This is an important consideration when handling an abrasive liquid as it can wear out a support bearing.

The speed of internal gear pumps is considered relatively slow compared to centrifugal types. Speeds up to 1450 rpm are considered common, although some small designs operate up to 3,450 rpm. Because of their ability to operate at low speeds, internal gear pumps are well suited for high-viscosity applications and where suction conditions call for a pump with minimal inlet pressure requirements.

For each revolution of an internal gear pump, the gears have a fairly long time to come out of mesh allowing the spaces between gear teeth to completely fill and not cavitate. Internal gear pumps have successfully pumped liquids with viscosities above 1,320,000 cSt / 6,000,000 SSU and very low viscosity liquids, such as liquid propane and ammonia.

Internal gear pumps are made to close tolerances and are damaged when pumping large solids. These pumps can handle small suspended particulate in abrasive applications, but gradually wear and lose performance. Some performance loss is restored by adjusting the pump end clearance. End clearance is the closeness of the rotor gear to the head of the pump

Advantages

- Only two moving parts
- Only one stuffing box
- Non-pulsating discharge
- Excellent for high-viscosity liquids
- Constant and even discharge regardless of pressure conditions
- Operates well in either direction
- Can be made to operate with one direction of flow with either rotation
- Low NPSH required
- Single adjustable end clearance
- Easy to maintain
- Flexible design offers application customization

Disadvantages

- Usually requires moderate speeds
- Medium pressure limitations
- One bearing runs in the product pumped
- Overhung load on shaft bearing

Applications

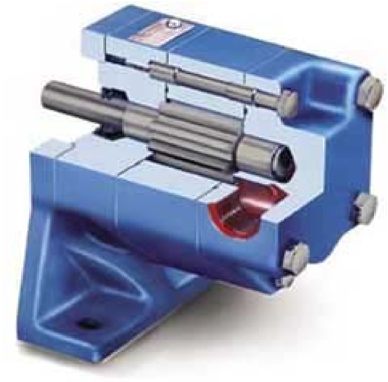
Common internal gear pump applications include, but are not limited to:

- All varieties of fuel oil and lube oil
- Resins and Polymers
- Alcohols and solvents
- Asphalt, Bitumen, and Tar
- Polyurethane foam (Isocyanate and polyol)
- Food products such as corn syrup, chocolate, and peanut butter
- Paint, inks, and pigments
- Soaps and surfactants
- Glycol

Materials Of Construction / Configuration Options

- Externals (head, casing, bracket) - Cast iron, ductile iron, steel, stainless steel, Alloy 20, and higher alloys.
- Internals (rotor, idler) - Cast iron, ductile iron, steel, stainless steel, Alloy 20, and higher alloys.
- Bushing - Carbon graphite, bronze, silicon carbide, tungsten carbide, ceramic, colmonoy, and other specials materials as needed.
- Shaft Seal - Lip seals, component mechanical seals, industry-standard cartridge mechanical seals, gas barrier seals, magnetically-driven pumps.
- Packing - Impregnated packing, if seal not required.

EXTERNAL GEAR PUMP OVERVIEW

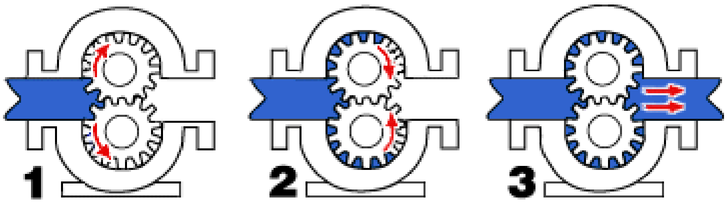


External gear pumps are a popular style of pump and are often used as lubrication pumps in machine tools, in fluid power transfer units, and as oil pumps in engines.

External gear pumps can come in single or double (two sets of gears) pump configurations with spur (shown), helical, and herringbone gears. Helical and herringbone gears typically offer a smoother flow than spur gears, although all gear types are relatively smooth. Large-capacity external gear pumps typically use helical or herringbone gears. Small external gear pumps usually operate at speeds up to 3000 rpm and larger models operate at speeds up to 640 rpm. External gear pumps have close tolerances and shaft support on both sides of the gears. This allows them to run to pressures beyond (delete) 200 BAR, making them well suited for use in hydraulics. With four bearings in the liquid and tight tolerances, they are not well suited to handling abrasive or extreme high temperature applications.

Tighter internal clearances provide for a more reliable measure of liquid passing through a pump and for greater flow control. Because of this, external gear pumps are popular for precise transfer and metering applications involving polymers, fuels, and chemical additives.

How External Gear Pumps Work



External gear pumps are similar in pumping action to internal gear pumps in that two gears come into and out of mesh to produce flow. However, the external gear pump uses two identical gears rotating against each other -- one gear is driven by a motor and it in turn drives the other gear. Each gear is supported by a shaft with bearings on both sides of the gear.

1. As the gears come out of mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the gear teeth as they rotate.

2. Liquid travels around the interior of the casing in the pockets between the teeth and the casing -- it does not pass between the gears.

3. Finally, the meshing of the gears forces liquid through the outlet port under pressure.

Because the gears are supported on both sides, external gear pumps are quiet-running and are routinely used for high-pressure duties such as hydraulic applications. With no overhung bearing loads, the rotor shaft can not deflect and cause premature wear. Usually, small external gear pumps operate at speeds up to 3000 rpm and larger versions operate at speeds up to 640 rpm.

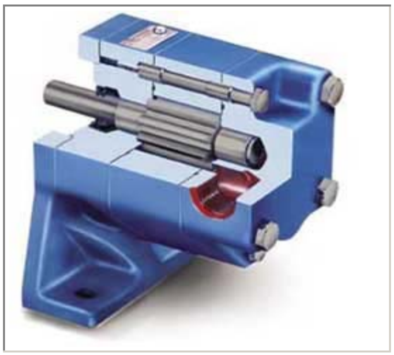


Figure 2. External gear pumps (shown is a double pump) are typically used for high-pressure applications such as hydraulics.

The design of external gear pumps allows them to be made to closer tolerances than internal gear pumps. The pump is not very forgiving of particulate in the pumped liquid. Since there are clearances at both ends of the gears, there is no end clearance adjustment for wear. When an external gear pump wears, it must be rebuilt or replaced.

External gear pumps handle viscous and watery-type liquids, but speed must be properly set for thick liquids. Gear teeth come out of mesh a short time, and viscous liquids need time to fill the spaces between gear teeth. As a result, pump speed must be slowed down considerably when pumping viscous liquids.

The pump does not perform well under critical suction conditions. Volatile liquids tend to vaporize locally as gear teeth spaces expand rapidly. When the viscosity of pumped liquids rises, torque requirements also rise, and pump shaft strength may not be adequate. Pump manufacturers supply torque limit information when it is a factor.

Advantages

- High speed
- High pressure
- No overhung bearing loads
- Relatively quiet operation
- Design accommodates wide variety of materials

Disadvantages

- Four bushings in liquid area
- No solids allowed
- Fixed End Clearances

Applications

Common external gear pump applications include, but are not limited to:

- Various fuel oils and lube oils

- Chemical additive and polymer metering
- Chemical mixing and blending (double pump)
- Industrial and mobile hydraulic applications (log splitters, lifts, etc.)
- Acids and caustic (stainless steel or composite construction)
- Low volume transfer or application

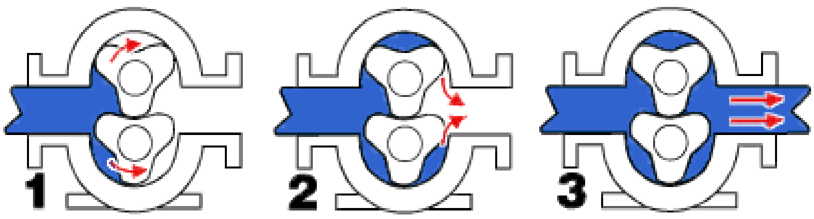
LOBE PUMP OVERVIEW

Lobe pumps are used in a variety of industries including, pulp and paper, chemical, food, beverage, pharmaceutical, and biotechnology. They are popular in these diverse industries because they offer superb sanitary qualities, high efficiency, reliability, corrosion resistance, and good clean-in-place and sterilize-in-place (CIP/SIP) characteristics.

These pumps offer a variety of lobe options including single, bi-wing, tri-lobe (shown), and multi-lobe. Rotary lobe pumps are non-contacting and have large pumping chambers, allowing them to handle solids such as cherries or olives without damage. They are also used to handle slurries, pastes, and a wide variety of other liquids. If wetted, they offer self-priming performance. A gentle pumping action minimizes product degradation. They also offer reversible flows and can operate dry for long periods of time. Flow is relatively independent of changes in process pressure, so output is constant and continuous.

Rotary lobe pumps range from industrial designs to sanitary designs. The sanitary designs break down further depending on the service and specific sanitary requirements. These requirements include 3-A, EHEDG, and USDA. The manufacturer can tell you which certifications, if any, their rotary lobe pump meets.

How Lobe Pumps Work



Lobe pumps are similar to external gear pumps in operation in that fluid flows around the interior of the casing. Unlike external gear pumps, however, the lobes do not make contact. Lobe contact is prevented by external timing gears located in the gearbox. Pump shaft support bearings are located in the gearbox, and since the bearings are out of the pumped liquid, pressure is limited by bearing location and shaft deflection.

1. As the lobes come out of mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the lobes as they rotate.

2. Liquid travels around the interior of the casing in the pockets between the lobes and the casing -- it does not pass between the lobes.

3. Finally, the meshing of the lobes forces liquid through the outlet port under pressure.

Lobe pumps (Figure 3) are similar to external gear pumps in operation, except the pumping elements or lobes do not make contact.

Pump shaft support bearings are located in the timing gear case. Since the bearings are out of the pumped liquid, pressure is limited by bearing location and shaft deflection. There is not metal-to-metal contact and wear in abrasive applications is minimal. Use of multiple mechanical seals makes seal construction important.

Figure 3. Lobes in lobe pumps do not make contact, because they are driven by external timing gears. This design handles low-viscosity liquids.

Lobe pumps are frequently used in food applications, because they handle solids without damaging the pump. Particle size pumped can be much larger in lobe pumps than in other PD types. Since the lobes do not make contact, and clearances are not as close as in other PD pumps, this design handles low viscosity liquids with diminished performance. Loading characteristics are not as good as other designs, and suction ability is low. High-viscosity liquids require considerably reduced speeds to achieve satisfactory performance. Reductions of 25% of rated speed and lower are common with high-viscosity liquids.

Lobe pumps are cleaned by circulating a fluid through them. Cleaning is important when the product cannot remain in the pumps for sanitary reasons or when products of different colors or properties are batched.

Advantages

- Pass medium solids
- No metal-to-metal contact
- Superior CIP/SIP capabilities
- Long term dry run (with lubrication to seals)
- Non-pulsating discharge

Disadvantages

- Requires timing gears
- Requires two seals
- Reduced lift with thin liquids

Applications

Primary applications for rotary lobe pump applications are with food, beverage, pharmaceutical and personal care products i.e in industries deemed to be ‘clean” industries.

Lobe pumps may also be used in other industrial applications as detailed below however specific care needs to be taken in these applications and manufacturers recommendations should be sought.

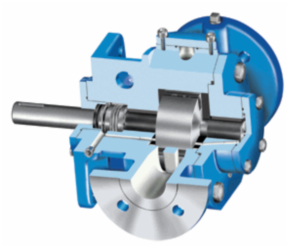
- Polymers
- Paper coatings
- Soaps and surfactants
- Paints and dyes
- Rubber and adhesives
- Pharmaceuticals
- Food applications (a sample of these is referenced below)

Materials Of Construction / Configuration Options

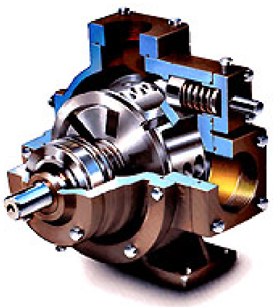
- **Externals (head, casing)** - Typically 316 or 316L stainless steel head and casing

- **Externals (gearbox) -** Cast iron, stainless steel
- **Internals (rotors, shaft) -** Typically 316 or 316L stainless steel, non-galling stainless steel
- **Shaft Seal -** O-rings, component single or double mechanical seals, industry-standard cartridge mechanical seals

VANE PUMP OVERVIEW



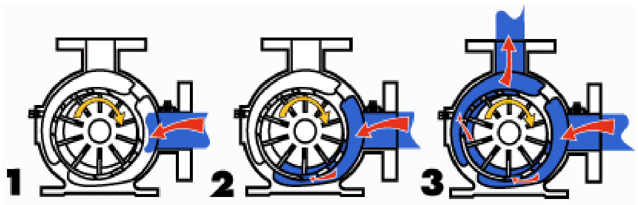
While vane pumps can handle moderate viscosity liquids, they excel at handling low viscosity liquids such as LP gas (propane), ammonia, solvents, alcohol, fuel oils, gasoline, and refrigerants. Vane pumps have no internal metal-to-metal contact and self-compensate for wear, enabling them to maintain peak performance on these non-lubricating liquids. Though efficiency drops quickly, they can be used up to 500 cPs / 2,300 SSU.



Vane pumps are available in a number of vane configurations including sliding vane (left), flexible vane, swinging vane, rolling vane, and external vane. Vane pumps are noted for their dry priming, ease of maintenance, and good suction characteristics over the life of the pump. Moreover, vanes can usually handle fluid temperatures from -32°C (delete) to 260°C (delete) and differential pressures to 15 BAR (delete) (higher for hydraulic vane pumps).

Each type of vane pump offers unique advantages. For example, external vane pumps can handle large solids. Flexible vane pumps, on the other hand, can only handle small solids but create good vacuum. Sliding vane pumps can run dry for short periods of time and handle small amounts of vapor.

How Vane Pumps Work



Despite the different configurations, most vane pumps operate under the same general principle described below.

1. A slotted rotor is eccentrically supported in a cycloidal cam. The rotor is located close to the wall of the cam so a crescent-shaped cavity is formed. The rotor is sealed into the cam by two sideplates. Vanes or blades fit within the slots of the impeller. As the rotor rotates (yellow arrow) and fluid enters the pump, centrifugal force, hydraulic pressure, and/or pushrods push the vanes to the walls of the housing. The tight seal among the vanes, rotor, cam, and sideplate is the key to the good suction characteristics common to the vane pumping principle.

2. The housing and cam force fluid into the pumping chamber through holes in the cam (small red arrow on the bottom of the pump). Fluid enters the pockets created by the vanes, rotor, cam, and sideplate.

3. As the rotor continues around, the vanes sweep the fluid to the opposite side of the crescent where it is squeezed through discharge holes of the cam as the vane approaches the point of the crescent (small red arrow on the side of the pump). Fluid then exits the discharge port.

Vane pumps (Figure 4) operate quite differently from gear and lobe types.

A rotor with radial slots, is positioned off-center in a housing bore. Vanes that fit closely in rotor slots slide in and out as the rotor turns. Vane action is aided by centrifugal force, hydraulic pressure, or pushrods. Pumping action is caused by the expanding and contracting volumes contained by the rotor, vanes, and housing.

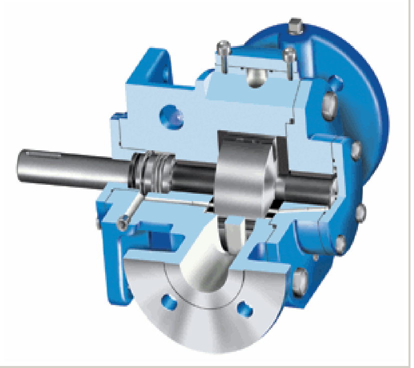


Figure 4. Vane pumps have better dry priming capability than other positive displacement pumps.

Vanes are the main sealing element between the suction and discharge ports and are usually made of a nonmetallic composite material. Rotor bushings run in the pumped liquid or are isolated by seals.

Vane pumps usually operate at 1,000 rpm, but also run at 1,450 rpm. The pumps work well with low-viscosity liquids that easily fill the cavities and provide good suction characteristics. Speeds must be reduced dramatically for high-viscosity applications to load the area underneath the vanes. These applications require stronger-than-normal vane material.

Because there is no metal-to-metal contact, these pumps are frequently used with low-viscosity non-lubricating liquids such as propane or solvent. This type of pump has better dry priming capability than other PD pumps. Vane pumps can run dry, but are subject to vane wear.

Vane pumps are not well suited to handling abrasive applications. Vane pumps have fixed end clearances on both sides of the rotor and vanes similar to external gear pumps. Once wear occurs, this clearance cannot be adjusted, but some manufacturers supply replaceable or reversible end plates.

Advantages

- Handles thin liquids at relatively higher pressures
- Compensates for wear through vane extension
- Sometimes preferred for solvents, LPG
- Can run dry for short periods
- Can have one seal or stuffing box
- Develops good vacuum

Disadvantages

- Can have two stuffing boxes
- Complex housing and many parts
- Not suitable for high pressures
- Not suitable for high viscosity
- Not good with abrasives

Materials Of Construction / Configuration Options

- **Externals (head, casing)** - Cast iron, ductile iron, steel, and stainless steel.
- **Vane, Pushrods** - Carbon graphite, PEEK®.
- **End Plates** - Carbon graphite
- **Shaft Seal** - Component mechanical seals, industry-standard cartridge mechanical seals, and magnetically-driven pumps.
- **Packing** - Available from some vendors, but not usually recommended for thin liquid service

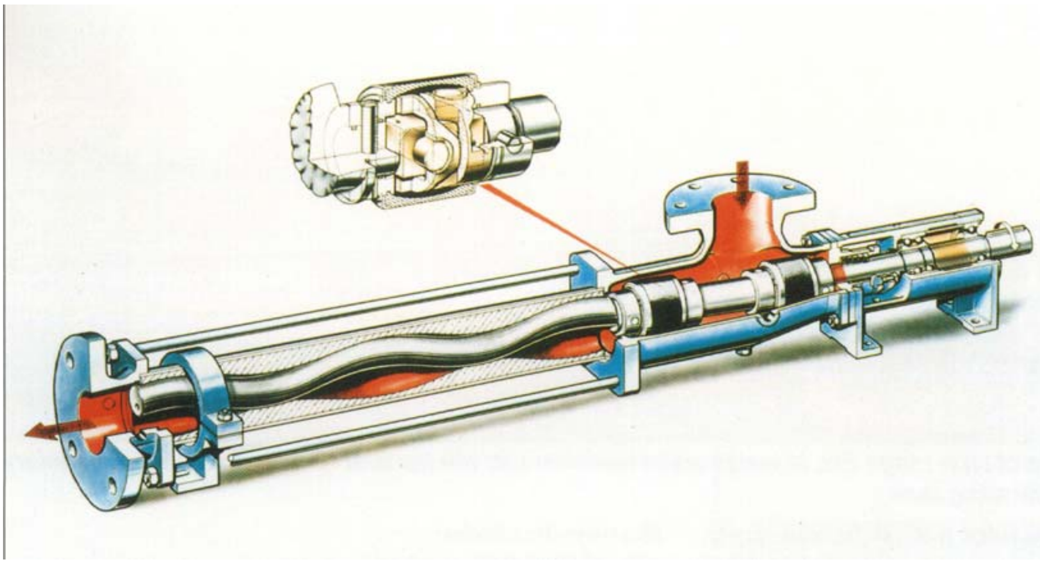
SCREW PUMP OVERVIEW

Within the rotary pumps family, single, twin and three screw pumps have earned reputations for some specific and significant applications.. Single-screw pumps are also known as progressive cavity or helical rotor pumps have some limitations and require some care in application. Multiple screw pumps can handle high pressure, temperature, speed and power combined. While other pump types can handle these variables well individually, their combined force is a challenge.

Progressive Cavity (PC) Pumps

The PC pump is made of three major sections:

A) The pumping element B) The suction housing C) The drive train



The pumping element is made from the rotor and stator elements. Normally, the rotor is made of steel or other metal and has the shape of a single helix (external shape). The stator is normally made from an elastomer and has the shape of a double helix (internal shape). The rotor is manufactured slightly larger than the stator so an interference fit exists when the rotor is inserted into the stator.

Some design enhancements could include features to make maintenance simpler and reliability better. A close-coupled, or so-called "block" design, results in a smaller pump package, less upfront cost and no drive alignment issues. Sealed pivot style universal joints (as in the above illustration) keep the joints lubricated.

Easy access to the mechanical seal is important to simplify seal service and reduce downtime with quick changeover. However, packings are still more accepted for sealing fluids in typical PC applications (as they rarely pump tough enough chemicals to require mechanical seals). When equipped with augers, PC pumps produce better NPSHR values with higher volumetric efficiencies and higher percent solids capabilities. Oversized open hopper inlets handle thicker liquids and eliminate bridging (for example, filter cake up to 55 percent solids can be handled by the auger-augmented PC pumps).

Improvements in the pumping element go beyond more traditional 1:2 geometry (single rotor lobe) to multi-lobe configurations, such as 2:3 (rotor/stator lobes) geometry. A multi-lobe design can increase flow per revolution and reduce initial pump cost. Equal wall stator doubles pressure capability per stage as compared to standard designs with constant stator outside wall thickness.

Tie rod construction makes the entire assembly much easier to service, as compared to more conventional threaded stator designs. Hollow cast rotors reduce inertia and result in lower vibrations. Coated chromed rotors resist wear and last longer.

A temperature probe, installed at the stator wall, can prevent rapid temperature rise and failure during dry running. In practice, few installations take advantage of this feature, since many maintenance departments tend to prefer simpler designs with fewer "gadgets."

Progressive cavity pumps have smooth output flow and good self-priming ability. Capable of pumping both thick and thin fluids, they are successful pumping liquids with high solids and abrasives content.

These capabilities have made progressive cavity pumps a choice for many tough applications. They work well in the wastewater treatment industry, but they perform equally well at the "opposite end of the spectrum" (the food industry) due to their minimal impact on shear sensitive fluids, such as sauces, cream products and similar fluids.

Through the years, advances in pump design, electronic monitoring and materials of construction have improved PC pump energy efficiency, decreased maintenance requirements and allowed them to handle more severe application conditions.

However, some designs actually have a clearance between these, referred to as a "single undersize rotor," "double-undersized" and even "triple-undersized." The designs with clearance between the rotating elements are rare (interference fits are probably common in 99 percent of applications). When designed with a clearance, it is limited to low differential pressures and relatively thick (viscous) product-otherwise the "slip" (loss of flow) would be substantial. As the rotor turns inside the stator, a cavity is formed between the two shapes and "progresses" (hence the name) axially from one end of the element to the other.

PC pumps, like other pump types, have limitations. Typically, they are not useable in high temperature applications because of the limitations of elastomeric stators. They require significant floor space and should not be run at speeds much higher than 300- to 400-rpm due to the unbalanced nature of the rotating element. However, when used correctly, the PC pump's benefits can be substantial. A PC pump will provide long-lasting service to any plant with proactive maintenance practices including vibration trending programs, root cause analysis and similar equipment-caring techniques.

Advantages

- Handles thin and highly viscous liquids
- Low shear pumping action
- Self priming capability (must have Liquid in the pump chamber)
- Can handle abrasive liquids
- Have one seal or stuffing box
- Non pulsing flow

Disadvantages

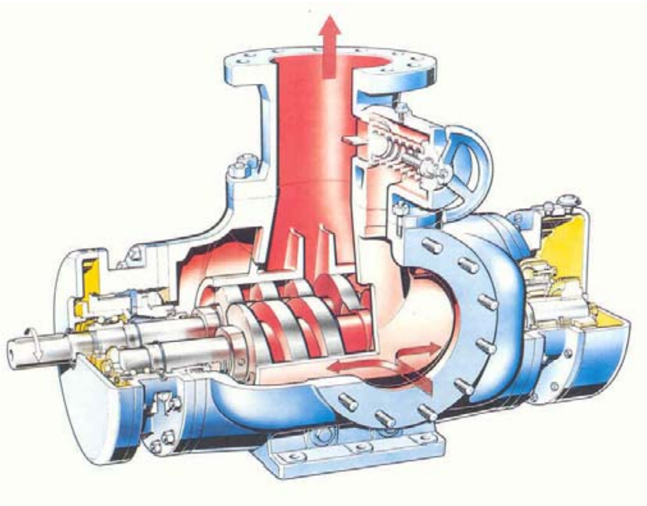
- Serious damage if run dry
- Temperature limitations due to elastomeric stator
- Long floor space requirement

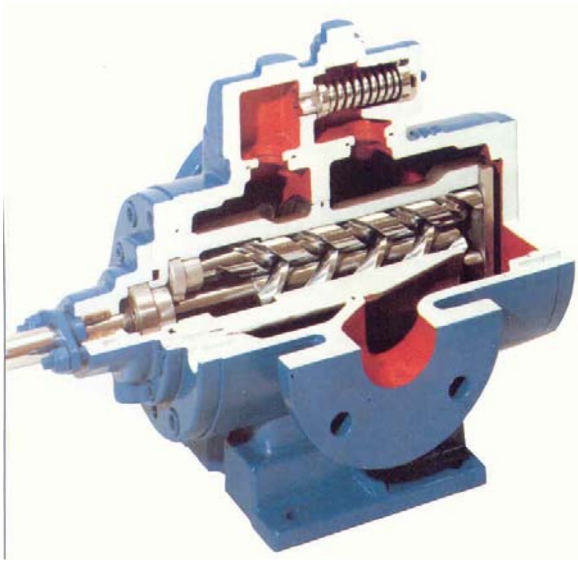
Materials Of Construction / Configuration Options

- **Casings** - Cast iron, steel, 316 stainless steel Alloy C.
- **Rotor** – Steel, 316 stainless steel Alloy C. Hard chrome coatings available
- **Stators** – Neoprene, natural rubber, Perbunan, Viton, PTFE, Hypalon and many others
- **Shaft Seal** - packed glands and component mechanical seals, industry-standard cartridge mechanical seals,

Multiple Screw Pumps

This section compares the twin and triple screw pumps. Unlike gear and lobe pumps, screw pumps are axial flow rather than radial flow machines; flow moves along the axis of rotation rather than perpendicular to it. This axial flow allows multiple screw pumps to operate at relatively high direct drive speeds while still maintaining low fluid inlet velocities and low NPSH requirements. Figure 1 illustrates the flow path within these pumps.





Each wrap of screw thread forms a cavity that moves axially from suction to discharge. The wrap, or cavity, acts as a pressure stage. Low pressure pumps have only one or two wraps (stages), while high pressure pumps may have 12 or more wraps. The staging effect allows each stage to handle a moderate pressure rise, resulting in low stress levels within the pump even at high pressure operation.

Triple screw pumps have one driven screw and two idler screws. There is contact between the driven and idler screws. In twin screw pumps, external timing gears and bearings keep the screws from contacting each other or their casing bores and do not rely on pumped fluid characteristics.

The majority of twin screw pumps are double suction designs, which effectively puts two single suction pumps in parallel in one casing. The double suction designs, both three-screw and two-screw, are inherently in hydraulic balance in the axial direction due to their symmetry.

In a radial direction, twin screw pumps are not hydraulically balanced and require radial bearings at each end of each shaft.

Triple screw pumps are fitted with one seal whereas twin screw pumps require four seals; one ate ach end of the two shafts.

Both twin screw and three screw pumps share many applications including hydraulic services, machinery lubrication, compressor and expander gas sealing and some refinery (heavy fuel, asphalt, vacuum tower bottoms, bitumen) and chemical processing (synthetic fibers, explosives, polyol, isocyanate) applications.

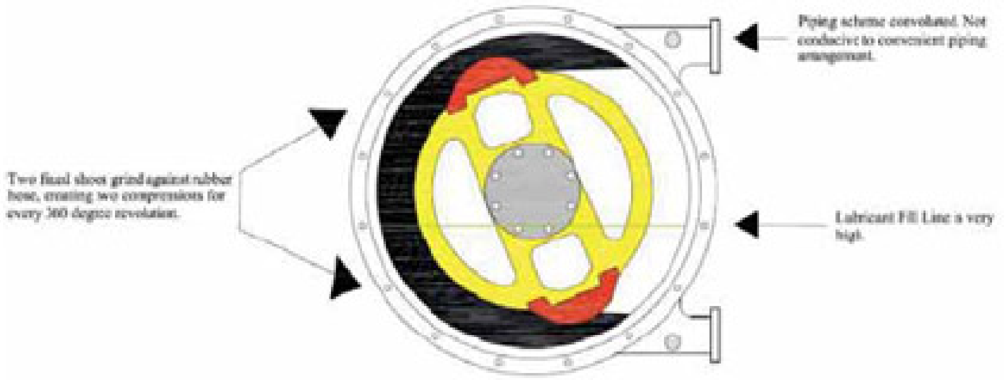
Examples of critical applications include modified twin screw pumps used to handle multiphase flow, i.e., oil well head flows ranging from nearly 100 percent gas to 100 percent liquid including liquid slugs. Three screw pumps find use aboard combat ships for hydraulic services where extremely quiet operation is necessary to avoid acoustic detection. Both twin and three screw pumps are used in medium and heavy crude oil pipelines operating at efficiencies far above centrifugal pumps.

Materials Of Construction / Configuration Options

- **Externals (head, casing, bracket)** - Cast iron, ductile iron, steel, stainless steel,
- **Internals (rotor, idler)** - steel, stainless steel.
- **Bushing** - Carbon graphite, bronze, silicon carbide, tungsten carbide, ceramic, colmonoy, and other specials materials as needed.
- **Shaft Seal** - Primarily component mechanical seals, industry-standard cartridge mechanical seals

Peristaltic Pump Overview

Peristaltic pumps (also known as hose pumps) have been around for many years, with some designs dating back more than 75 years. The pumping action is provided by rotating shoes squeezing a hose and hence enclosing a volume of liquid which is progressed to discharge by the rotating shoes.



The shoe design hose pump uses two or more fixed shoes to compress the hose twice per revolution by grinding against the hose.

They are excellent devices for pumping slurries, due to their ability to handle very abrasive slurries. Hose pumps are also very good at dosing chemicals, since they are a positive placement device that can very accurately control the flow rate desired.

Hose pumps can run dry for long periods of time without damage to the pump. Typically the only wearing part is the rubber hose, which is also the only part in contact with the pumped medium.

NPSHA is not a concern for hose pumps because they create their own suction on the inlet side. Finally, hose pumps will never cavitate.

The biggest challenge is manufacturing the hose itself, which is the main element and only repair part. As such, the hose is the source of the greatest MTBF.

The slower a hose pump is run, the better, because it places fewer revolutions on the hose. One school of thought suggests that the abrasiveness of the slurry is what destroys the hose in a hose pump. This is not the reality, because the number one factor in determining hose life in a hose pump is how many compressions are placed on the rubber hose. The number two factor that contributes to hose wear is the amount of stress being placed on the hose during a compression and how much heat is generated from that compression force.

In other words, the best way to maximize hose life and eliminate pump downtime is to reduce the number of compressions on the hose and compress the hose in the less damaging manor.

There are basically two types of pumps that can be considered a hose pump, but there is a clear distinction between *hose* pumps and *tube* pumps. The difference between these two types of pumps are that tube pumps typically do not have a glycerin bath, pump at very low pressures and also are very small and low flow rate devices.

A hose pump is more of an industrial piece of equipment than a piece of lab equipment. Hose pumps typically range is size from 12 mm to 150 mm and typically have a maximum pressure capability of ~15 bars, depending on manufacturer. This discussion is focused on industrial hose pumps, rather than tube pumps.

There are many designs of hose pumps, but there are essentially only three means employed by all of these designs to compress the hose. The first is the shoe design, where two or more fixed shoes compress the hose twice per revolution by grinding against the hose. This type of design damages the hose the most because it generates a lot of heat and creates a lot of stress/damage to the hose on each revolution.

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Shoe designed pumps have a significant limitation regarding the speed at which the pump can be operated. Because of the high drag/friction across the rubber hose, the pump heats up significantly. Due to this heat and friction, these types of pumps cannot run at very high speeds.

For example, a 80 mm pump may be capable of running at only 40-rpm continuously, which, in turn, limits the amount of flow that can be produced continuously. Manufacturers of this type of pump tend to push the user to the next larger size pump so the rpm is kept lower. Though this strategy is correct, the user of a rolling design peristaltic pump can typically work with a unit that is one size smaller.

Also, a limiting factor on the shoe type of pump involves running a very low rpm. The high drag created from a very low rpm may frequently trip the variable frequency drive (VFD).

Advantages

- No pumping moving parts
- Seal/less configuration
- Non-pulsating discharge
- Good for high-viscosity liquids
- Can handle abrasive
- Self priming capability
- Low shear pumping action
- Easy to maintain

Disadvantages

- Requires moderate speeds
- Pulsing flow
- Low hose life
- Large space requirements
- Application may be limited by hose material availability

Materials Of Construction / Configuration Options

As the liquid contacts only the hose and the connections, the limitation is the hose material. Many hose materials are available from various manufacturers. Connections are available in steel, stainless steel and higher alloys.