PD Pump Throwdown: 5 Reasons Why Vane Pumps Beat Gear Pumps

BOTH OF THESE LEGACY PUMP TECHNOLOGIES HAVE THEIR BENEFITS IN CRITICAL LIQUID-HANDLING APPLICATIONS, BUT SLIDING VANE PUMPS OFFER A WIDER RANGE OF OPERATIONAL ADVANTAGES, MAKING THEM THE BETTER CHOICE

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While the sliding vane and internal/external gear pump operating principles have set the standard in reliable, efficient and safe positive displacement pump operation for centuries, sliding vane pumps – as illustrated above by the multiple Blackmer® Sliding Vane Pumps used side-by-side in an oil-refinery application – will functionally outperform their gear pump cousins in a number of important ways. These include volumetric consistency over the life of the pump, component lifespan, ability for dry-run operation, relief valve cracking pressure, and compatibility with viscous and solids-laden liquids.

Introduction

Gear and sliding vane pumps have marched side-by-side through history as among the most reliable and versatile positive displacement (PD) – alternatively called fixed displacement – pumping technologies ever invented. That reliability and versatility make gear and sliding vane pumps popular choices for use in a wide array of loading/unloading, transport and metering applications, whether from ships, railcars or tank trucks, process to process within a manufacturing plant, to and from storage tanks, or onto transport vehicles for delivery to bulk-storage facilities or end-user locations. In these applications, they can be tasked with handling an expansive range of critical commodities, including crude oil, refined fuels, biofuels, chemicals, solvents, and raw and finished food-grade materials.

As a PD pump, gear pumps, which are available with either external or internal gear designs, will deliver a constant amount of liquid with each revolution of the gears, while their tight clearances and speed of rotation restrict any fluid from moving backward, or "slipping," during their operation. Since the gears are rigid, the pumps create a smooth, pulse-free flow, but also one that can handle very high pumping pressures, especially those needed when transferring high-viscosity liquids.

Sliding vane pumps feature a rotor with vanes that slide into and out of it as the rotor turns. This sliding motion creates chambers into which the liquid flows, and as the rotor turns, the liquid is moved to the outlet where it is discharged as the pumping chamber is squeezed down. Each revolution of the rotor displaces a constant volume of fluid with little chance for slippage, which is the very essence of a PD pump. Variances in pumping pressure have little effect on the sliding vane pump's flow rate, and the open flow profile provides a gentle and shear-sensitive environment within the pump.

Although both gear and sliding vane pumps have proven their mettle over many decades of successful operation in critical liquid-handling applications, sliding vane has unique functionality unmatched by gear. In fact, there are six points of comparison between gear and sliding vane pumps that help spell out the differences between the two:

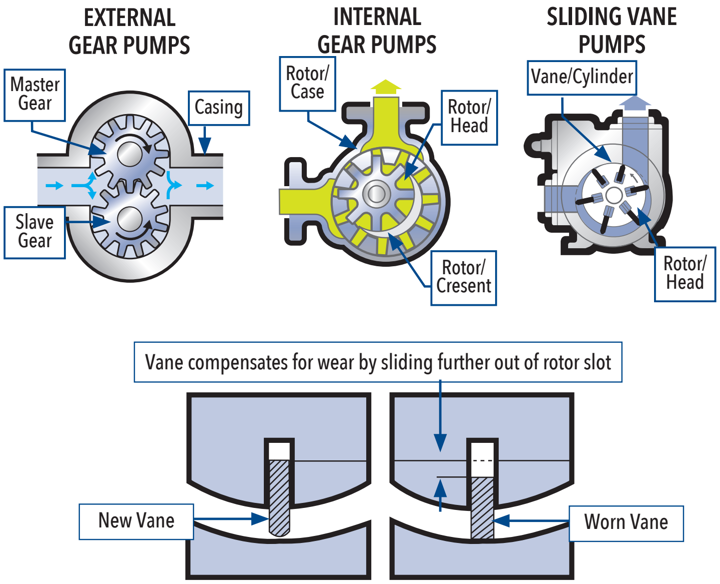
1) Internal Clearances

All PD-pump technologies require tight internal clearances in order to minimize slip and optimize volumetric efficiency. For internal gear pump models, the clearances are tightest where the rotor/case, rotor/head and rotor/crescent mesh, and they are at their tightest when the pump is taken out of the box and first put into service. However, all of these components – because they constantly contact each other as they rotate – will wear while the pump is in operation. As the wear increases, tightness decreases, resulting in product slip that will compromise volumetric consistency. So, for every gallon that is moved through a gear pump, its efficiency is lowered with no chance of ever improving, with the ultimate remedy being the replacement of the pump. This is called flow degradation or flow erosion.

Sliding vane pumps achieve tight clearances where the rotor/head and vane/cylinder meet, with a brand-new pump having the tightest clearances possible. Unlike gear pumps, though, the contact surfaces self-adjust for wear. The edges of the vanes that contact the cylinder will wear, but will continue to slide out of the rotor and stay in constant contact with the cylinder. This means that even after many years and millions of gallons of transferred liquids, internal slip will not occur, guaranteeing volumetric consistency throughout the life of the pump. This is called flow sustainment.

2) Component Life

The design of gear pumps relies on cantilevered support for its driver and idler gears, much like the support system for an end-suction centrifugal pump. Since the pump load is perpendicular to the cantilevered support for both gears, shaft deflection occurs during operation. This puts strain on the cantilevered support, which opens the door to a whole series of potential operational risks, including:

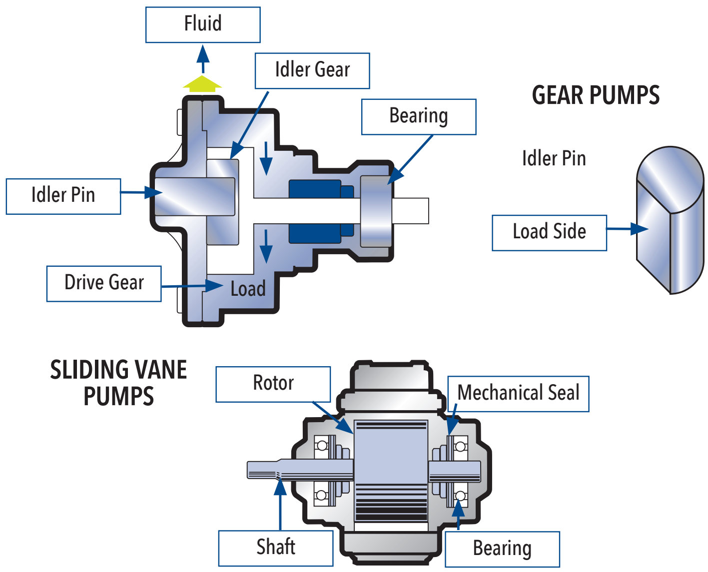


The clearances of a gear pump are tightest when it is taken out of the box, but then begin to degrade as soon as the pump is put into operation. Sliding vane pumps, on the other hand, suffer no clearance degradation because the vanes self-compensate for wear.

- Reduction of mechanical seal life because it is difficult to seal a moving surface
- Movement of the seals away from the bearing, which increases deflection at the sealing surface
- Reduction of shaft life because the shaft is deflected twice during every revolution

This means that a 500-rpm pump will suffer 60,000 deflected load cycles during every hour of operation, which will shorten the life of the shaft. Other component concerns with cantilevered support include idler-pin wear, which affects the clearance relationship between the idler and the rotor gear, resulting in increased wear and reduced flow rates, and crescent wear that increases slip and reduces flow.

Opposed to the cantilevered support of gear pumps, sliding vane pumps have a between-the-bearing support design, which means that the rotor is supported equally on both sides, resulting in minimal shaft deflection and the prevention of cyclical deflection and fatigue. Further, the sealing surfaces are immediately adjacent to the bearings (the most stable location), making them stationary and ensuring longer seal life. The ultimate benefit of the between-the-bearing design is that no uneven loads occur, which means even wearing of all components.



The strain of shaft deflection will cause gear pumps to lose efficiency while sliding vane pumps feature a between-the-bearing design that prevents shaft deflection from occurring.

3) System Functionality

It is an unavoidable fact of their operation that gear pumps will have metal-on-metal contact. As such, they are not designed for dry-run operation and if the pump does run dry, the metal-on-metal contact will cause galling that will reduce pump life and reliability, with a corresponding increase in maintenance costs and downtime.

Since sliding vane pumps have no metal-on-metal contact, they are designed for dry-run operation with no galling or effect on pump life. Operationally, the dry-run capabilities of sliding vane pumps makes them perfect for liquid-transfer applications that feature the following conditions:

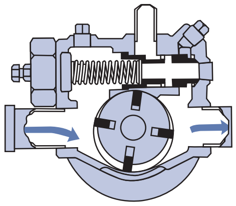
- **Self-Priming:** Even if a sliding vane pump starts completely empty, it is still able to draw a vacuum, compress the air in the piping, push the air through the discharge piping and draw liquid from the suction source until the pump is primed, all without damaging the unit.
- **Suction Lift:** Sliding vane pumps pull such excellent vacuum, that lifts exceeding 25 feet (8.3 m) are possible. This is ideal for top-offload, underground storage or berm applications.
- **Line Stripping:** The ability to run dry, operate in both directions (bi-directional) and compress air make sliding vane pumps ideal for product-recovery applications that require the evacuation of piping and hoses. The benefits are twofold: high-value raw and finished products are not simply flushed down the drain after manufacturing runs, and expensive cleaning chemicals and time-consuming processes are not needed to flush the system.
- **Accidental Dry Run:** Being able to run dry eliminates the concerns that dry-run operation can accidentally occur whether through operator error, malfunctioning instrumentation, valve failure, etc.

4) Relief Valve Cracking Pressure

Gear pumps have a reduced-port linear trim, which means that they have two set points for their relief valves: cracking and full bypass recirculation. Therefore, the pump's motor must be sized for the higher set point, resulting in the need to upsize the motor by at least one size, resulting in less efficient operation and higher energy costs. This lowers the capacity of every gear pump. Imagine purchasing a 100-psi (6.9 bar) pump, only to find that it is actually only useful up to 75 psi (5.2 bar),because its valve begins to crack open and recirculate internally.

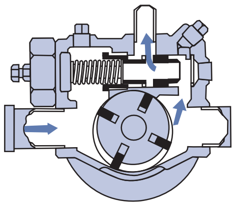
Conversely, sliding vane pumps have a full-port, quick-opening trim, meaning that one set point covers both cracking and full bypass recirculation. Because of this, the motor does not need to be upsized since it can be sized for the cracking pressure. This optimizes the capacity of every vane pump. Imagine purchasing a 100-psi (6.9 bar) pump and enjoying a full operational range up to the 100-psi set point.

COMBINATION RELIEF/BYPASS VALVE



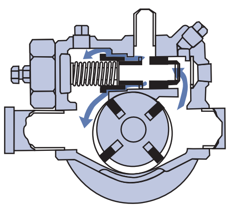
Normal Operation

Valve is completely closed during normal operation with discharge line open.



Back-to-Tank Bypassing

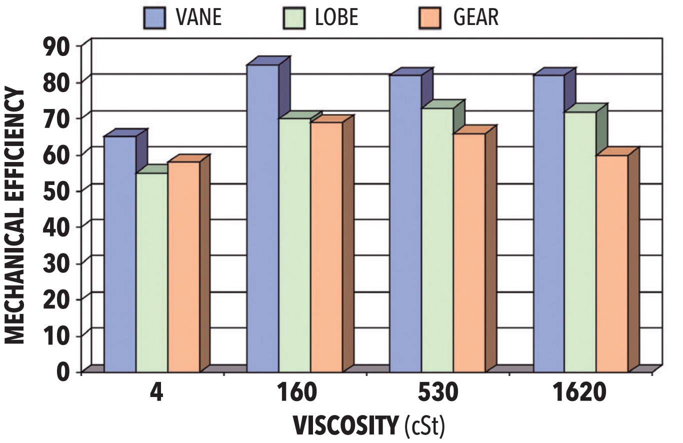
Discharge pressure exceeding the valve setting opens valve to second stage, returning all or part of pump flow back to supply tank.



Pressure Relief

If back-to-tank line is closed, valve opens to third stage, passing flow back to inlet side of pump.

Energy Costs – Mechanical Efficiency Comparison, PD Pumps: Vane / Lobe / Gear



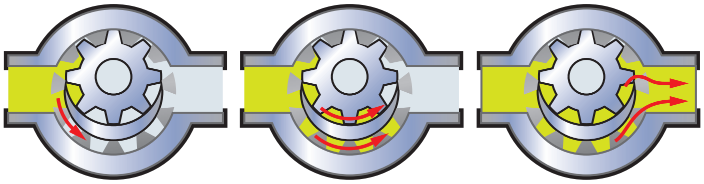
189 - 379 L/min (50-100 GPM);
3.45 - 6.90 Bar (50-100 PSI);
4-1,620 cSt viscosity; same model on all viscosities

5) Liquid Sensitivity

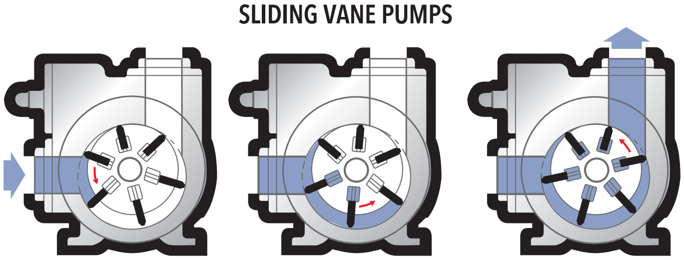
Gear pumps rely on a liquid film to prevent metal-on-metal contact damage. As such, gear pumps prefer viscous liquids with a viscosity greater than 100 centipoise (cP). Thin liquids, therefore, are not thick enough to create an adequate film. Gear pumps also have poor solids-handling capability because their meshing operation creates continuous pinch points within the liquid path, which leads to premature gear wear. The meshing gear and crescent in the internal gear model also prevents the handling of liquids with suspended solids. Finally, since gear pumps require the gears to be lubricated during operation, they have sensitivity to non-lubricating liquids like solvents and many chemicals.

Since there is no metal-on-metal contact in a sliding vane pumps, there is no need for a minimum liquid viscosity. This means that these pumps have a liquid-handling range from ultra-thin liquids (0.2 cP) all the way up to liquids with a thickness of as much as 22,500 cP, with no fall off in performance when handling thin (3-100 cP) or medium-viscosity (100-5,000 cP) liquids. Vane pumps can also handle liquids with small particulates up to 40% concentrations. Sliding vane pumps also require no self-lubrication so both lubricating and non-lubricating liquids can be handled equally well. In fact, sliding vane pumps are renowned for operating reliably under continuous cavitation in low net positive suction head (NPSH)

GEAR PUMPS



SLIDING VANE PUMPS



applications, where multi-phase vapor/liquid mixtures are expected. Imagine using the same pump for condensate and crude oil; sliding vane pumps are well suited for both ultra-low viscosity and non-lubricating applications, as well as thick crude applications with suspended solids.

6) Final Considerations

There are a few areas where gear pumps have the operational edge over their sliding vane cousins. The efficiency and service life of sliding vane pumps is mitigated when they are asked to handle abrasive liquids because the vanes are designed to adjust to 100% efficiency, which greatly accelerates wear. Gear pumps are able to "break in" at a lower operational efficiency, which makes them more tolerant to abrasive liquids. The temperature threshold for sliding vane pumps has a general upper limit of 240°F (115°C), though some models can handle temperatures as high as 500°F (265°C), while all gear pumps are compatible with liquids up to 800°F (425°C). Lastly, while sliding vane pumps operate best with liquid viscosities in a range from 0.2 to 22,500 cP, gear pumps have a maximum viscosity rating of 1 million cP.

Conclusion

In the end, while sliding vane and gear pumps have proven to be workhorses in a number of critical and diverse industrial liquid-handling applications, the preponderance of operational evidence clearly indicates that sliding vane generally provides more functionality and higher reliability, becoming the better choice for systems that demand sensitivity to a wide range of operating conditions. This is especially true for applications with low-abrasion liquids with viscosities up to 22,500 cP and operating temperatures less than 500°F (260°C).

About the Author:

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