Overview of Positive Displacement Pumps

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The selection of a pump technology can be a significant factor in system design for the many industries under pressure to increase productivity and quality standards, improve throughput, and reduce energy costs. This is particularly important in markets such as oil and gas, municipal water and wastewater, pharmaceutical, chemical, and power generation. Let's take a closer look at a key technology which can help drive system efficiency in several areas: positive displacement.

What is a positive displacement pump?

Positive displacement pumps are designed to capture a certain amount of fluid and transfer or displace it in one direction. These pumps have a very specific action – to push fluid out in a controlled amount for accurate dosing or treatment. By design, they are less susceptible to flow changes based on system pressure. This increases the level of accuracy and dependability of flow rates.

Positive displacement technology differs from other pump technologies such as centrifugal pumps. A centrifugal pump's reliability diverges with increased pressure. The discharge side of the pump assembly begins to pump less fluid until it gets to the point where it can't pump against the pressure and it simply recycles the fluid. A centrifugal pump's purpose is primarily as a mover of fluids, but is not generally tied to repeated controlled injection, whereas a positive displacement pump will always continue operating at the same volume.

Types of Positive Displacement Pumps

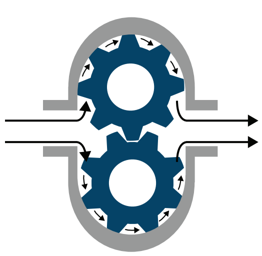
Positive displacement is used to describe a large group of different pumps, which fall in to three types of operation:

- **Rotary:** fluid is continuously moved when the rotary or gears are rotating
- **Reciprocating:** a piston, plunger, or diaphragm moves liquid into the pump reservoir where inlet and outlet valves control the amount of fluid entering as well as the discharge rate of fluid
- **Linear:** a piston in the cavity moves fluid in a straight line

Different types of positive displacement pumps are designed for different applications and offer specific advantages and disadvantages.

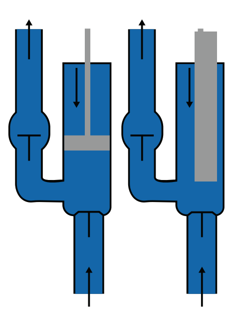
Rotary Type

Gear pump
Screw pump
Rotary vane



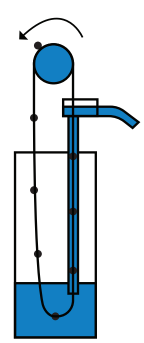
Reciprocating Type

Plunger pump
Piston pump
Diaphragm pump
Circumferential piston pump



Linear Type

Rope pump
Chain pump



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Linear Example

One type of a linear pump is a rope pump. It is simple in design and construction, allowing for a low-cost solution, generally used for water-based applications. It is also easily powered by alternative energy sources like wind or solar power. While the simplicity of this design allows for simple use and maintenance, it limits the ability to work with high volumes or in high pressure applications.

Rotary Example

Peristaltic pumps, a type of rotary pump, are often used in medical applications or laboratories, as they can be miniaturized specifically for these devices. When the pump is new, it effectively meets the requirements of a positive displacement pump – pumping at a constant flow rate. However, this type of pump relies on an elastomeric tube, which can wear at different spots and cause changes in flow rates. This makes it a less reliable option for long term use and harsh applications.

Reciprocating Example

In our case, Milton Roy manufactures metering pumps which use a piston or a plunger that pulls fluid in and pushes out a specific amount of fluid at a certain rate based on the pump's settings. The metering pump is a positive displacement chemical dosing device with the ability to vary capacity manually or automatically as process conditions require. It features a high level of repetitive accuracy and can pump a wide range of chemicals including acids, bases, corrosives and viscous liquids or slurries. The pumping action is developed by a reciprocating piston which is either in direct contact with the process fluid or is shielded from the fluid by a diaphragm. Metering pumps have the integrated ability to change capacity and can also apply variable speed to increase the pump's turndown ratio. This is slightly different from other positive displacement pumps which can only use variable speed tech to change flow. The technology used in metering pumps is best for a controlled rate, repeatable accuracy, and linearity. This feature makes this type of pump the best alternative for applications that need to inject a specific dosage of various chemicals that include a wide range of characteristics in pH, viscosity, solids content, specific gravity, and other factors that make them difficult to handle.

Processes requiring such chemical dosage include:

- Downstream, upstream, and midstream oil and gas
- Water and waste treatment
- Chemical manufacture
- Industrial water
- Pulp and paper

Metering pump technologies are well suited for environments that require fluctuating flows, such as water treatment plants and oil and gas applications. Using signals it receives, the metering pump will respond automatically to change the flow of the chemical being injected into the water.

Creating an Optimized System for Your Application

System Overview – what goes into a system?

The key to success, regardless of the type of pump you use, is that the system must be designed strategically so that everything functions effectively. A system refers to everything that makes your process function, from where the tank is holding the chemical to the point where it's injected. This means there are multiple points of consideration: tank, chemical selection, injection point, piping, pumps, measuring devices, flow meters, and the various accessories that are used.

Designing the "right" system can lead to increased dependability and decreased cost of ownership. However, companies can struggle to pick all the right pieces. There are so many ways to build a system that can work, but few options for the most efficient solution.

For example, peristaltic pumps have recently found use in place of a metering pump for municipal applications because the pump can be very effective when dealing with chemicals that off- gas, such as sodium hypochlorite. A system designed with this pump may have acceptable performance; however, the tubes require constant maintenance or replacements, thereby increasing the cost of ownership. And as the tube wears, its ability to maintain the same capacity is compromised. Metering pumps can be just as successful pumping off-gassing liquids if the pump and system are designed properly to avoid gas binding. When properly applied and used in a well-designed system, metering pumps will far outlast peristaltic pumps and provide maintenance-free operation for a significantly longer period.

Generally speaking, pumps are designed to fit their specific intended applications. Metering pumps are a slight exception to this since they can leverage positive displacement technology to handle everything from low pressure to high pressure and all different types of fluids. Additionally, manufacturers of highly customized metering pumps can offer a unique solution — increasing accuracy and efficiency. Possible areas of customization or modification include:

- Multiplex pumps on a common motor
- Unique wetted materials.
- Modifications for specific liquid characteristics
- Response to various process signals
- Inclusion of process sensors

Considerations for Positive Displacement Pumps

Accuracy

As we talked about in the introduction, positive displacement pumps serve an important purpose, so accuracy and consistency are critical regardless of pressure changes. Understanding the pump and how it achieves accuracy is important. For example, with metering pumps, you get a repetitive amount that you can measure and that you can count on with every stroke of the piston.

Footprint

Footprint, or size of the pump, is sometimes a consideration and is usually based on your application. For example, if you're looking for a solution for offshore oil or an oil platform – every square foot of your operation will cost much more than the space required in a field for a water treatment plant.

Chemical Requirements

The type of pump that's purchased or how it is customized is largely based on what type of chemical, its corrosiveness, viscosity, and how accurate the dosing of the chemical needs to be. For example, polymers can be a difficult material to pump. A facility may choose a peristaltic or a progressive cavity pump based on design or they could optimize their system to suit a metering pump to handle the flow requirements.

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Flow Requirements

Positive displacement pumps can be used for a wide range of pressure requirements (10 psi through 30,000 psi) due to their ability to keep flow consistent regardless of changes in pressure. Pumps catering to low pressure (50 or 100 psi) are typically best for water treatment applications such as municipal water plants and wastewater plants. While the pressure tends to be low, the amount of variability of flow is often very high; this is referred to as turn down.

Applications such as offshore oil and gas, for example, are pumping gases like methanol down to the oil well site to keep it from freezing. In this process, pumps are required to operate effectively despite the high well pressures, which become even higher as you go deeper offshore. These applications can reach the 20,000 plus psi range.

Turn down is simply a measurement of how far the maximum flow can be decreased while still maintaining - accuracy. Metering pumps are the best fit for applications measuring turn down.

Efficiency

There are two types of pump efficiency: electrical and hydraulic. Electrical efficiency tends to be a big focus for the automotive market. The pump industry sees a lot of demand from motor manufacturers to create motors with maximum efficiency to reduce energy costs.

Hydraulic efficiency is directly tied to the type of pump chosen. Certain pumps have leak through between pieces of the unit, such as the liquid end of the pump gear. If an application requires high efficiency, buyers will want to avoid a plunger pump or a pump with no diaphragm seal inside of it to prevent hydraulic loss. High-pressure applications, in particular, are subject to more loss of hydraulic power because the increased flow causes more leaks. In these cases, facilities need to look very closely at the theoretical flow and how it is impacted by pressure to understand efficiency. Metering pumps offer 80-90% efficiency rates at standard conditions, making them an efficient option even under high pressures.

Trends in Pump Technology

Keeping up with increased demands in size reduction, performance, efficiency, and environmental protection continues to shape how today's products are designed, and positive displacement pumps are no exception. Here are just a few ways in which pump technology continues to evolve.

Communication. One of the most influential forces shaping product development is the ability of the pump to communicate. The basic needs of a pump, such as certain flows and pressures, are going to change with every application, but there is an increased demand for a pump that can talk back for better process control. Plants are operating with fewer and fewer people; in some cases, they're operating with no personnel onsite at all. The number of pumps that Milton Roy has deployed that respond to an automated control signal are much higher than a few years ago, and this trend continues to grow.

Sealing Dependability. Diaphragm technology is ideal for those looking to address environmental and efficiency concerns, since it's designed to prevent leaking. This technology has evolved in positive displacement pumps and in metering pumps in particular.

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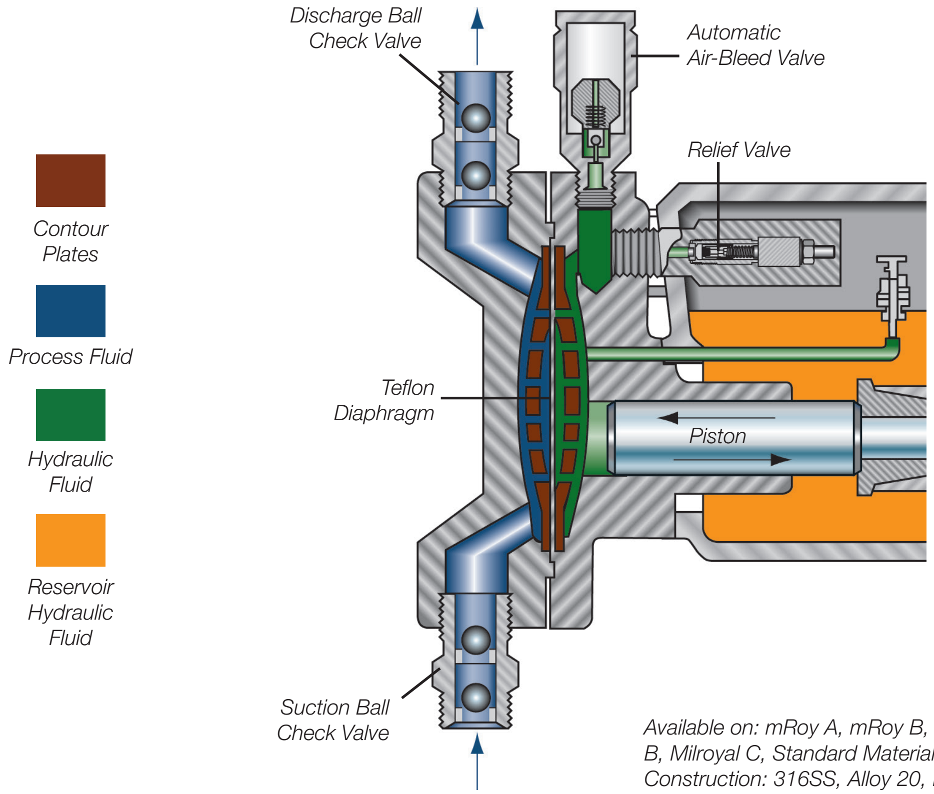

Available on: mRoy A, mRoy B, Milroyal B, Milroyal C, Standard Materials of Construction: 316SS, Alloy 20, Plastic

What is a diaphragm? A diaphragm acts as a seal or barrier within a pump. In a hydraulically balanced diaphragm, it is between the process fluid and hydraulic fluid that the pump is operating on. This allows for pressure to be automatically transmitted without any loss. There are also mechanically actuated diaphragms, where the piston is connected to the diaphragm. These are typically only appropriate for low pressure or limited lifetime applications.

While the dependability of the sealing action has increased, there have also been additions of other technologies to support the process, such as diaphragm leak detection systems. This helps teams know if the diaphragm is failing and when maintenance is required. Having the system issue a warning before total failure helps to prevent the fluid from leaking outside. Detection systems are also essential to the hydraulic efficiency of a pump, as any connection could potentially be an additional point of hydraulic loss. As this design has evolved, it has allowed manufacturers to create a more efficient pump and that directly influences the performance of the product.

Conclusion

As explored in this white paper, each positive displacement pump brings applications unique advantages and this technology continues to evolve. Plant managers should carefully consider accuracy, footprint, chemical and flow capabilities, and efficiency of each pump before selecting the right option for any system. If you’re not sure what the best fit for you is, contact an engineer.

Schedule a call with Milton Roy to learn more.