

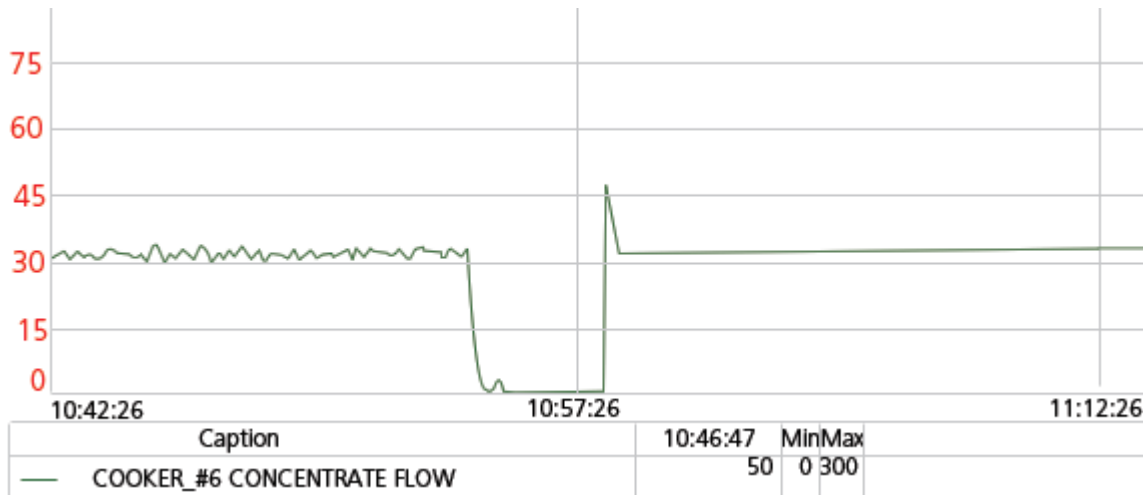
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Valveless flow control: The paradigm shift from centrifugals and control valves to progressive cavity pumps

WATER UTILITIES COULD SAVE
TIME AND MONEY IF THEY
EMBRACED THE USE OF
PROGRESSIVE CAVITY PUMPS
FOR CHEMICAL APPLICATIONS.

A paradigm shift—an intellectually revolutionary change from one way of thinking to another—doesn't just happen; it is driven by agents of change. Do you see a duck or a rabbit in Joseph Jastrow's classic illustration (first published in *Popular Science Monthly* in 1899)? You may see a duck or a rabbit; however, there is a distinct possibility that at first glance you decided what the image was, and that is how you will continue to decipher the image going into the future, unless your point of view is prompted to change. There are current paradigms—or methods of thinking—that limit progressive cavity pump (PCP) use in chemical processes that need to shift. For many, the logic is to use a centrifugal pump and control valve for flow control and to use a PCP only for high-viscosity applications. However, PCPs are particularly well suited for chemical applications because of their valveless design, controllable flow, and low pulsation. The term for this innovative use of PCPs in such applications has been coined as “valveless flow control.” In order to cajole a paradigm shift from the conventional use of centrifugal pumps with control valves, the many advantages of and opportunities and applications for valveless flow control with a PCP must be identified and demonstrated.

FIGURE 1 Historical graph showing improved flow rate after installing a progressive cavity pump



PCP BASICS

Various ranges of PCPs can gently meter and convey fluids of any viscosity in a wide range of temperatures (especially with even wall stators), with or without solids. In a PCP, a single helix rotor turns inside a double helix stator to create cavities that progress from the suction to dis-

charge. The compression fit between the rotor and the stator creates seal lines that keep the cavities separate as they move through the pump with each rotation. The compression enables the pump to act like a valve. The result is flow with very little pulsation and low shear rates. Slip is less of an issue, and when the pump stops,

nothing will flow through it. The compression between the rotor and stator enables users to mount the pumps vertically. Nonsuspended solids in slurries won't settle in the pump casing and cause wear issues when pumps are mounted vertically.

Typical applications in which PCPs can replace centrifugal and control valve combinations include wastewater treatment, chemical metering applications, and any application in which flow control is vital. For example, an application transferring slurry to a blending tank would typically prompt the need for a centrifugal pump and a control valve to control flow.

CENTRIFUGAL PUMPS JOIN THE MIX

Centrifugal pumps are a common type of pump that includes a shaft-driven impeller that rotates inside a casing. Liquid flows into the suction port, or inlet, of the casing and is propelled to the outside of the casing, exiting through a discharge port. Centrifugal pumps are designed for high-flow applications and conveying liquids with relatively low viscosity with consistencies such as water or very light oil. Flow-control valves regulate the flow or pressure of a fluid and are generally incorporated



A progressive cavity pump using smart conveyance technology saves on maintenance time and costs. An added advantage is prolonged rotor and stator life.

as the final element of a control loop to control flow within the required operating range. Control valves can be identified as pressure regulators and flow-control, altitude, or relief valves. They can be fitted with actuators or can be automatic, which do not require an external power source. Common issues with centrifugal/control-valve combinations include cavitation, leaks, obstructions, erosion, hysteresis, and modulation. Some can lose prime between batches or from alternating pumps. In many cases if a valve fails the only choice is to repair or replace it.

IS THERE A SIMPLER SOLUTION?

Valves could be eliminated altogether. Considering process control, a PCP, flow meter, and variable frequency drive are much simpler than a centrifugal pump and control valve combination. The PCP self-priming and acts as both a pump and control valve in one, providing much better flow control. Recent innovations in PCP technology and the success of several flow-control installations at chemical process plants have resulted in proof that using a PCP improves performance and cuts costs. PCP advantages include increased reliability and reduced maintenance, capital, operating, and energy costs. Additionally, PCPs can be made from specialty materials resistant to abrasive or corrosive chemicals. PCPs solve a multitude of flow-control issues compared with other pumps that require control valves. There is no worrying about internal or external air leaks or obstructions in the suction or discharge pipework. Hysteresis and modulation can also be virtually eliminated.

Hysteresis is the phenomenon in which the response of a physical property lags behind changes in the effect causing it. Hysteresis increases when the stem seal (usually packing) in a control valve is tightened to decrease leakage. Additional force is eventually required to overcome the seal's resistance to movement, which

results in modulation and less-than-precise flow control.

A historical graph produced by the control room of a facility shows the difference a PCP makes with regard

to flow control (Figure 1). In the test the centrifugal and control valve combination was taken offline just before 11:00 a.m. and replaced with a PCP. The data showed the PCP's

FIGURE 2 Characteristic curves comparing an impeller pump with a progressive cavity pump

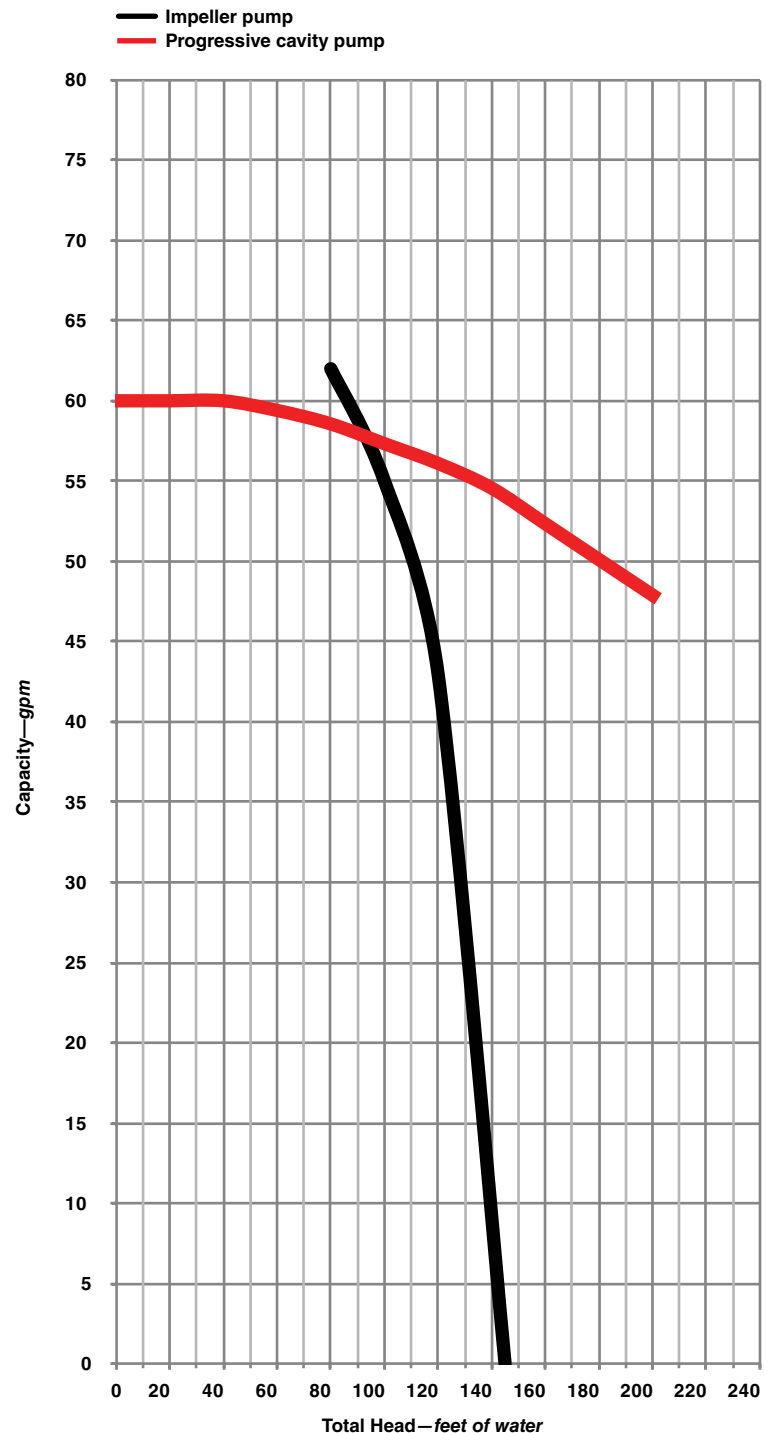


FIGURE 3 Performance data for a progressive cavity pump

Pump Type		BN 17-6L /				
		Norm.	Min.	Max.	Nenn.	
Capacity	[Q]		20	60	56.72	USGPM
Differential pressure	[p]		60	39	60	psi
Pump speed	[n]		100	249	249	rpm
Allowed speed min			53	34	53	rpm
Allowed speed max			800	800	800	rpm
Operating power *	[Pb]		1.46	2.86	3.62	HP
Operating torque	[Mb]		77	61	77	lb.ft
Volumetric efficiency	[η vol]		0.75	0.91	0.86	
Hydromechanical efficiency	[η hm]		0.64	0.52	0.64	
Overall efficiency	[η ges]		0.48	0.48	0.55	
Sliding velocity	[Vg]		0.38	0.94	0.94	m/s
Sliding velocity min	[Vg min]		0.08	0.21	0.21	m/s
Sliding velocity max	[Vg max]		0.48	1.18	1.18	m/s
NPSHr value			2.14	2.63	2.58	m
Chamber volume		1004.68				cm ³
Starting power	[Pa]	4.43				HP
Starting torque	[Ma]	119				lb.ft
Axial load	[Fax]	1741				N
Motor speed	[nM]		706	1745	1740	rpm
Frequency	[f]		24	60	60	Hz

* Required power at pump shaft

flow rate “flatline,” and the difference is clear. The control valve modulated as it tried to respond to the flow setpoint, which led to a wavy line. The PCP reliably displaced an exact volume per revolution and was not as affected by downstream pressure changes, leading to highly reliable flow control.

Using a PCP with a variable frequency drive (VFD) is a solution to reduce hysteresis. Control loops that depend on control valves experience hysteresis as dead time in their dynamic response and compensate by applying additional reset (integral) action. When the hysteresis becomes too large, the control loop may become unstable and oscillate about the setpoint more

than desired. The cure is to rebuild the control valve—a costly maintenance operation.

COST CONSIDERATIONS

So how much will a paradigm shift to reliable valveless flow control cost? When comparing the costs of both potential flow control solutions, operators should compare the cost of a PCP with the combined cost of a centrifugal pump and control valve. The cost of a complex control valve and actuator combined with a centrifugal pump often exceeds the cost of a PCP by 1.25 to 1.5 times. Additionally, the lifecycle costs—including capital, operating, maintenance, and energy costs—should be considered.

Typically centrifugal pumps are simple to maintain (whereas control valves are not so simple because an entire separate set of calibration and diagnostic techniques come into play) but a PCP with smart conveying technology¹ (SCT) is also simple (see the photograph on page 52).

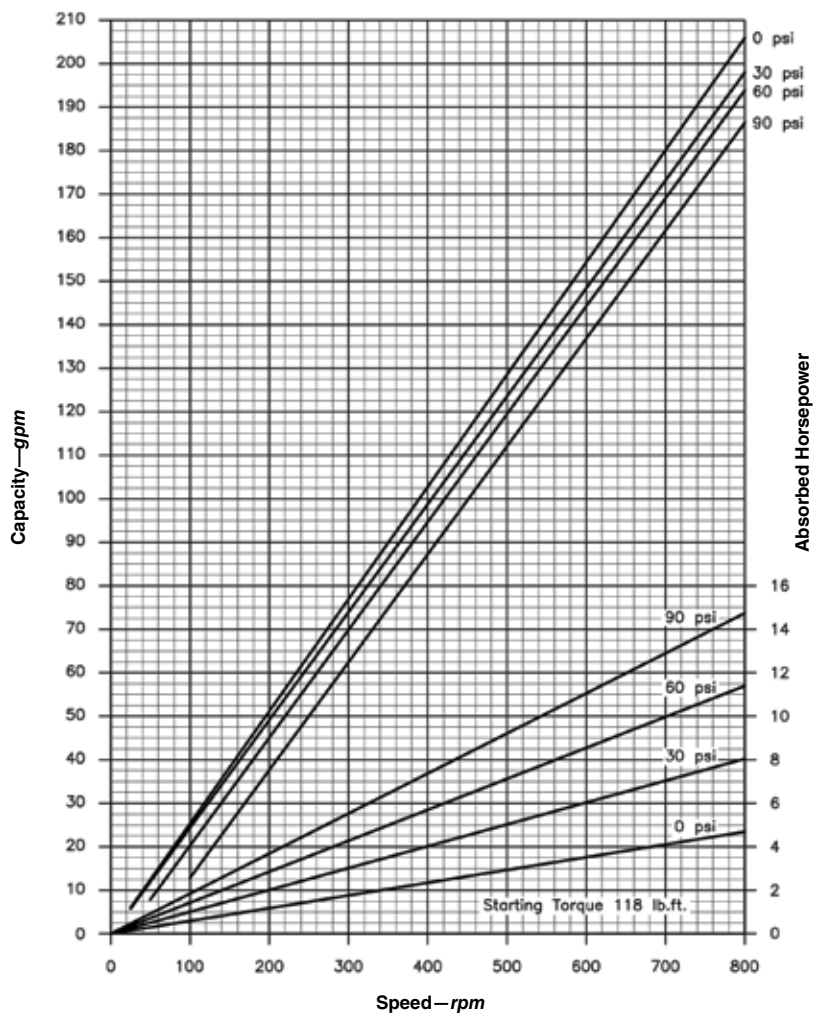
By separating the stator into two halves with this innovation, PCPs with SCT will reduce service times substantially and no longer have to be removed from the installation for maintenance. Dismantling and reassembly of piping and the removal of other equipment components are eliminated. There are also reductions in the time and effort required to replace worn components. Additionally, PCPs with the SCT design

allow the stator to be readjusted, giving longer stator and rotor life. This is because of the integrated retensioning device. A simple readjustment of the stator increases the service life of the stator and rotor and essentially lowers lifecycle costs by reducing service times and parts costs. A PCP also lowers lifecycle costs by reducing energy costs. Although modern control valves are more sophisticated, the power medium is often compressed air, one of the most expensive sources of energy in a plant. Electric actuators are quickly becoming a popular alternative as plants seek ways to reduce energy costs and offer precision, but retrofit is costly.

EFFICIENCY CONSIDERATIONS

The centrifugal pump's best efficiency point should also be considered (Figure 2). Horsepower is calculated for 20, 40, and 60 gpm using the 8.5-inch impeller versus an SCT pump. Although starting horsepower on the SCT pump is higher (for a brief second), brake horsepower is lower, as can be seen in the illustration of a screen capture provided by the manufacturer (Figure 3). A typical control valve using a spring diaphragm actuator takes a 4–20 mA signal to position the valve. This signal is then converted to a pneumatic signal that increases or decreases the pressure to the spring diaphragm actuator. This mix of electric and pneumatic technology often results in unstable flow control when compared with a PCP. As a standard rule of thumb, a PCP will provide better efficiency when pounds per square inch is greater than the gallons per minute. This makes PCPs ideal for flow control applications requiring low flows and high pressures. This leads to another issue—turn down—which PCPs are apt to handle more of without deadhead or running out on the curve when trying to achieve a wide range (Figure 4). Again, a control loop consisting of a PCP, VFD, and flow meter is simpler. A

FIGURE 4 Characteristic curves for a progressive cavity pump



Values based on water at 68°F

VFD can take the place of a pneumatic controller. Pump speed controls the flow. Response time is immediate, and hysteresis is dramatically reduced and virtually eliminated, invoking a flat line on the flow chart indicating more precise dosing and mixing, which results in better quality control. This may lead to consideration of other options like eliminating batch mixing in blend tanks and going with more cost-effective continuous, online blending. Multiple-component inline blending is a popular application for PCPs because mul-

multiple components can be precisely metered continuously, without slip, and without pulsations.

Take a look at Jastrow's illustration again, and think about which animal you saw when you first began reading this article. If at first you chose a duck, maybe now you can begin to identify the outline of a rabbit's face, facing the right. Do you see its upturned nose and two pin-straight ears? If at first glance you saw a bunny, can you now see how it very well may be a duck looking to the left? Can you almost hear "quack, quack" coming from

its slightly open bill? The point is it doesn't matter which animal you perceived at first glance. What matters is that you can now see the possibility that it could be something else, something entirely different once you've opened your mind to consider alternatives. Can you change your old way of thinking? Can you be an agent of change in your industry? Consider a progressive cavity pump application next time there is a capital upgrade project at your facility.

ABOUT THE AUTHORS



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<http://dx.doi.org/10.5942/jawwa.2014.106.0051>

FOOTNOTE

¹seepex Inc. Enon, Ohio

ADDITIONAL RESOURCES

How a Physical Pump Model Helped Save Construction Costs and Reduce O&M Headaches. Teem, R.A.; Sarrouh, S., 2011. AWWA Annual Conference. Catalog No. ACE_0075097.

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