An Overview of Stepper Motor Diaphragm Metering Pumps

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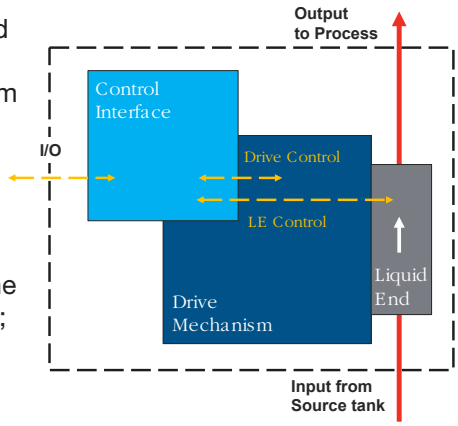
Stepper motor metering pumps provide several advantages over traditional positive displacement pump technologies. The following article provides an overview of the use of stepper motors in diaphragm metering pumps, and the benefits of this technology.

Diaphragm metering pumps are a type of positive displacement pump used for high precision chemical injection applications. Known for their ability to withstand high pressures with limited maintenance requirements, diaphragm metering pumps are trusted by both operators and engineers, and are typically the preferred option for most chemical metering applications.



Metering pumps typically consist of three separate modules: a control interface, a drive mechanism, and a fluid handling assembly (liquid end). Though there are a number of technologies and pump designs available, the following article will provide an overview of stepper motor drive technology; a new class of pump technology that is featured in Milton Roy's Proteus® series of pumps.

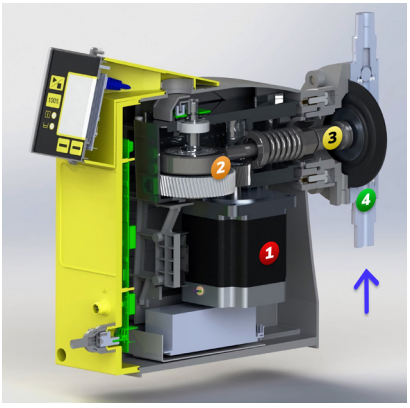
Overview

Stepper motor metering pumps have established a place amongst traditional technologies, such as solenoid driven or AC motor driven pumps, by providing a unique solution with some distinct benefits. Housed in a high-strength plastic housing, the internals of the pump feature a novel design that consists of a self-lubricated and enclosed drive; removing the need for an oil bath. The pump also houses on-board controls, integrated Input / Output (IO), and industrial grade electronics.

How it works

What makes stepper motor metering pumps unique is their ability to control the exact position of the stroke at any given moment.

- The **stepper motor (1)** turns a **gear set (2)**, dividing a full rotation into precise, equal steps; starting and stopping within a fraction of a degree of rotation.
- This rotational motion of the **gear set (2)** is translated into linear motion via an **eccentric shaft (3)**.
- This drives a piston, which is mechanically connected to the **diaphragm (4)**. Only the process side of this chemically resistant diaphragm comes into contact with the fluid being pumped.



LMI's Excel XR

Benefit

The ability to have full, precise control over the stroke profile provides two key advantages:

Constant Dosing: As the pump capacity is turned down, the motor compensates by slowing only its discharge stroke, allowing the suction stroke to remain at full speed. This results in continuous injection of the process fluid into the system. Constant dosing eliminates the issue of "slug feeding"; that is letting a large amount of chemicals into a system due to long gaps between each stroke.

Anti-Cavitation Properties: Independent control of the suction and discharge stroke speed allows the operators to slow down the suction stroke of the pump when pumping highly viscous fluids (such as polymers), or where there is a low vapor pressure chemical that off-gas (such as sodium hypochlorite), preventing cavitation and extending the life of the pump.

Constant Dosing

The first major advantage of using a controlled stroke profile is to allow a constant flow of chemicals into the system. The following charts illustrate the benefits of using a control stroked profile, with the negative Y axis (-), highlighted in green, representing the suction stroke; the positive Y axis (+), highlighted in blue, representing the discharge stroke, and the X axis representing time.

As the pump strokes the diaphragm position is shown by the gray sine wave, relative to its neutral position (y=0).

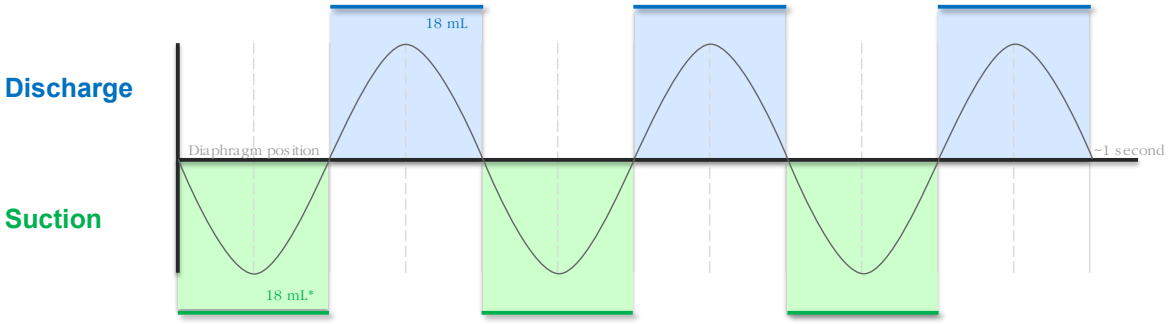


Figure 1: Stroke profile at 100% - At full speed, suction and discharge stroke profiles are very similar

Using LMI's new Excel XREx4 metering pump as an example, the pump operates with a stroke volume of 18mL at 184 SPM (approx. 3 strokes per second); the Y axis shows minimal loss between suction and discharge, and a full volume exchange from suction line to discharge line. Both of these characteristics are considered normal for positive displacement pumps.

The key benefit of using a controlled stroke profile becomes evident as capacity is turned down.

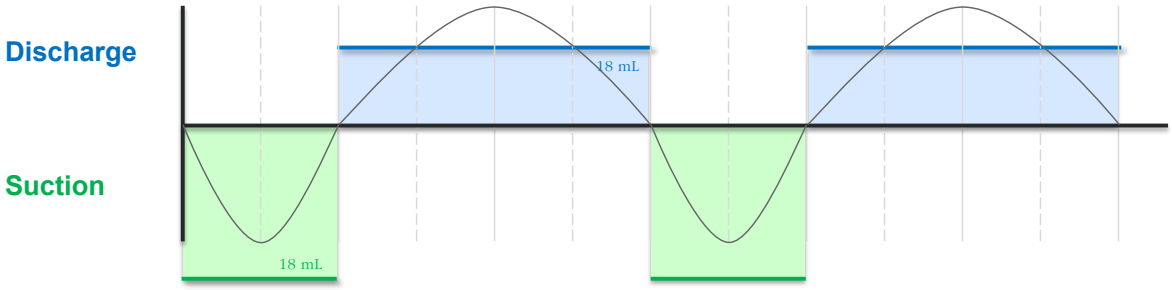


Figure 2: Stroke Profile at 66% - As capacity is turned down, discharge stroke slows while suction remains the same

When capacity is turned down to 66%, the pump continues to maintain the same volume (18mL) over a longer period of time (2 strokes per second), without sacrificing suction speed.

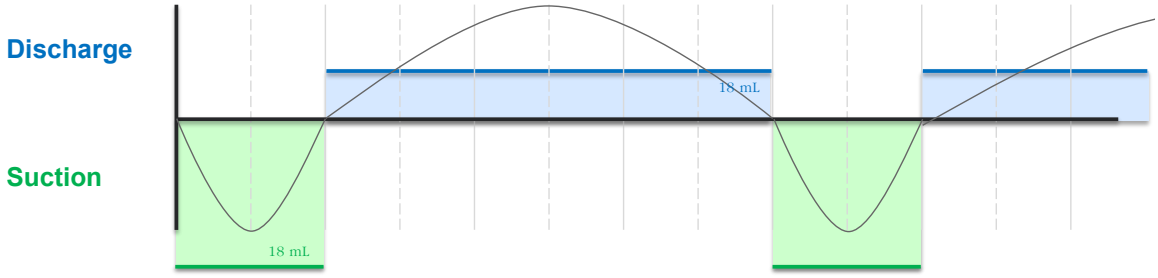


Figure 3: Stroke profile at 50% - As capacity is turned down, discharge stroke slows while suction remains the same

The effect becomes even more pronounced when capacity is turned down to 50%, allowing the pump to maintain its pumping volume at 1.5 strokes per second (see figure 3).

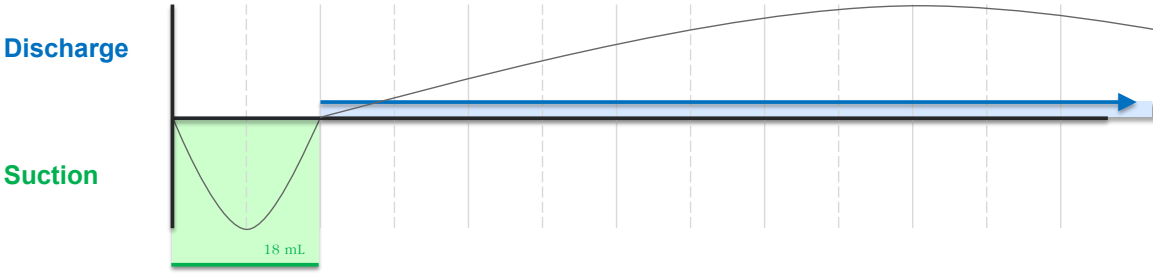


Figure 4: Stroke profile at 20% - Continuing to turn down shows a smooth discharge stroke over the full duration – this results in continuous injection

As the pump is turned down to 20%, the advantage becomes clear. Similar to the operation of a syringe, the pump is able to perform a full speed suction stroke, and then slow down to make a long, continuous injection of the fluid for the remaining duration of the stroke. (see figure 4)

Anti-Cavitation Properties

The second major advantage of using a controlled stroke is the ability to eliminate suction cavitation when working with off-gasing liquids. Suction cavitation can occur when fluids are subjected to a sudden drop in pressure, causing vapor bubbles to form within the pump head. As the bubbles are subject to changing fluid and pressure conditions, they are compressed against the liquid, imploding against the internal surfaces of the pump.

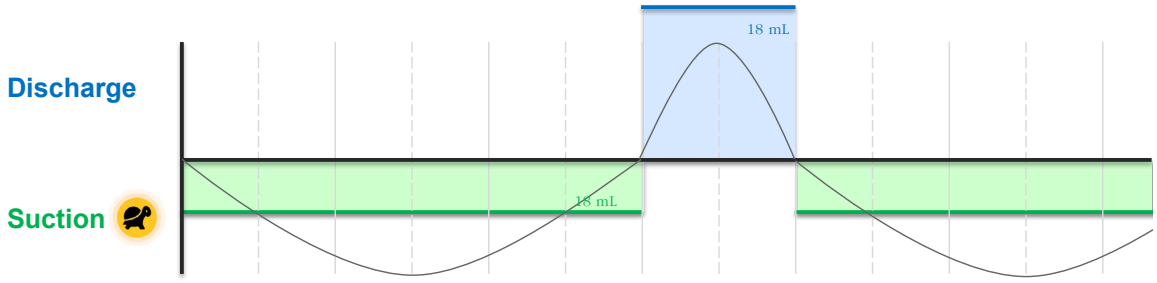


Figure 5: Slow mode at 50% suction and 100% discharge - Slow Mode allows full control of the suction stroke Anti-cavitation for high viscosity (polymers) or off-gassing fluids (sodium hypochlorite and peracetic acid)

With full control of the stroke profile, suction time can be reduced independently of the discharge stroke; allowing a more gradual intake of fluid to prevent the formation of air bubbles and eliminating cavitation.

Conclusion

LMI's Excel XR series of pumps provides several clear benefits over traditional diaphragm metering pumps. The pump's use of a stepper motor allows precise control of both the suction and discharge stroke profiles; allowing the pump to deal with increasingly complex dosing applications while maximizing performance and avoiding cavitation.

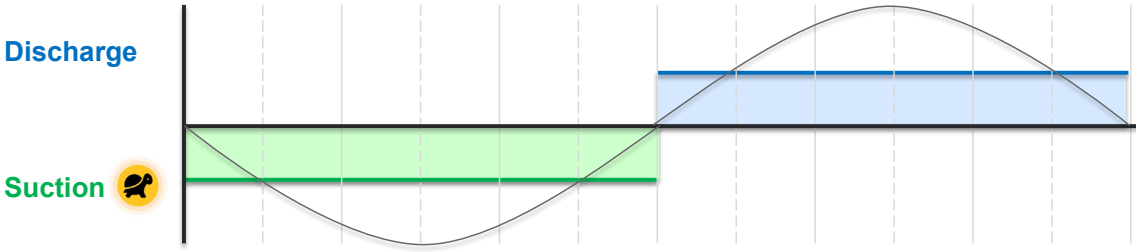


Figure 6 Slow mode at 50% suction and 50% discharge - Each stroke profile can be independently controlled to desired condition, a key advantage in dealing with complex metering applications.

Additionally, the Excel XR series of pumps feature integrated controls and logic, reducing cost and complexity by allowing operators to control the pump via a simple touchpad interface; removing the need for additional PLC programming and logic.

The result is a mechanically-actuated diaphragm pump that is driven by advanced variable speed technology, providing the most accurate and reliable performance in the industry.

To learn more about stepper motor drive technology, check out LMI's Excel XR series of pumps.

www.excelxrpumps.com