

Gear Pumps: A Simple Solution for Metering Applications

by Greg Miller, Liquiflo

Metering or dosing refers to the delivery of an accurately measured amount of liquid. Metering, in one form or another, is used throughout all industries — from paper making to film processing, to chemical manufacturing, to plating, cleaning, etc. Until recently, many users have considered only diaphragm pumps or piston pumps for their metering applications.

Advances in electronics over the last 15 years, however, have closed the gap between rotary and diaphragm pumps, making metering with gear pumps a very simple and extremely accurate solution. These days, the traditional reasons for selecting a diaphragm pump over a gear pump are no longer valid. Typically, gear pumps can compete directly with diaphragm metering pumps up thru 10-15 bar.

Metering Situations

There are three basic metering situations:

- Metering at a constant flow rate over a range of differential pressure;
- Delivering a metered flow in a set proportion to a process variable for the purpose of controlling the process variable (e.g., keeping a pH level constant);
- Delivering a given volume of fluid irrespective of flow rate – Batch processes (e.g., filling a tank to a specified level or volume).

Diaphragm and piston pumps historically have been associated with the first of the above metering situations, because of the following characteristics they possess:

- Precise volumetric displacement
- "Infinitely" adjustable range
- Pressure "stiffness" (i.e., the ability of a pump to maintain consistent flow rate over a wide pressure range)



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*No longer are
diaphragm and piston
pumps the only
players in the game.*

How Gear Pumps Measure Up

These features mentioned on the previous page are what made diaphragm and piston pumps synonymous with metering applications in the past. In light of new technologies, though, such pumps can no longer claim metering as their exclusive territory. Equipped with appropriate drives and controls, gear pumps are now fully capable of performing well in all three metering situations:

In metering situation (a), the desire is to maintain a set flow rate against a varying differential pressure. Diaphragm, piston and gear pumps inherently exhibit this characteristic within certain conditions. Gear pumps lose their pressure stiffness with low-viscosity liquids. However, by using closed-loop feedback control, the flow rate can be maintained by automatically adjusting the motor speed as the pressure varies. This allows the gear pump to function like a diaphragm pump and maintain its pressure stiffness in the low-viscosity operating region.

In metering situation (b), the set point is based on maintaining a process variable at a given value and the flow rate is varied according to this requirement. Prior to closed-loop feedback — which now puts diaphragm and gear pumps on equal footing — many processes had to be done in batch mode since manual adjustment was impractical, if not impossible.

In metering situation (c), a “metering” pump is not required at all. It is dependent on total amount delivered by the flow by either continuous monitoring, such as with a totalizing flow meter, or by limit switches triggered by tank liquid level, pH, weight, etc.

Operation Without Feedback

When operating without feedback control, the metering capability with either type of pump is a function of many variables. The differential pressure affects both slip in the pump and motor speed — both of which affect the flow rate. (See Figure 1.) The differential pressure in turn is a function of viscosity and density, which are primarily functions of temperature. Viscosity, in addition to affecting the differential pressure, also independently affects slip. (See Figure 2.)

The impact of these factors is much more pronounced in the gear pump when operating on thinner fluids (i.e., the gear pump is not as “pressure stiff” as diaphragm pumps in the lower range of viscosities). However, at a viscosity of around 50 cps or higher, gear pumps’ volumetric efficiency and pressure stiffness increases to rival that of diaphragm pumps. (See Figures 2 and 3.) Diaphragm pumps, on the other hand, start to become less pressure stiff at the higher viscosities due to delay in reseating of the check valves and the high instantaneous flow rates associated with pulsing type pumps.

Figure 1 Torque vs. Speed Characteristic for NEMA Design B Motor

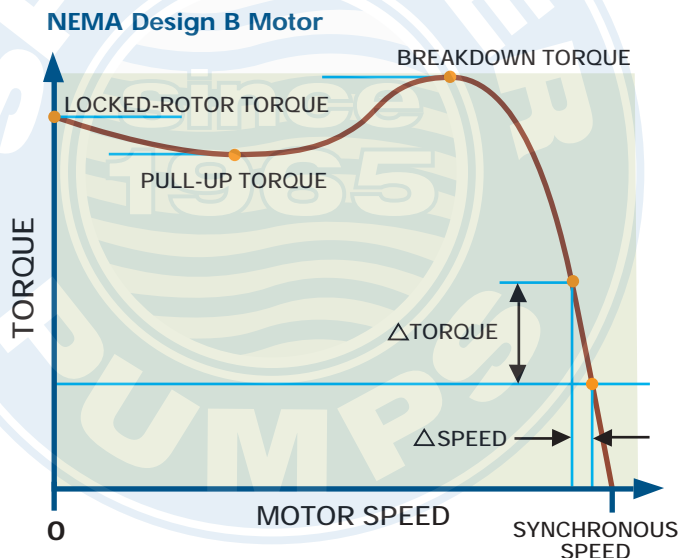
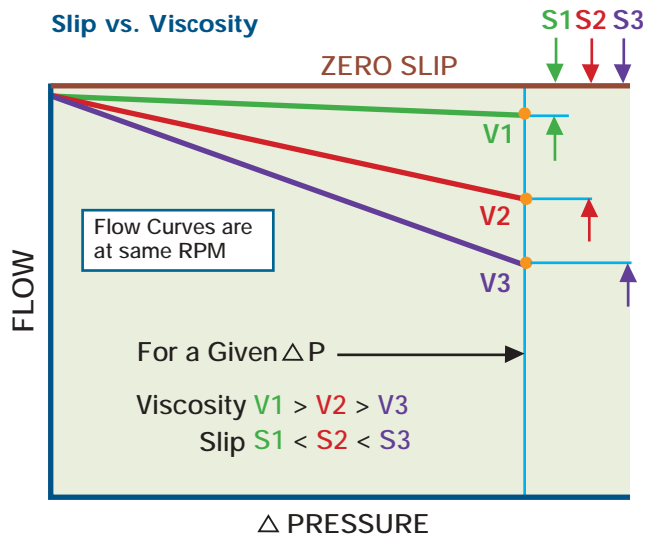


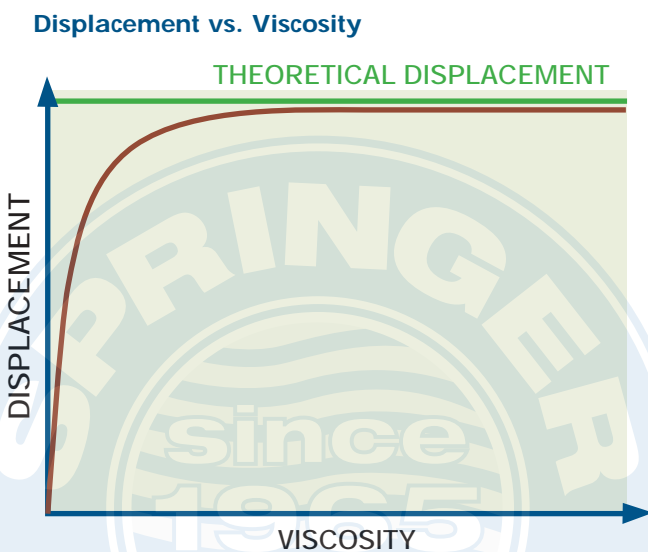
Figure 2 Flow vs. Pressure Curves Showing Slip vs. Viscosity



Operation Using Feedback Control

Economical closed-loop feedback systems have changed the ability of the gear pump to compete at the lower end of the viscosity range. The burden for accuracy and repeatability has been moved from the pump to the instrumentation. Pressure stiffness is no longer the primary factor. Flow meters with analog outputs capable of down to +/- 0.25% accuracy coupled with PID controls allow gear pumps to achieve accuracies in the range of +/- 0.5% to +/- 2.0%. In addition, the adjustability available in the diaphragm-metering pump is easily matched with DC motors coupled with SCR (silicon controlled rectifier) controllers capable of 20:1 turndowns or AC inverter duty motors coupled with VFD (variable frequency drive) controllers capable of 1000:1 turndowns. (See Figures 4 and 5 for examples of gear pumps in metering applications using feedback control.)

Figure 3 Curve Showing Displacement vs. Viscosity (Volumetric Efficiency)



Gear Pump Advantages in Metering Applications

Diaphragm metering pumps also can and do employ the same closed-loop technology that enables gear pumps to meter. However, in the final analysis, gear pumps can provide accurate and repeatable flow rates within the same general range of diaphragm metering pumps, and they offer the following advantages:

Virtually no pulsations This allows flows to be easily and accurately measured with standard flow meters. Pipe diameters can be much smaller in relation to those used with pulsing diaphragm pumps whose pipe diameters are based on high instantaneous flow rates.

Lower NPSH requirements Gear pumps require less NPSH because of their steady non-pulsating flow characteristics. Diaphragm or piston style pumps require higher NPSH because of their pulsations. (NPSH available decreases further as the viscosity of the fluid increases.)

Simplicity of design Gear pumps are extremely simple to understand and maintain. There are no check valves to clog or fail, and no pulsation dampeners need to be placed in the line.

Multiple seal arrangements or mag-drives Rotary gear pumps are available with single-mechanical seals, double-mechanical seals or seal-less mag-drives. There are no diaphragms to rupture, allowing process fluid to leak or destroy the pump, or gear box lubrication oil to enter the process that is being controlled.

Accurately controlled flow With standard instrumentation such as flow meters, pH sensors, and variable speed drives, accuracies of +/- 0.5% are easily achievable.

Ease of automation With off-the-shelf electronics such as variable speed motors, flow meters and pH sensors with standard 4-20 mA analog outputs, configuring a gear pump for a metering application becomes a very simple process.

Low cost With the price of electronics being a fraction of what it was just 10 years ago, the cost to automate and maintain more efficient rotary gear pumps has decreased significantly. Metering using gear pumps is now considered to be one of the most cost-efficient methods of metering in industry today.

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Figure 4

Shows a schematic hook-up of a metering application precisely controlling the pH range of a process. Depending on the condition of the process, a varying amount of solution needs to be added to maintain the process at the desired pH level. The system is set up to maintain this exact pH level and is continually being monitored by the pH sensor. The signal from the pH sensor will either speed up or slow down the motor speed to maintain the desired pH value.

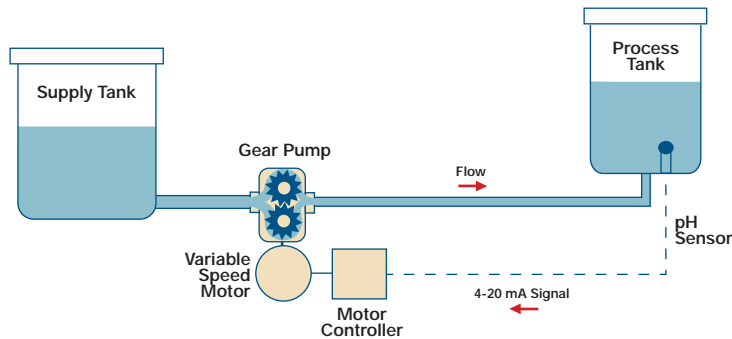
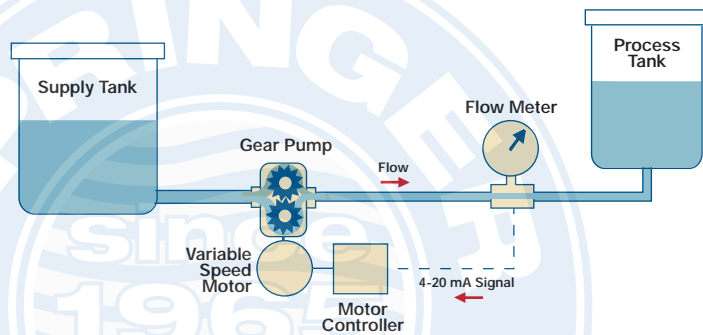


Figure 5

Shows a schematic hook-up of a metering application precisely controlling the flow rate of a liquid into a process. A 4-20 mA signal coming from the flow meter controls the speed of the pump to accurately administer a designated flow rate into a process. The system is set up to maintain an exact flow rate that is continually being monitored by the flow meter. The signal from the flow meter will either speed up or slow down the motor speed to maintain this flow rate value. Either DC motors with SCR controllers or AC duty motors with VFD controllers are commonly used.



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