Metering With Gear Pumps

Mr. Fred Koval and Mr. Nick Valente

When a plant engineer is required to select and specify a chemical metering pump, the decision is often regarded as a simple choice between a reciprocating plunger pump or a diaphragm pump. Gear pumps are seldom even considered. This understanding has evolved over the years until the terms metering and reciprocating pump have nearly become synonymous.

Conventional Metering Pumps,

whether reciprocating plunger or diaphragm (disk or tubular shape), operate on the same common principle. The volume of the pumping chamber is altered by the reciprocating action, which changes the pressure exerted on the fluid being pumped. The pumping action is controlled by a pair of unidirectional check valves, Figure 1 .

Displacement is determined by the plunger cross-sectional area, stroke length and cycle rate. In theory, reciprocating pumps displace a constant volume of fluid with each stroke of the plunger. The discharged fluid may vary from the ideal because of erratic action of check valves or variation in the flexing action of the diaphragm during successive pulses.

Additionally, reciprocating plunger pumps deliver output in pulses, exhibit limitations in suction lift, are sensitive to changes in liquid viscosity, and require *a* complex drive for varying stroke.

The discharge from a reciprocating pump is delivered in pulses. This pulsing effect or slug feeding can be minimized by using phased duplex or triplex heads, or surge chambers, but only with an added cost penalty.
Many applications for example, pH control, highly critical exothermic reactions, or applications in which it is necessary to monitor flow through a rotometer or an instrumented flowmeter require uniform discharge for optimum results.

Reciprocating plunger pumps usually require a flooded suction for optimum service. They are essentially pressure intensifiers and exhibit poor suction lift characteristics. An elevated reservoir, a pressurized supply tank, or feed pump may be required with liquids that do not flow freely and liquids that have low vapor pressures. Viscosity of the liquid entering the pump may change when the fluid is of an in-process intermediate nature, or if the temperature changes radically. When viscous liquids must be handled by reciprocating pumps, oversized suction lines and low cycle rates are required to assure that the chamber is completely filled during each stroke. When high capacities are required, the cost of the pump increases accordingly

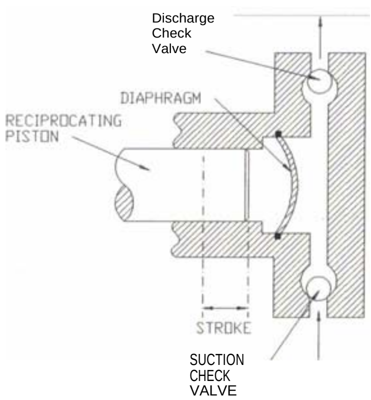


Fig 1. A pair of unidirectional check valves is required in the operation of reciprocating plunger and diaphragm pumps. Ball-check or disk-plate valves may be lightly springloaded to increase seating rate, but suction lift is reduced.

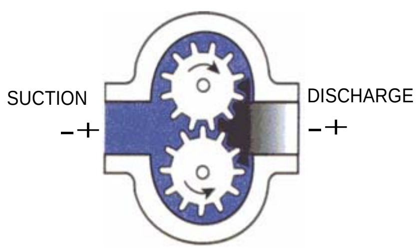


Fig 2. Rotary gear pumps are positive-displacement pumps operating to trap equal increments of fluid in the space between gear teeth and the pump housing for transport between intake and discharge ports.

Fig 3. Local manual bypass control system has a constant-speed pump operating to deliver a volume exceeding the maximum required by the process. The flow is divided, and the required portion is delivered to the process and the excess is returned to the supply tank. Backpressure and relief valves are used in this system for optimum performance. The backpressure valve maintains constant pressure in the discharge line. Flow to the process is precisely controlled by adjustment of the bypass control valve. The relief valve protects the pump and other system components against over-pressure. Output from the relief valve should always be piped to the supply tank, or to a safe drain, and never returned to the pump intake.

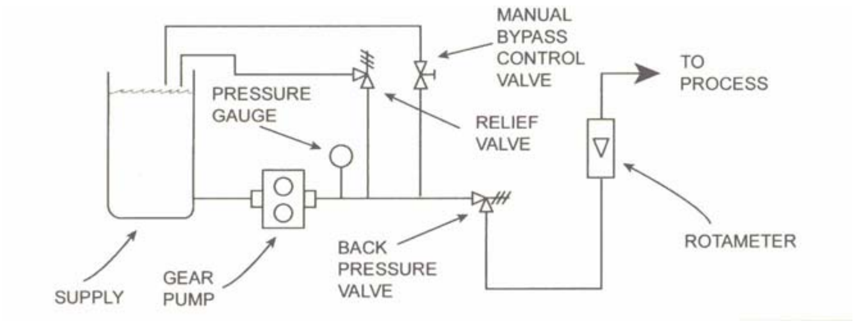


Fig 4. Remote manual bypass control can be provided by replacing the manual bypass valve shown in Figure 3 with an air or electrically operated control valve. The bypass control valve is then made a slave to a remote pneumatic or electrical manual loading station

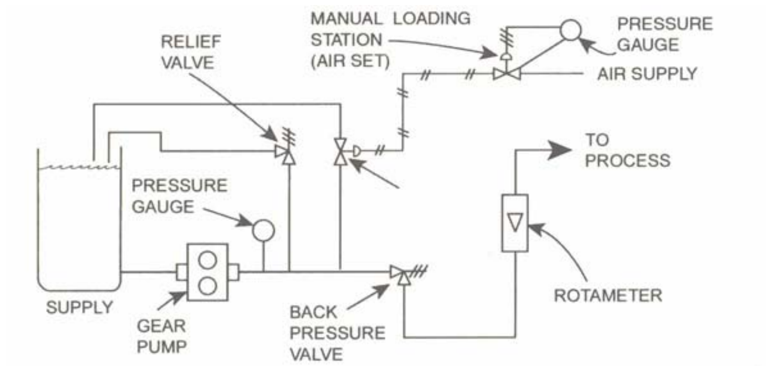
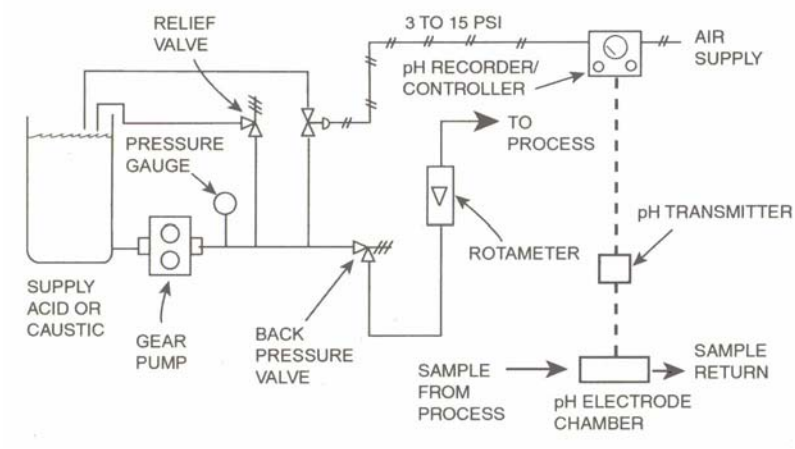


Fig 5. Remote automatic bypass control is provided with the bypass system shown in Figure 4 by feeding the signal from a suitable controller, in this case pH, to the control valve in the bypass line. This basic automatic control system may be used in a variety of applications in which an output signal is available from a control device such as a temperature, pressure or turbidity monitoring controller. The system is simple to troubleshoot and allows a range change (within limits) by changing the valve trim.



The ability to vary the stroke length during operation increases the complexity of the drive design in reciprocating metering pumps. Several methods are available: direct stroke adjustment, eccentric cam adjustment, and lost-motion devices to limit movement of the plunger during a portion of the return stroke.

An Alternative Method

In many applications, specifically when high pressures are required, the reciprocating pump is preferable, if not the only choice. The rotary gear pump is an alternative that should not be overlooked for low to moderate pressure (100 psi or less) applications.

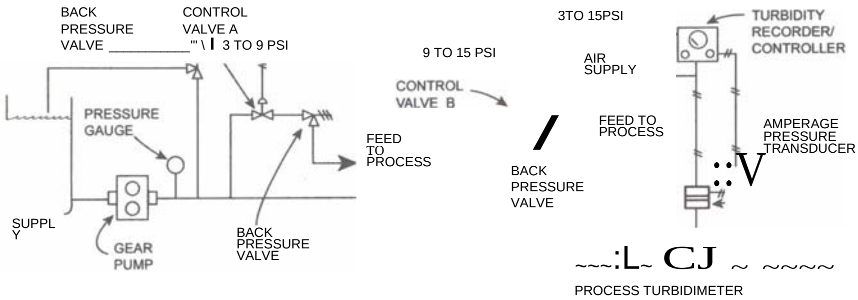
The rotary gear pump merits consideration because it overcomes many of the problems encountered with reciprocating metering pumps and is generally much less expensive.

The cost factor is particularly significant when pumped liquids require corrosion-resistant materials. The rotary gear pump operates by picking up fluid at the suction port in the cavities formed between the gear teeth and housing, and carrying the fluid around the outer diameter of the gears to the discharge port, Figure 2.

By design, it displaces a relatively constant volume per revolution and delivers essentially pulse-free linear flow. The quantity of fluid (flow rate) delivered to the process may be varied in three basic ways, wjth varying degrees of control sophistication:

- Bypass metering local manual control Figure 3; Remote manual control Figure 4; Remote automatic control Figure 5; Or Dual-rate output control, Figure 6.
- Variable speed metering local manual control Figure 7; Remote manual control Figure 8; Or remote automatic control Figure 9.
- Ratio metering local manual

Fig 6. *Dual-rate output bypass control is illustrative* of a *two-level system* for *turbidity control* or *other similar service. Under certain conditions* a *system must* be *designed* to *cope with an occasional upset when* a *greatly increased volume* of *liquid is temporarily required. In the system illustrated,* an *oversized pump is used with* two *control valves.*



"The degree of accuracy is a function of instrumentation accuracy and the degree of sophistication used in the design of the control system. "

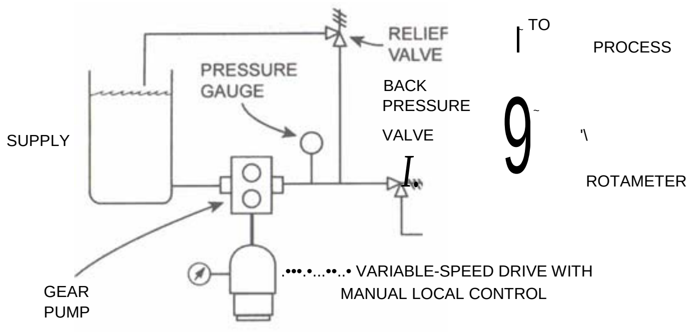
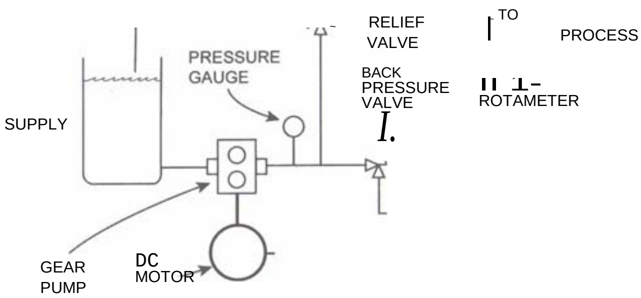
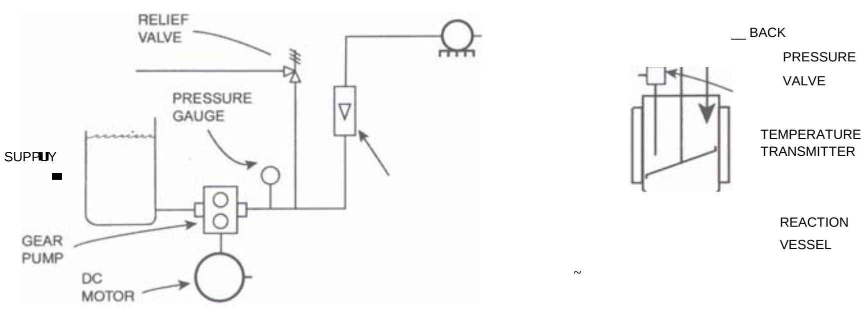


Fig 7. *Local manual variable-speed control can* be *based* on a *number* of *variable-speed drives: mechanical-speed drive, hydraulic transmission, air motor;* or *silicon-controlled rectifier (SCR) drive.* A *variable-speed drive with manual adjustment is illustrated.*





Under normal *operating conditions the flow rate is controlled by Valve* A *operating* on a *control signal* of 3 to 9 *psi. In the event* of an *upset* causing a *demand* for a *quantity* of *treatment chemical exceeding the maximum that will pass Valve* A, *Valve* B *is operated by the* 9 to 15 *psi signal* to *satisfy the increased demand* of *treatment chemical required by the process system.*

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Fig 8. *Remote manual variable-speed control changes feed rate by using* a *mechanical* or *hydraulic variable-speed drive equipped with* a *pneumatic* or *electrical operator;* or an *SCR drive with* a *remote control station.*

Fig 9. *Remote automatic variable-speed control uses the basic system illustrated in Fig* 8. *The variable-speed· device* is *controlled by* an *output signal (air* or *electrical) received from* a *control device, typically* a *temperature controller monitoring reaction temperature and using the change in this signal* as *the basis* for *changing the feed rate.* A *totalizing meter added* to *the system limits the total quantity* of *reactant used. The meter stops the pump when* a *predetermined amount* of *reactant has been added* to *the system.*

Fig 10. *Local manual ratio metering control* can be *used* to *merge* two or more *liquid streams such* as a *resin and catalyst,* at a *constant ratio using* an *SCR package with speed control* for *each pump. After the ratio between streams is established, the total quantity can* be *changed without disturbing the original ratio.*

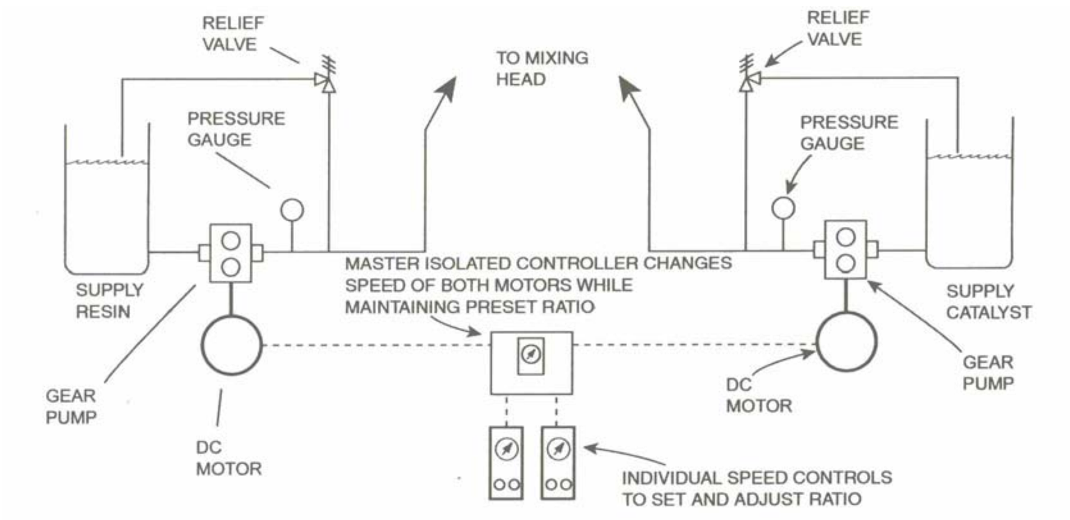
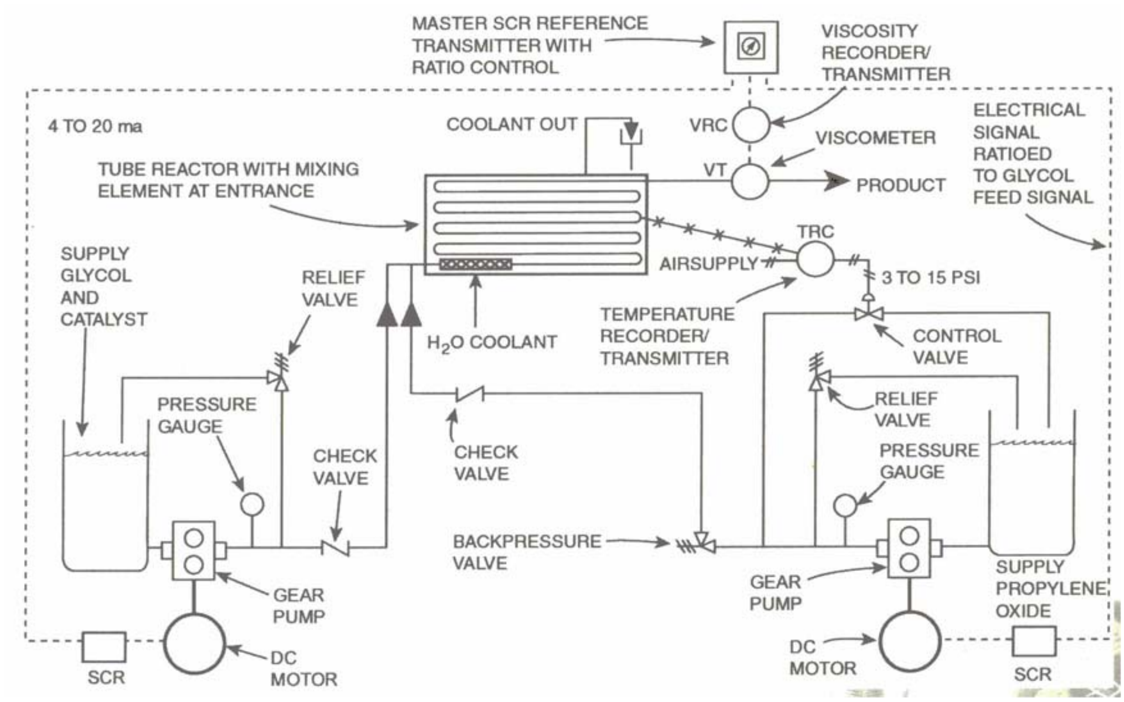


Fig 11. *Remote automatic system uses* a *combination* of *variable speed and bypass control.* A *viscometer determines residence time and adjusts rate* of *glycol feed. Propylene oxide feed is automatically controlled* at a *ratio adjustable* to *the rate* of *glycol feed. Temperature controller reduces propylene oxide feed rate* to *control readion temperatures in the event the ratio control system calls* for a *quantity* of *propylene oxide that would result* in a *larger exothermic reaction than the system is capable* of *handling.*



About the Authors

Fred Koval is an *engineer who has supplied fluid process equipment* to *the chemical processing industry* for *over* 36 *years. Currently, Mr. Koval is* a *sales manager* for *Burt Process Equipment (Hamden, CT).* *Nick Valente has* an AS. *in mechanical engineering, B.S. in business management and M.S.* in *management. Mr. Valente is* a *member* of *AWWA (American Water Works Association), WEF (Water Environment Federation and HI (Hydraulic Institute). He has been in the industrial equipment industry for 15 years and currently is the global marketing manager for Pulsafeeder, a unit of Idex Corp (Rochester, NY).*