Chemical Dosing With Metering Pumps

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PROBLEM: To add a precise amount of chemical into a process stream in order to produce a desired result on a continuing basis.

SOLUTION: It can be done very effectively with a metering pump, if the exact requirements are taken into consideration........

- "add" - at what pressure?
- "precise" - how accurate? If stated in percentage, a percent of what?

- "liquid" - of what viscosity, what specific gravity, what temperature, what percent of solids?

- "chemical" - what materials of construction are needed to be compatible?

- what will be the effects of pulsating flow and can they be eliminated, if necessary?

ALL of these questions, with exception of the last ones, also apply to centrifugal pumps and a variety of other types. It is these last questions, pertaining to pulsating flow, that must be understood and dealt with when metering pumps are used.

PULSATING FLOW is caused by the reciprocating action of a plunger in a bore, the most basic operating part of a hydraulically actuated metering pump. Just like a doctor uses a hypodermic needle to precisely measure medicine for injection into you, a metering pump uses a plunger inside a bore to measure, either directly or indirectly, chemicals for injection into a process stream:

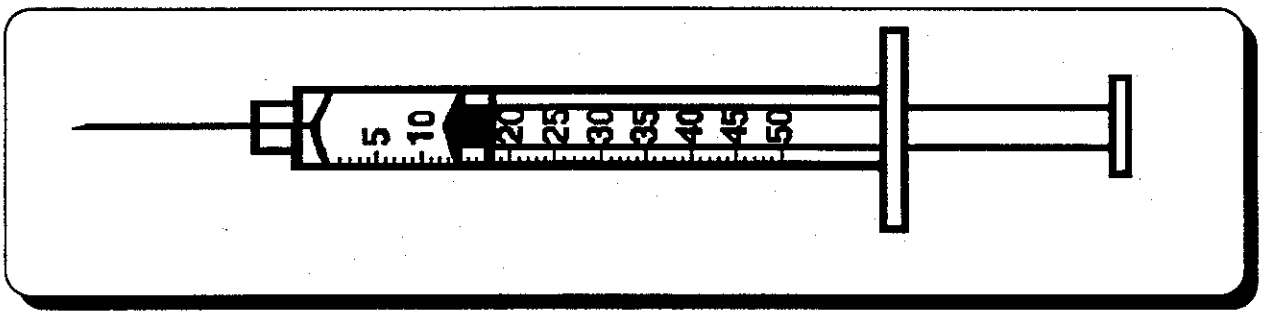

fig. 1

Inside most industrial-grade metering pumps used today, you will find a reciprocating plunger precisely measuring hydraulic fluid, which is then used to move a diaphragm a certain displacement.

POSITIVE DISPLACEMENT is the term used to describe this type pump. The flow is forced, not induced as with a centrifugal pump. There is little or no internal "slip", therefore any attempt to throttle down the output with a valve will only increase the pressure in the discharge line and the velocity of the liquid through the valve. Without proper safeguards, this could cause considerable damage to the pump and discharge piping.

RECIPROCATING MOTION of the plunger causes pulsations in both the suction and discharge piping. Conversion of the rotary motion of the driving motor to the back and forth motion of the plunger, as shown in fig. 2:

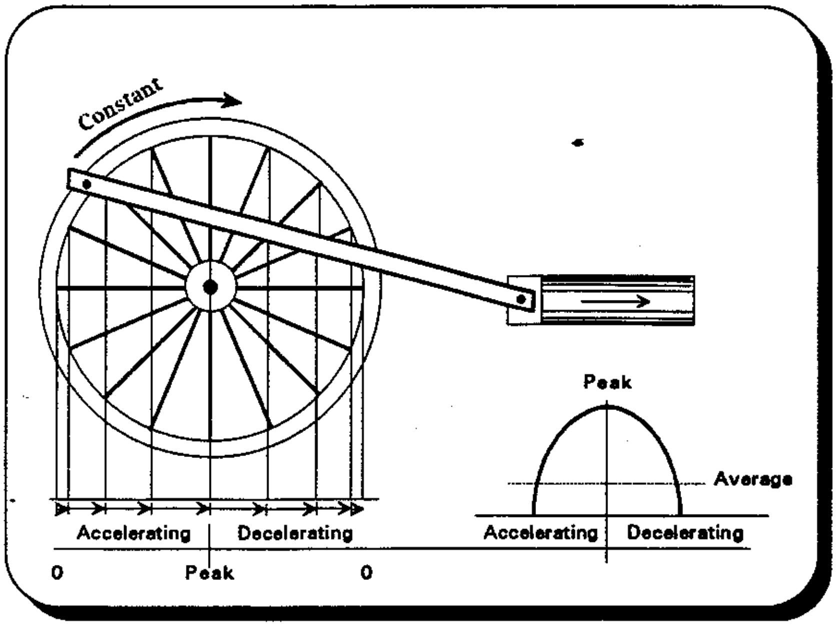

fig. 2

creates a sinusoidal wave as shown in fig. 3:

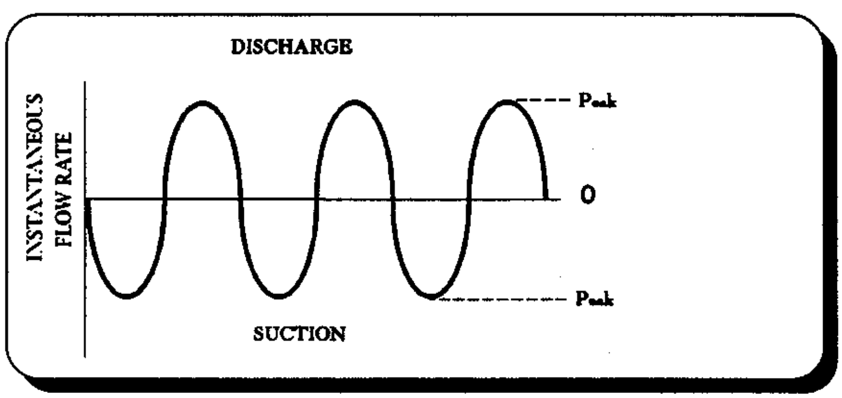

fig. 3

CHECK VALVES keep the liquid flowing in one direction, not just sloshing back and forth. As shown in fig. 4, when mounted facing in the same direction, check valves installed at the inlet and outlet of a metering pump keep the flow moving upwards.

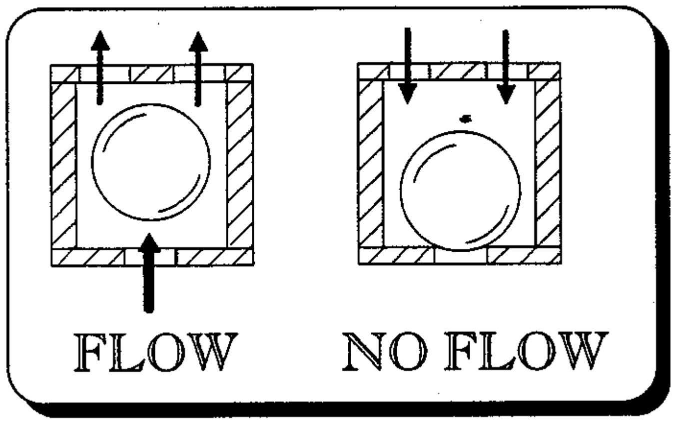

fig. 4

Now, if you could see into either the suction piping or the discharge piping, you would see a "bumpy" flow like fig. 5:

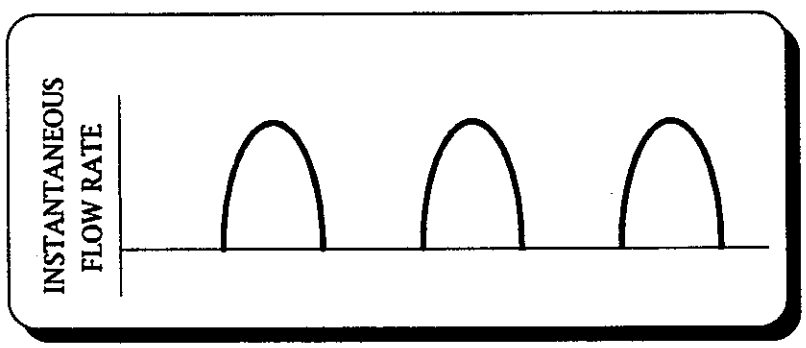

fig. 5

These are pulsations and can best be seen in the jumping and banging of undersized discharge pipes.

N.P.S.H. is the main concern caused by pulsations in the suction piping. It stands for Net Positive Suction Head and is a calculation of the net sum of all the pressures available to push the chemical into the pump head. Remember, you can no more "suck" or pull a liquid into a pump than you can push a rope. If, when the plunger retracts, a negative pressure is produced, the chemical may vaporize, or "flash", and just sit there. There has to be enough pressure from the atmospheric pressure on the supply tank, difference in elevations, etc. to push the liquid into the pump.

LONG SUCTION LINES are the most common source of N.P.S.H. problems. The longer the pipe, the bigger the "slug" of chemical that has to be accelerated from a stop to peak velocity and decelerated on each and every stroke of the pump. Also, the smaller the i.d. of the pipe, the faster that slug must be accelerated and the more friction loss will rob N.P.S.H.. The cardinal rule is to keep suction piping as short as possible. If a long suction line is unavoidable, a standpipe is often a simple solution. A standpipe is no more than a vertical, open top pipe, taller than the supply tank, mounted close to the suction side of the pump. Properly sized and installed, the only pulsations will be between the pump and the standpipe which, in turn, will be filled by gravity.

DISCHARGE PULSATIONS are most troublesome when there is a flowmeter in the line or a uniform volume of chemical is needed at all times. Flowmeters do not like pulsations of any kind, period. If a chemical is injected into a process stream with pulses in the flow, the concentration of that chemical will not be uniform downstream of the injection point for some distance. Those applications call for pulsation dampeners. A pulsation dampener is a gas-filled cushion, as shown in fig. 6:

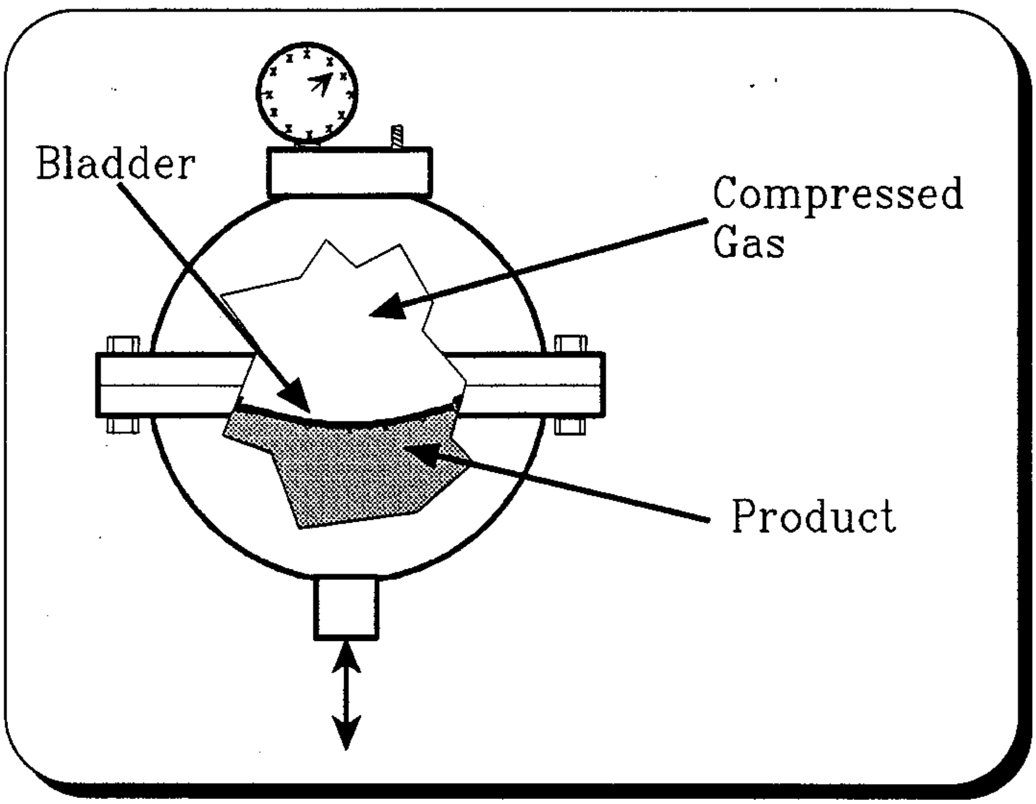

fig. 6

Some energy from the discharge stroke is absorbed by the gas cushion and fed back on the suction stroke, resulting in a smooth flow.

SYSTEM DESIGN is critical to the proper operation of metering pumps. The pump, itself, is the heart of the system, but ancillary items may be necessary, and their placement in the system may be crucial to accurate performance.

THE SOURCE of the chemical supply is very important. Metering pumps should, whenever possible, have a flooded suction. That is, the elevation of the supply tank should be higher than the suction inlet to the pump, not just the pump base. A shutoff valve must be included so that the pump can be serviced and the calibration column, as explained later, can be used.

SUCTION PIPING should be as short and as big in diameter as possible. This reduces N.P.S.H. requirements, as previously discussed. Especially with chemicals like Sodium Hypochlorite, which tend to gassify, the suction piping should slope downward to the pump, allowing trapped bubbles to migrate back to the supply tank.

A CALIBRATION COLUMN should be installed just before the suction inlet. It is a graduated tube piped into the system so that it can be made the sole supply source for the pump. By measuring the time it takes to draw a specific amount from the tube, the exact output of the pump can be determined. This is especially useful as an ongoing diagnostic tool to check the condition of the pump.

A SAFETY VALVE should be piped into the system immediately after the discharge check valves. However, the safety valve itself should be located at the end of the line where it empties back into the supply tank. The function of the safety valve is to protect the piping from overpressure in the event of a blocked discharge. The metering pump is protected by its own internal safety valve.

A PULSATION DAMPENER, if required, should be the next item installed in the discharge line. As a rule of thumb, the gas volume of the pulsation dampener should be fifteen to thirty times the volume of one stroke of the metering pump.

A BACK PRESSURE VALVE is required if the metering pump is discharging into a system pressure less than about thirty psi, depending on the particular pump. A metering pump will not be accurate pumping into atmospheric pressure. The back pressure valve should be located close to the injection point into the system.

THE COMPLETE SYSTEM should resemble the example shown in figure 7. The Applications Engineering department of the company supplying the metering pump(s) should be consulted to be sure that all components are correct.

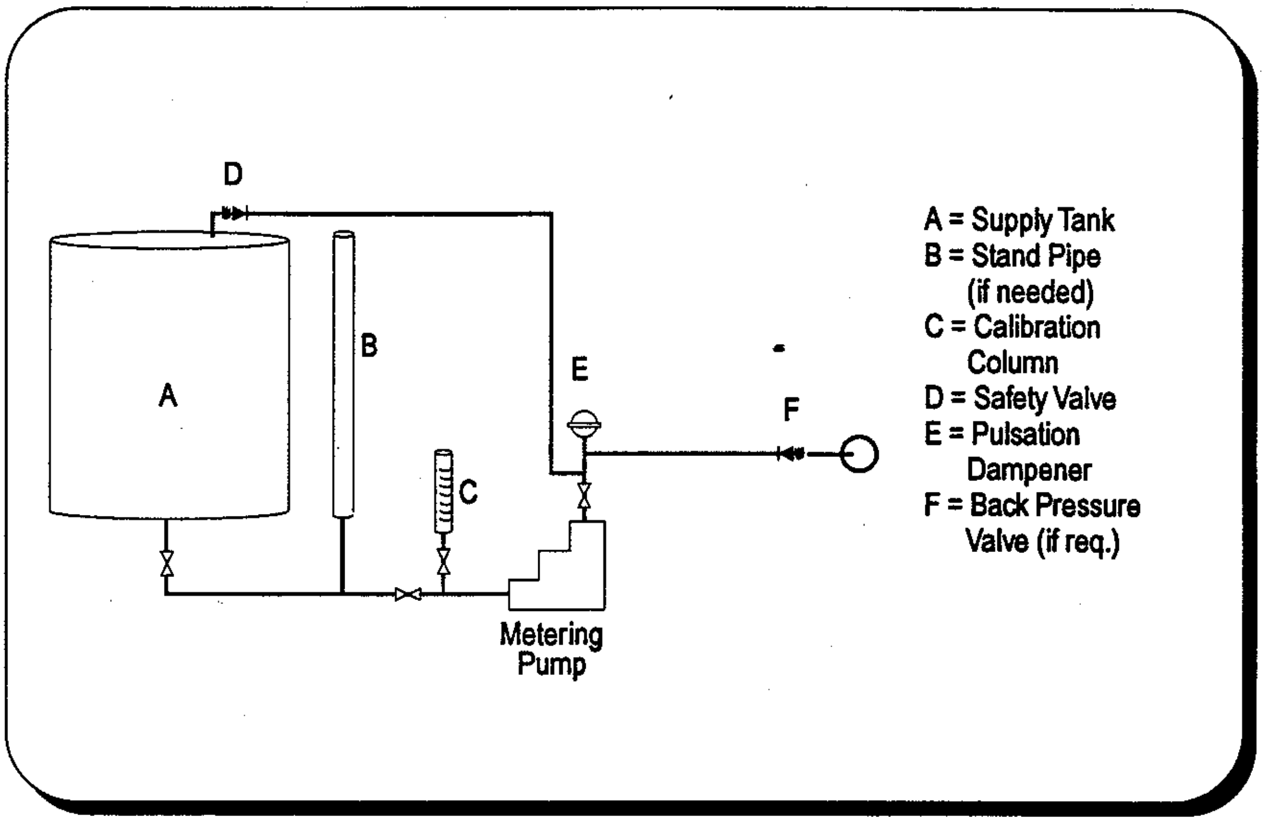

fig. 7

METERING PUMPS must be thought of as a system, not just a pump. When the function of each component is understood, the design of a precise chemical feed package is not difficult.

WHEN AND WHERE are metering pump systems used? They should be used in applications that exploit the qualities that are unique to this family of pumps:

- ACCURACY - When a very precise flow is required, nothing can beat a true metering pump. "True" means having a steady-state accuracy of ± 1% or better. However, determine ± 1% of what. There are two accepted practices, percent of rated flow or percent of mean delivered flow. At a pump setting of 10%, the first method can allow a 10% error, but the second, still only a 1% error.

- SEALLESS - A diaphragm type metering pump has no seals to leak product into the atmosphere. For extremely hazardous applications, double diaphragms with leak detection is available. Having two diaphragms without leak detection is of no added value to safety.

- HIGH PRESSURE - Originally designed to inject chemicals into boilers for water treatment, metering pumps are capable of pumping into very high pressures.

There are other features, such as ability to handle corrosive materials, slurries and viscous products, but they are not unique to just metering pumps. Of all their attributes, metering pumps are usually specified for their accuracy. When their peculiarities are understood, their application is easy.

This paper is similar to a seminar on metering pumps that is available at no cost to your company or group. There are one and two hour versions and, if necessary, a shortened version. If you would like to have a seminar that might include your design, operating and/or maintenance people, please write or FAX:

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This paper is a brief synopsis of a part of a book about chemical injection and metering pumps that is presently being written. If you would like a complimentary copy, when they are published, please fill out the following information and mail it to:

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