Complexities of Multi-Point Calibration

Technical Bulletin Three

Over the past decade multi-point injections systems have been very popular because of their ability to allow one pump to inject into several locations; thus eliminating the need for several pumps, controllers and associated equipment. However, many users of these systems are constantly frustrated at the difficulties in calibrating and ensuring the correct amount of chemical is injected at each point. As it turns out, it is not only controller and motor technology that drive accuracy of a multi-point system; but, stroke length, piston diameter, and pump speed which play a very important role in ensuring accurate injection and simple calibration.

Lets get a basic understanding of the issues by thinking about how a positive displacement piston pump works, Figure 1. As the piston moves through its cycle the intake stroke delivers zero fluid. During the discharge stroke fluid is delivered. This will be considered 1 complete cycle.

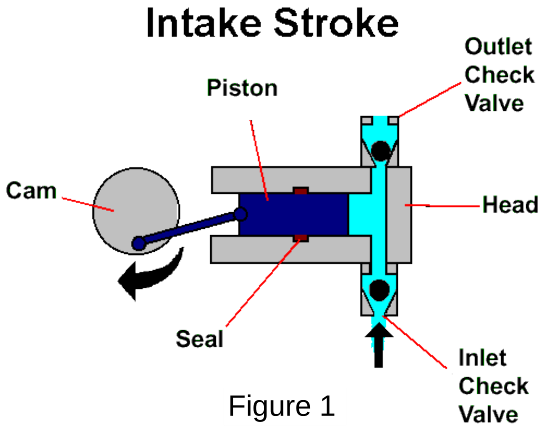


Figure 1

So if the timing is such that the pump has one (or multiples of) complete cycle then the amount of fluid delivered is understood ie. (volume of the chamber). However, if the pump does not complete a full cycle for instance 1 ½ cycles then the volume is only known if you know where the stroke started. If the pump started at the beginning of the intake stroke, 1 ½ cycles would deliver the same volume as 1 cycle because the final ½ cycle would be the second intake stroke which as stated earlier delivers zero fluid. Conversely if the pump performed 1 ½ cycles starting at the beginning of the discharge stroke then the pump would deliver the same volume as 2 full cycles. The problem that occurs on a multipoint system is the location of the piston during the start of the cycle and end of the cycle is not known.

Stroke length has a significant effect on multi-point accuracy and the ability to calibrate the system. To demonstrate this concept simulation software was used to determine the theoretical injection rate of each point of a multi-point system. Effects of seals, packing, valving, pressure differences are all neglected in this simulation. The only source of error during this analysis is stroke granularity.

The majority of chemical pumps in the United States today have stroke lengths between 0.622in and 1.125in and deliver approximately 0.0687 to 0.124 cubic inches per cycle. For this reason, one pump design/configuration chosen for the simulation was a stroke length of 1.123". This will represent the "Long Stroke" part of the simulation. All simulations were performed using a five-point injection system with 3/8" plunger diameter and 4Q/day rate. Figure 2 shows the theoretical injection rate of each individual injection point for long stroke design. The simulation uses five points all calibrated for 4 Q/day. In Figure 2 each color represents an individual injection points calibration over time. One calibration every minute. All points can be seen to oscillate between 3 Q/day and 5.7 Q/day, which is significantly different than the set point of 4 Q/day.

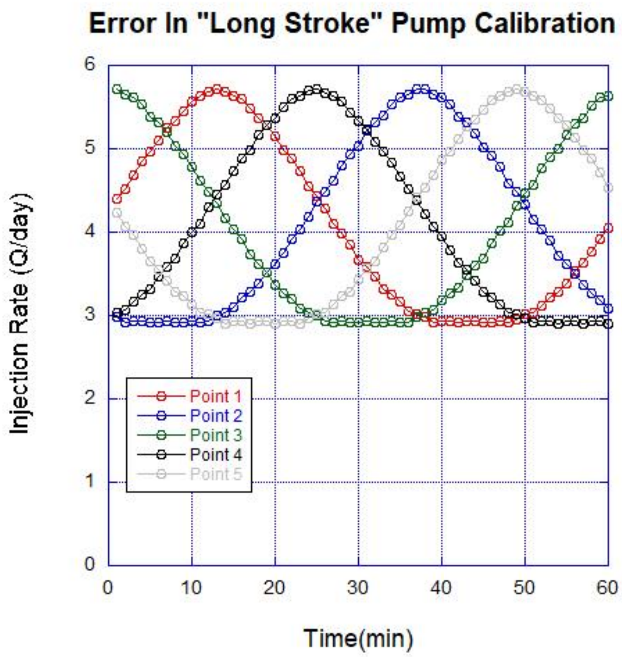
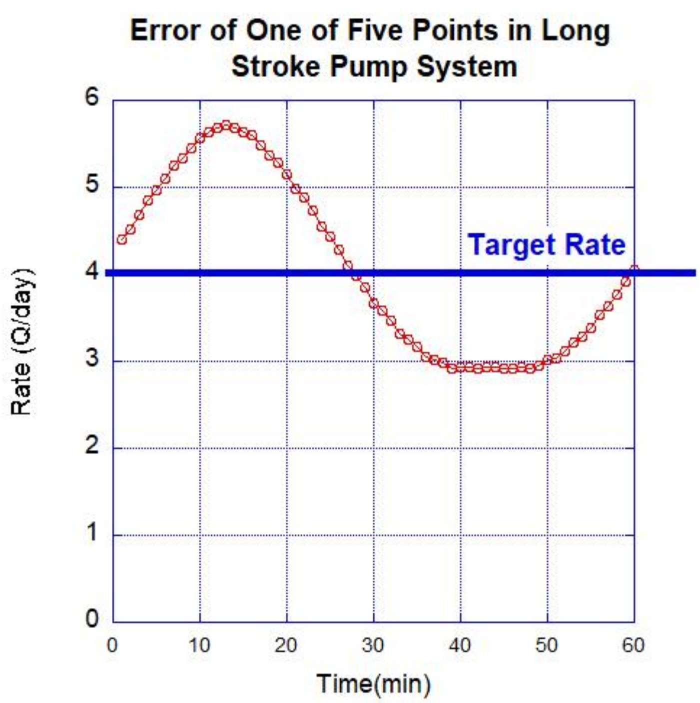


Figure 2

Figure 3 shown below breaks out one of the five points for clarity.



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The simulation was repeated using Sirius' Comet pump which has a stroke length of 0.150in, piston diameter of 0.375, and chamber volume of 0.0138 cubic inches. Figure 4 shows the Comet with a 5 point multiplexor exhibits excellent accuracy at all points over time, coming very close to the target rate of 4 Q/day on all points.

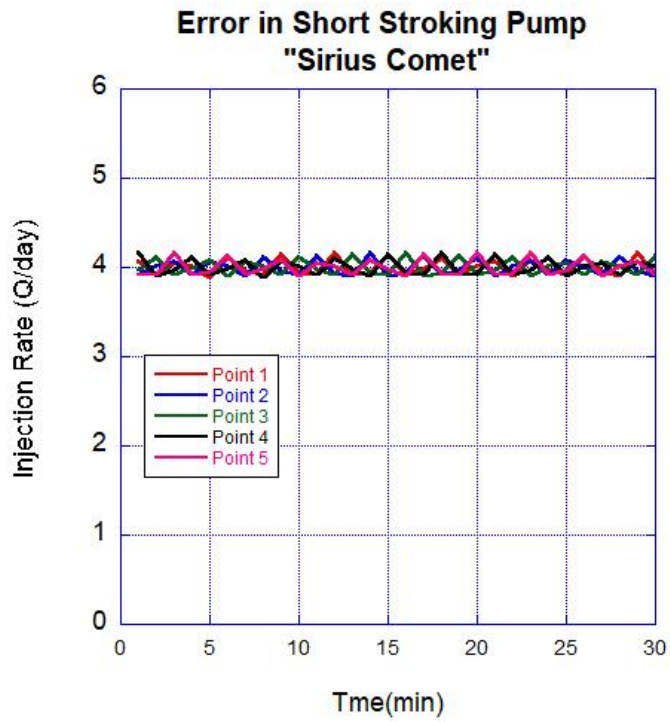

Figure 4

In order to inject 4 quarts with the long stroke pump, 1.45 discharge strokes / minute are required. By contrast the Sirius Comet pump has a stroke length of 0.15in, delivers a volume of 0.0138 cubic inches and requires 12.9 discharge strokes to deliver 4 quarts. This means that the chance of having partial strokes is masked by a factor of 8 to 1. The simulation clearly shows that the smaller chamber pumps stroking at higher RPM's are significantly more accurate when used in a multi-point injection system.

The difficulty in getting an accurate calibration on a long stroke slower pump does not stop there. The simulation above assumes all points are set to 4 Q/day. In reality most points vary in their required rates. Because the long stroke pump system is highly dependent on where the previous points start its injection, a small change in one rate changes randomness of all others. The problem is due to stroke length which makes subdividing flow too course and impossible to accurately predict or calibrate rate of individual points.

Both pump designs (long and short) can further improve accuracy by using smaller pistons or doubling the number of heads, but the 8 to 1 advantage ratio of the Comet pump (short stroke) remains. Having said this, it is crucial to note that discharge stroke shortening alone is not the answer; particularly, if the stroke shortening is done by adding dead time to the piston movement. This is a common practice using stroke pins, stroke limiters, and other such devices. This dead time further exasperates the lack of continuous injection. Yes, the number of strokes will increase but the benefit is eroded by reducing the rotational angle for which the pump discharges fluid. Another problem arising from stroke limiting a long stroke pump is that pump capacity may no longer meet the combined volume of all points without exceeding pump duty cycle limitations.

The best approach is to use a pump with a full 180 degrees of discharge stroke to get the most chemical contact time for your process. Combine this with controller and motor technology which is capable of managing a wide dynamic range of variable speed operation along with Sirius' patented ability to automatically transitioning to ON/OFF duty cycle operation for extreme flexibility in rate control. This approach delivers performance in the following areas; 1) Allows for precision in calibration, 2) Uniform fluid delivery to ensure efficient use dollars spent on chemical, 3) and because injection rate is controlled by managing variable speed RPM for every injection point individually the combined volume delivery is possible. The user commands the rate, the controller calculates the details, the result is reliable, accurate, and cost effective injection, with maximum chemical contact time for your process.