Innovations in Autonomous Local Control for Wellsite and Pipeline Chemical Injection

Technical Bulletin Six

Autonomous local control is local monitoring of multiple parameters combined with intelligent control adjustments, automatically made without manual interaction, analysis or human input. This is a natural progression as technology transforms oil and gas production into a digital oilfield.

For Producers, two of the highest costs of operations are manpower and the chemical. Traditionally, chemical pumps are not reliable or accurate. As a result, over injection of chemical becomes a safer and less expensive option than dealing with well problems, created by insufficient chemical. Generally, 20-30% unnecessary chemical is used. In addition, a vast majority of the chemical pumps on the market are manually adjusted making automation difficult at best.

Sirius Controls Inc., has developed Smart technology that addresses both the over injection and manpower costs by using autonomous local control (Figure 1).

Figure 1- Intelligent Controller with Patented Chemical Pump

There are several ways autonomous local control reduces a producer's costs through manpower reduction and chemical optimization. How will automating a chemical pump's response to changing process conditions, environmental conditions, and automating the operator's (pumper's) tasks, benefits the Producer?

AUTONOMOUS LOCAL CONTROL ADJUSTMENTS FOR CHANGING ENVIRONMENTAL CONDITIONS

Chemical pumps, operating on solar power, have problems related to accuracy and consistency due to voltage variations. Most of the time, the discrepancy between the recorded rate of injection and the amount of fluid injected over a longer period of time are misunderstood or unexplained. However, the principles behind these errors are quite simple.

All brushed DC motors have a linear relationship between voltage and RPM, meaning as voltage decreases or increases so does the RPM of the motor. The vast majority of solar chemical pumps in the oil and gas industry use a DC motor coupled to a positive displacement chemical injection pump. This means that changes in battery voltage have a direct effect on injection rate. (Figure 2)

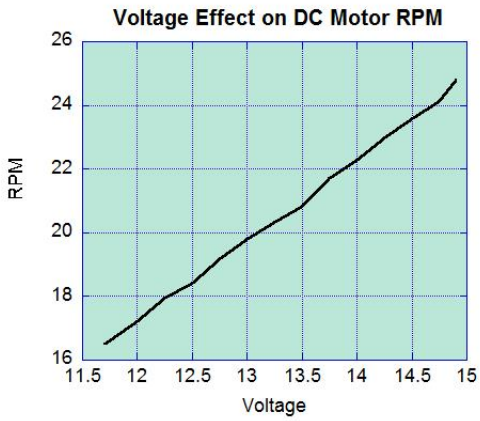

Figure 2 – Voltage Effect on DC Motor RPM

There are several reasons that can cause the voltage supply to the DC motor to fluctuate. The main causes are listed below:

- Solar panels are used to charge the batteries during the daylight. At night or during days of cloud cover, the batteries discharge. Lead acid batteries in their fully charged state are about 13.8 volts and fall to 12.0 volts in a nearly depleted state, which is about a 13% difference. A properly designed solar system will fluctuate 1.0 to 1.3 volts from day to night; approximately 7.5 to 10% change in voltage. The variations in the voltage of a solar pump due to 1) day/night variation and 2) trend change over a week are shown in Figure 3.

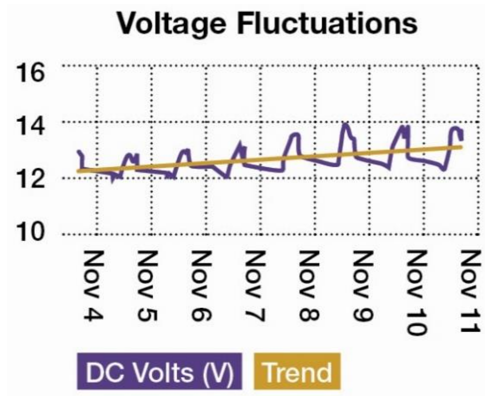

Figure 3- Voltage fluctuations

- Ambient temperature changes alter the charge levels of standard solar charge regulators. From 68ºF (20ºC) to -22ºF (-30ºC) the voltage charge levels are adjusted by approximately 1.5 volts, or about 10%.

- Battery voltage also fluctuates with ambient temperature. Typical lead acid batteries will change their voltage approximately 3 volts when temperatures fluctuate from -40ºF (-40ºC) to 104ºF (40ºC). Variations in day to night of 18ºF (10ºC) can result in swings of 3% in the battery's voltage. (Figure 4)

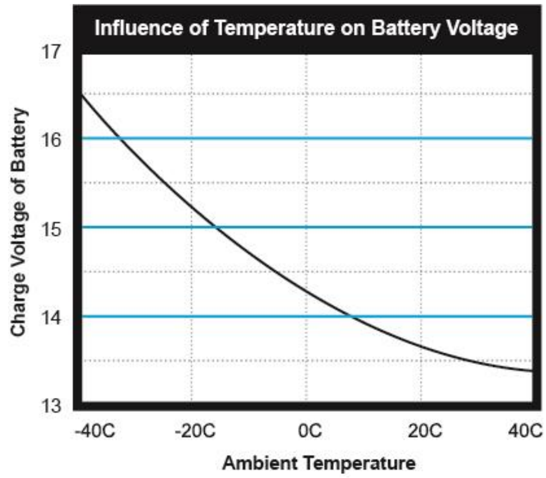

Figure 4- Influence of Temperature on Battery Voltage

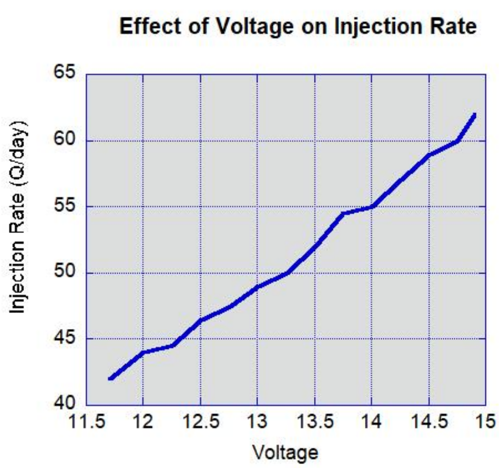

Figure 5 - Effect of Voltage on Injection rate

The fluctuations in voltage described above will result in similar changes in injection rate. Depending on the system's design, geographic location, climate, and the battery's state when the system was calibrated, the rates can easily vary 10 to 25% or more, due entirely to changes in voltage. Figure 5 shows the response of a pumps injection rate as the voltage is changed along the normal voltage cycle of a battery.

The variability in injection rate explains why many operators experience different rates when they calibrate in the morning or in afternoon.

Calibrating a system on a voltage peak will result in under injecting. Conversely, calibrating a system when the voltage is low results in over-injecting when the sun is shining or the batteries are fully charged.

Autonomous local control can mitigate the effects of voltage fluctuations and stabilize the chemical injection rate. (Figure 6). The injection rate was set to 52 Q/day (horizontal black line). The blue line indicates the response of a commonly used pump operating over the range. As shown the injection rate varies directly with voltage. The red line shows the response of the same pump using an Intelligent controller with the patented "voltage compensation" feature enabled. The battery voltage is recorded during the pump calibration process and used to automatically compensate and adjust the injection rate as voltage naturally fluctuates. The error without voltage compensation can exceed 30% over the range a battery operates from full charge to depletion.

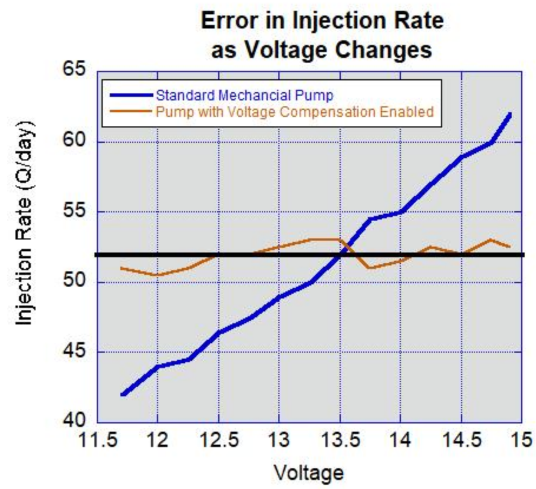

Figure 6- Error in Injection rate

Another example of the benefits of autonomous local control is the use of a table within an intelligent controller to adjust methanol rates based on ambient temperature. It is common to turn pumps on and off based on a single temperature; however, this more complex method allows the producer to optimize injection rates over a series of temperature zones. This significantly reduces the amount of methanol consumed. Traditionally, using an on/off signal the methanol would be injected constantly at the same rate after temperature dropped below 55-60°F (blue line). Using autonomous local control, the methanol is controlled at different rates based on the temperature at the time, significantly reducing chemical injected. Temperature swings over a two-week period at a location in Montana are used to illustrate in Figure 7.

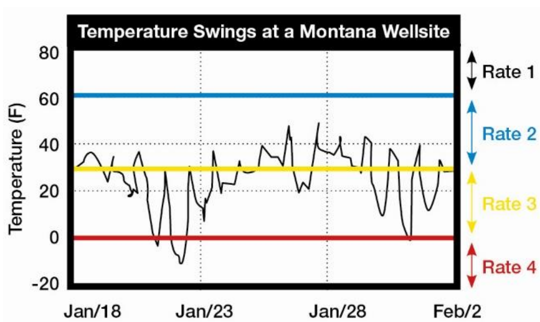

Figure 7- Temperature Swings

AUTONOMOUS LOCAL CONTROL ADJUSTMENTS FOR CHANGING PROCESS CONDITIONS

All pumps exhibit sensitivity in their output due to injection pressure. This is commonly known as the pump curve. The curve represents the rate response of the pump due to changes in process pressure. Many factors contribute to this including DC motor loading causing a drop in RPM, compression of elastomers and piston seals, fluid compressibility, and others. Traditionally, chemical injection pumps are calibrated at a given pressure. When the process pressure changes the output of the pump will vary as you slide up or down the pump curve. These errors, can be very significant and can easily exceed 50% or more of the set injection rate. (Figure 8)

Using patented motor technology and unique pressure sensing software, changes in process pressure can be detected. The detected pressure changes can be used to correct the pumps output and essentially flatten the pump curve. The red line in Figure 8 shows how the error in injection rates due to changes in pressure are eliminated.

Figure 8

AUTONOMOUS LOCAL CONTROL USED TO REDUCED OPERATOR TIME ON LOCATION

All operators (pumpers) have been frustrated calibrating, and making rates changes to traditional manually adjusted mechanical chemical pumps. To adjust rates, they use a series of charts, tables, and calculations to select the optimum pump, piston, stroke length, and on/off duty cycle. This can take an experienced operator 5 to 30 minutes depending on how many calibrations are necessary. Over the course of a year, the man hours spent making these adjustments, result in thousands of wasted dollars for every Operator (Pumper).

The utilization of an Intelligent Controller makes the calibration process extremely simple and only necessary on the initial set up of the pump. During the calibration process, the operator (pumper) is prompted for the drawdown. At this point, the Intelligent Controller has all the information needed to control the pump directly in Quarts per day, or other units of flow. The flow rate is now entered and displayed in Q/day, rather than an arbitrary number or a unit of time or cycle rate. Further rate adjustments can be performed with two buttons, which instantly change the injection rate of the pump by accurately adjusting the speed of patented brushless motor technology, resulting in precision RPM variation providing continuous injection into your process for the most effective chemical treatment. At extremely low injection rates the controller uses patented software to automatically change from continuous to intermittent flow resulting in a seamless change for the operator. No tables, no charts, no calculations or manual/mechanical adjustments are required.

A comparison of time required to make a rate change, using both an Intelligent controller (Fusion) and a traditional manual, mechanically adjusted pump is illustrated in Figure 9.

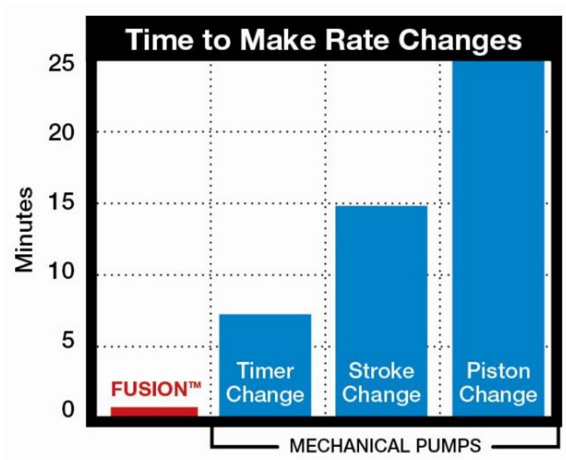

Figure 9

FIELD APPLICATION

A midstream company in the Permian Basin, Texas was having high pipeline corrosion problems. Traditional mechanically controlled chemical injection pumps were used to inject corrosion inhibitor. Corrosion coupons were used to determine metal losses, which exceeded 1.8 mills per year. These traditional pumps were controlled with a timer that turned the pumps on and off providing chemical to treat the process fluid. Atomizers were used to help disperse the chemical to improve the effectiveness of the chemical. Due to the intermittent nature of the pump and timer, a pulsation dampener was required to reduce slugging through the atomizer nozzle. This intermittent injection via traditional mechanical pumps caused pockets of untreated fluid through the pipeline. In an unsuccessful attempt to decrease metal losses in the pipeline chemical injection rates had to be increased.

In order to optimize and improve pipeline corrosion loss, Sirius solar powered pumps were installed replacing the traditional solar powered mechanical pumps. The nozzles on the atomizers were resized to reflect the continuous injection rather than intermittent pumping. The pulsation dampeners were removed from the process because the continuous flow eliminated the sluggish pump behavior. Voltage compensation ensured that during night time and periods of low battery power the chemical injection rate remained constant. In some applications a flow meter was used to provide local feedback to the Sirius controller ensuring accuracy of fluid injected.

Autonomous local control along with continuous injection, and effective atomizers resulted in complete pipeline fluid treatment, eliminating untreated pockets and reducing the amount of chemical used. The pipeline corrosion rate was reduced from greater than 1.8 mills per year to less than 0.3 mills per year. Chemical usage was reduced and downstream problems were mitigated.

CONCLUSION

Upstream Oil and Gas production companies are adopting these new digital technologies to optimize production, reduce manpower, adopt predictive maintenance, and reduce chemical consumption. Putting smart controllers at the wellsite is a step forward in creating the Digital Oilfield as producers look to increase profitability.