AUTONOMOUS CHEMICAL OPTIMIZATION AND REMOTE MONITORING: A CASE STUDY

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INTRODUCTION

With the development of new digital technology over the last several years, our industry has seen many benefits of remote monitoring and automation in sectors within drilling, completion, and production. High resolution data has been made available to multiple functions within an operating company. The data enables event detection, actionable workflows and understanding the health of equipment on surface and below. One area that has lagged is remote monitoring and automation of production chemicals applications. There has not been much progress in leveraging production chemical data and automating algorithms to control chemical pumps that can integrate with existing artificial lift optimization software. Much of the data is recorded manually and intermittently only to be stored in a database managed by the chemical vendor. In some cases, the data remains on a written piece of paper. Then reports are created and shared with the operator, but at the cost of valuable time that could be used to adjust chemical dosing based on a well's performance. There are chemical service companies emerging in the market that offer a digital solution, but it requires the use of another software to leverage all of the capabilities. Yet, operators are moving to a single solution where all of the data, control, and analysis are contained in one system.

If we were to look at this situation through a different lens, production chemicals are almost always a large portion of any operator's lease operating expenses (LOE), and chemical related problems are many times causal factors of well failures. We know how important proper and consistent application of our chemical programs is but how many times has a field operator came across an empty chemical tank, closed valve or tripped GFCI plug on chemical pump?

This paper will review initial pilot testing of automated chemical pumps on a group of newly completed wells south of Midland, TX. A six-well pad consisting of two manually operated chemical injection pumps and four automated chemicals pumps with controllers from two different manufacturers. The four chemical controllers were connected to host software already being leveraged for artificial lift optimization, and an algorithm was built to control chemical dosing based on the daily production volumes from each well. We will walk through the objectives for this project, how the equipment and software were configured, and the results we found after six months of data collected.

OBJECTIVES

With this being the first project of its kind in the company in its business unit, there were many potential learning opportunities. To contain the scope of the project and deliver results there needed to be a clear understanding of whether or not the project would be successful. The initial objectives of this pilot test were to 1) seek to identify potential chemical cost savings during the early life of the well by autonomously linking chemical injection rates to production volumes; 2) confirm that chemicals are being consistently applied at the prescribed dosages; 3) set up notifications alerting personnel of potential problems, such as low tank volume or insufficient pump rate; 4) be able to use the historical chemical tank level data to assist in approval of chemical delivery invoices; 5) determine if operational efficiency of chemical vendor can be improved by needing to check tank volumes and pump rates less frequently; 6) help identify other applications in which this technology could be beneficial such as saltwater disposal chemicals or methanol injection for compressors.

PROCEDURE

Hardware

For this initial project we wanted to implement the chemical controllers as a "bolt-on" style addition to the standard chemical tanks and chemical pumps that we were already utilizing. We installed the automated controllers on to the existing chemical pumps for these wells and powered the controllers from the existing solar panels that were powering the chemical pumps. We then set a pole at each site and mounted custom communication boxes on each. Inside the communication box we installed a breaker, a power supply, a POE (power over ethernet) device, an ethernet switch and an ethernet radio. A visual representation of the hardware setup in the field is shown in Figure 1 below.

Software
The chemical pump controllers were added to the software by loading the register map in the host software database. The chemical controllers were then associated to the particular wells where chemicals were injected, creating a parent-child relationship. A new database table was created to carry out the necessary tasks involved in the automation of the chemical controller as shown in Figure 2. The target parts per million (PPM) of chemical concentration was information gathered by the chemical vendor based on the chemical type and application. A maximum change allowed handler was created to not exceed more than a 10% change in the chemical injection rate in the case of erroneous production data. The type of production fluid was defined based on the requirements of the chemical selected for the application. The options defined for use were a 0 for total liquid volume, 1 for water only, or 2 for oil only. After all the data was entered into the database table, a prescribed dosage target of chemical in quarts per day (QPD) was calculated daily by the software based on new well test information. The volume in QPD was then sent as a write commend via Modbus protocol to the chemical injection controller. The controller regulated the pump speed to deliver the chemical downhole based on the time of day the dosage target was received.

History graphs were also built in the software to trend the time series data recorded by the chemical controllers on site. The data was retrieved from the controllers on a defined polling interval and stored in the software database. We will explain in more detail what we discovered in these history graphs later in the paper but having the data available enabled us to understand what was previously out of reach. Having the software analyze the data to discover insights and take action was only part of the equation. There needed to be a way to catch any behavior from the data that was not meeting our expectations. We decided to utilize an internal alarm system within the software to send automated email notifications to the well optimization analysts and the chemical vendor representatives to alert on low tank volumes or low voltage issues. Figure 3 shows two examples of the alarm notifications sent via email. Without the use of history graphs to trend the data over time, these alarms and notifications would not have been possible.

Testing
To understand and record what the algorithm was doing within the software, a data log was created and saved to the server where the software application lives and runs. This log recorded all the information necessary to make sure the algorithm was performing as expected. An example of the log is shown in Figure 4. The most recent production rate was pulled from the database, the previous injection rate and the calculated new injection rate if required, if the 10% max clamp was used, writing the command, and the well status. The key piece of information about the status is that the software scans the artificial lift controller for a well status, and if the well status returned as not running, the chemical pump would be turned off. This was a crucial step to make sure there was no chemical needlessly pumped and to reduce the risk of a possible spill on location. Likewise, if the well status returned as running, the chemical pump would stay on and continue trying to meet the QPD target.

RESULTS AND CONCLUSIONS

We quickly discovered that our existing solar powered chemical pump setups were unable to supply adequate power throughout the night on the gas-lift wells due the high casing pressure that the chemical pumps had to overcome. We found this to be a substantial discovery as it would have been hard to detect this problem without remote surveillance as the pumps were functioning properly during the day when checked by the chemical representative, but during night hours the pumps would stop working. This discovery is evident in Figure 5. We had to upgrade our solar power system on the gas lift wells by installing larger solar panels and an extra battery to provide enough power to consistently achieve target chemical injection volumes as shown in Figure 6. We then set up low voltage alarms so that we are immediately notified if there is insufficient power supply, or the system has been turned off inadvertently. The low voltage alarms and low tank volume alarms have proven to be immensely beneficial by providing

instantaneous notifications of problems related to chemical system rather than relying on a human to discover the issues days or weeks later. Also, by remotely monitoring tank levels and alarming on low tank levels we ensure that chemical deliveries are made on time.
Another benefit from monitoring and trending tank levels is the ability to use the historical data to assist in confirming chemical invoices.

Lastly, after comparing invoices before and during the trial, we found there was no net difference in chemical spend. As evident in Figure 7, the automated chemical dosing closely matched the production of decline in an example well from the trial. Typically, what we see when chemical pumps are manually controlled, there is the traditional "stairstep" trendline where at times the chemical rate was set too high based on production and other times the chemical rate is too low. This creates a reactive scenario where the chemical rate is always "chasing" the production. When you consider over/under chemical rate and average that over a period of time, it closely matches the average amount of chemical used on an automated system. This results in chemical costs being very similar, but with the automated system the wells have the benefit of receiving the required amount of chemical at the correct time based on production volumes.

OTHER APPLICATIONS

Based on the foundational work completed from this case study, we believe there are other applications where chemical automation may be beneficial. During the winter months in west Texas where we experience drastic changes in temperature very frequently, freezing of gas lines and compressor components becomes a serious problem due to compressor downtime and the subsequent losses in production. To aid in the winterization of surface equipment, one project recently started is focusing on remote monitoring and optimization of methanol injection for gas lift compressors. Methanol lowers the freezing point of the gas in the gas lift compressor lines, but like the case study above, ensuring that we are injecting the right amount of methanol at the right time is crucial. Development is currently underway to target optimal methanol injection rates based on the measured ambient temperature on location. Alarms will also be created to notify on low methanol injection rates, low voltage supply, and low methanol tank volumes.

NOVEL

Chemical programs have historically been controlled manually by a chemical vendor technician or operator on location in a reactive manner. Chemical tanks running dry, the loss of power, and lack of accountability can all be mitigated and resolved by automating chemical injection and enabling remote control.

ACKNOWLEDGMENTS

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Figure 1 – Images of the chemical tanks, solar panels, chemcial pumps, and controllers used at one of the producing wells in the pilot project.

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NodeID	Id	InjectionPPMTarget	ChangeAllowedPct	ProductionFluidBasis
[redacted] ChampX Chem Pump	1	100	10	0
[redacted] ChampX Chem Pump	2	100	10	0

Figure 2 – An example of the sctrucutre of the data in the software used to automate the chemical injection controller.

Low Tank Level

Low Voltage

Figure 3 – Examples of email notifications based on data retreived from the chemical injection controllers.

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Friday, October 15, 2021 6:00:06 AM ---> Working on ChampX Chem Pump
Friday, October 15, 2021 6:00:06 AM --->    Production Rate: 753
Friday, October 15, 2021 6:00:06 AM --->    Old Injection Rate: 11.4
Friday, October 15, 2021 6:00:06 AM --->    New Injection Rate: 12.7
Friday, October 15, 2021 6:00:06 AM --->    Change too big, clamped to: 12.54
Friday, October 15, 2021 6:00:06 AM --->    Writing Injection Rate: 12.54
Friday, October 15, 2021 6:00:20 AM --->    Write Result:OK
Friday, October 15, 2021 6:00:20 AM --->    Well Status:Running Pump Status:Running, Auto
Sunday, October 17, 2021 6:00:07 AM ---> Working on ChampX Chem Pump
Sunday, October 17, 2021 6:00:07 AM --->    Production Rate: 519
Sunday, October 17, 2021 6:00:07 AM --->    Old Injection Rate: 8.7
Sunday, October 17, 2021 6:00:07 AM --->    New Injection Rate: 8.7
Sunday, October 17, 2021 6:00:07 AM --->    No rate changes needed
Sunday, October 17, 2021 6:00:07 AM --->    Well Status:Running Pump Status:Running, Auto
Sunday, October 17, 2021 6:00:07 AM --->    No status changes needed
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Figure 4 – Excerpt from the data log created in the software to store information required to understand what the algorithm is recording the steps it is taking to automate the chemical injection controller.

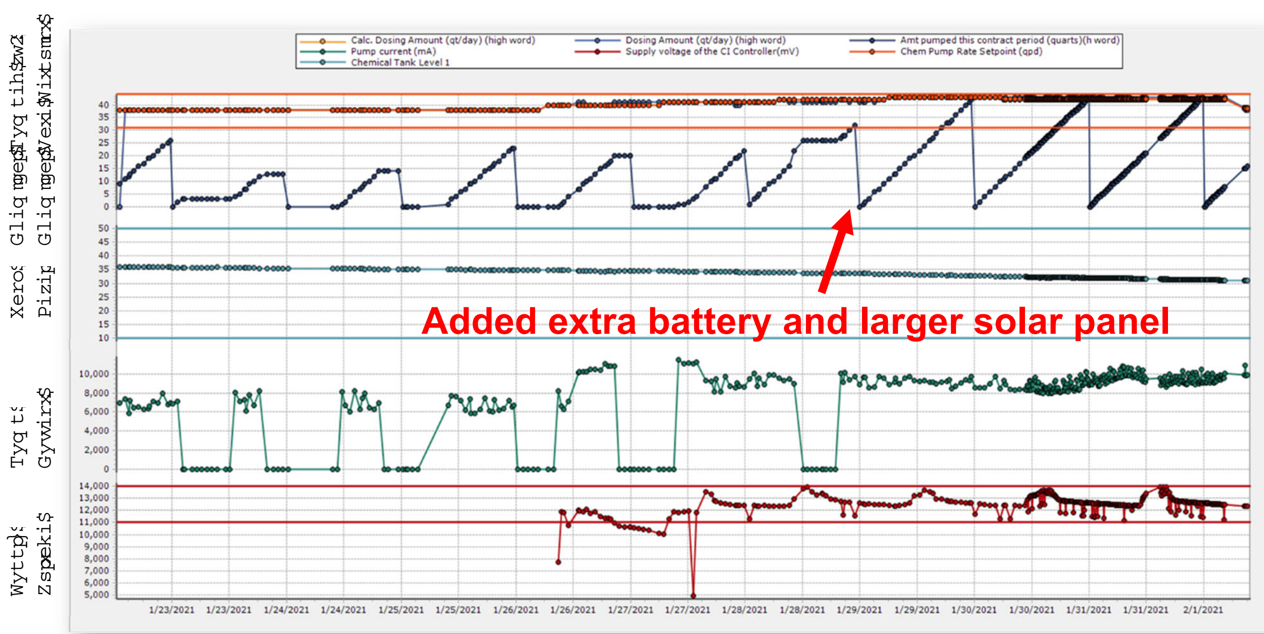

Figure 5 – Trended data from the discovery of the batteries not supplying enough voltage to the chemical pumps to ineject chemical during the night.

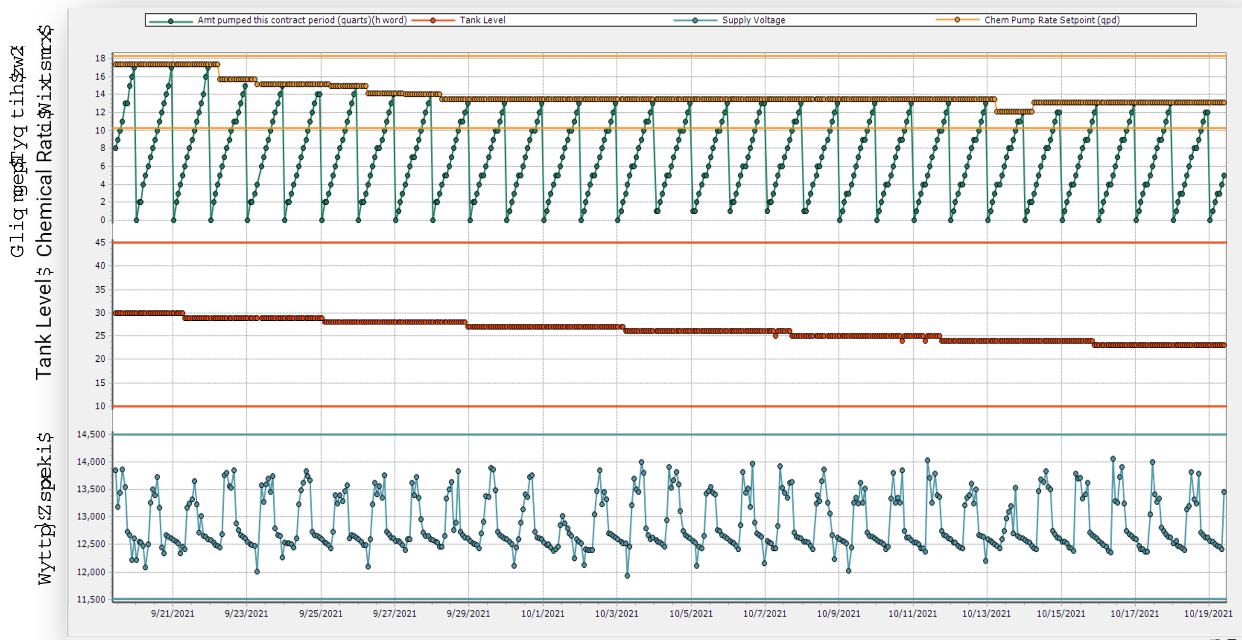

Figure 6 – Trended data of the chemical injection controller recording the amount of chemical pumped per day, the associated chemical pump setpoint, the chemical tank level, and the supply voltage.

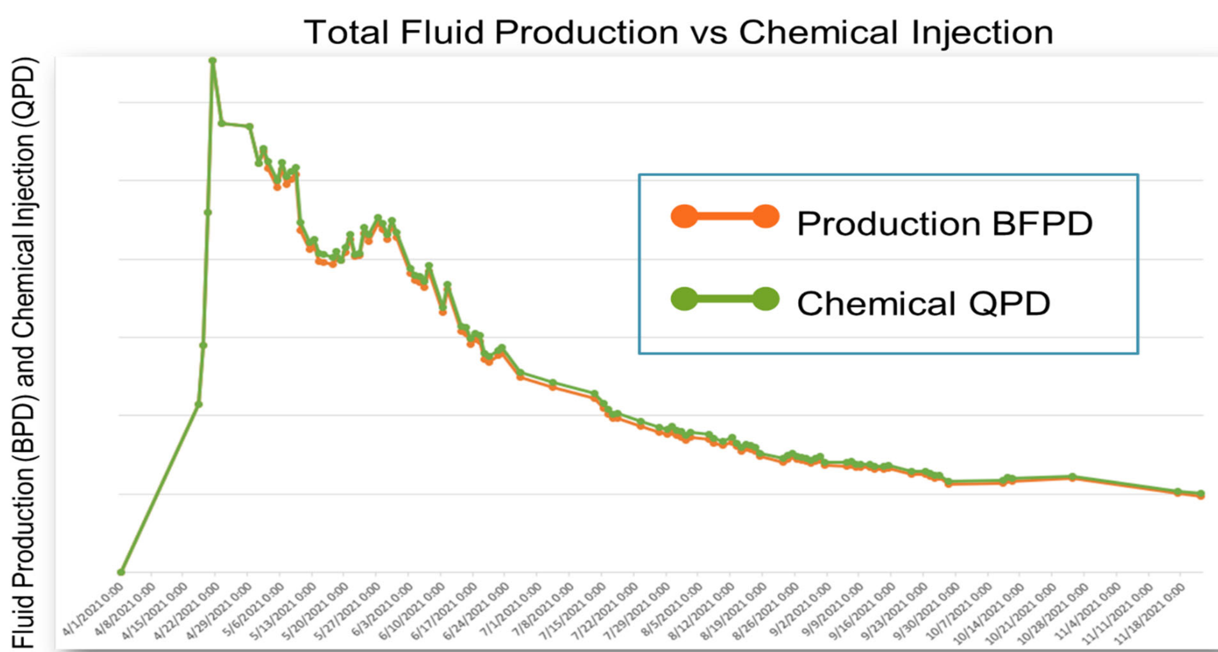

Figure 7 – Trended data to signify the rapid decline in production during the early life of a well used in this project and the associated chemical injection.