AUTONOMOUS VSD SETPOINT OPTIMIZATION FOR SUCKER ROD ARTIFICIALLY LIFTED OIL AND GAS WELLS

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ABSTRACT

Automation has been used for many years now as a means for oil and gas operators to optimize sucker rod pump wells. Traditional automation for rod pump wells involved operating the well at a fixed speed and idling the well based on a preprogramed time (time clocks) or fillage (pump off control). However, utilizing a Variable Frequency Drive (VFD)is a more sophisticated method to allow operators to increase their runtime by detecting when there is less fluid to produce and slowing the unit down, accordingly. Although utilizing a VFD can provide significant improvements in production and failure reduction, in some cases operators are not able to realize the full advantage of their rod pump wells with VFDs because the VFD setpoints are not optimized. Optimizing VFD setpoints is not necessarily challenging, but in many cases requires many iterations of user intervention which takes time, and with the ever-changing nature of some reservoirs, that job may never be complete for a given well. However, utilizing a host software with algorithms developed by industry experts, VFD setpoint optimization can be done autonomously. Using domain-specific algorithms, the host software can detect deficiencies in VFD operations and iterate through setpoint changes to determine the optimal setpoints. Utilizing host software, the algorithms can constantly check to make sure that the setpoints are keeping the well running optimally, even when reservoir conditions change. By identifying issues like excessive cycling, lost production, unnecessary speed changes, and poor pump fillage, the algorithms implement changes that improve the performance of the well and help operators leverage the full capabilities of their VFD.

INTRODUCTION

A Variable Frequency Drive (VFD) is a sophisticated method for operators to increase their production runtime by detecting when there is less fluid to produce and slowing down the unit accordingly. While optimizing VFD setpoints is not necessarily challenging, it often requires several iterations of user intervention, which can become a long and cumbersome, manual process. Additionally, with the ever-changing nature of some reservoirs, this task may never be complete for a given well.

To address these challenges, algorithms have been developed to help optimize VFD setpoints more efficiently. By identifying issues such as excessive cycling, lost production, unnecessary speed changes, and poor pump fillage, these algorithms can implement changes that improve the performance of the well and help operators leverage the full capabilities of their VFD.

One key advantage of using algorithms to optimize VFD setpoints is the speed at which changes can be made. Rather than relying on manual intervention, algorithms can quickly and automatically adjust VFD setpoints based on real-time data. This not only saves time but also ensures that the well is operating at optimal performance levels.

Another advantage of using algorithms is their ability to identify and address issues that may not be immediately apparent to operators. For example, excessive cycling may not be noticeable to an operator, but an algorithm can detect this issue and implement changes to reduce cycling and improve overall performance.

Additionally, algorithms can help operators to better understand the performance of their VFD by providing detailed performance data and visualizations. This can help operators to identify trends, patterns, and potential issues, which can then be addressed proactively.

While algorithms can be highly effective in optimizing VFD setpoints, it is important to note that they are not a replacement for skilled operators. Rather, algorithms should be seen as a tool that operators can use to enhance their abilities and optimize their VFDs more efficiently, which is especially beneficial as engineers are tasked to look after more wells than they did before.

STATEMENT OF THEORY AND DEFINITIONS

Optimizing a VFD for a sucker rod pump artificially lifted well can provide numerous benefits, including improved efficiency, increased production, and extended equipment lifespan. In this article, we will discuss these benefits in greater detail.

Firstly, optimizing a VFD can improve the efficiency of a sucker rod pump artificially lifted well. The VFD controls the speed of the pump motor, and by adjusting the VFD setpoints to match the well's unique downhole conditions, the operator can reduce the energy consumption of the system. This can lead to significant energy savings over time, which translates into lower operating costs and increased profitability for the well.

Secondly, optimizing a VFD can increase production. By adjusting the VFD setpoints, operators can match the pump speed to the well's current production conditions. For example, if the well is producing less fluid, the VFD can slow the pump down to prevent excessive fluid buildup, which can damage the pump or cause it to shut down. Conversely, if the well is producing more fluid, the VFD can speed the pump up to increase production. By optimizing the VFD, operators can maintain the ideal pump speed for the well conditions, which can lead to increased production over time.

Thirdly, optimizing a VFD can extend the lifespan of the equipment. By controlling the pump speed more precisely, the VFD can reduce the wear and tear on the pump and motor. This can lead to longer equipment life and reduced maintenance costs over time. Additionally, by preventing excessive fluid buildup or pump shut downs, the VFD can reduce the risk of equipment damage, which can further extend the lifespan of the equipment.

Fourthly, optimizing a VFD can improve well stability. By adjusting the VFD setpoints to match the well conditions, operators can prevent excessive cycling of the pump. Cycling occurs when the pump starts and stops frequently, which can cause stress on the equipment and reduce its lifespan. By reducing cycling, operators can improve the stability of the well and reduce the risk of equipment failure.

Finally, optimizing a VFD can improve operator safety. By preventing excessive cycling or pump shutdowns, the VFD can reduce the risk of accidents or injuries. Additionally, by providing real-time data and performance insights, the VFD can help operators identify potential issues before they become safety hazards.

All these stated benefits can lead to significant cost savings over time, as well as increased profitability for the well. Additionally, by providing real-time data and performance insights, the VFD can help operators identify potential issues proactively, which can further enhance safety and efficiency. Overall, optimizing a VFD for a sucker rod pump artificially lifted well is a worthwhile investment that can provide significant benefits over the long term.

Leveraging autonomous algorithms to optimize a VFD can not only ensure the previously mentioned goals are met but do so with minimal engagement from the end user. Additionally, the host software users can be confident that their wells have reliable algorithms applying objective logic to make sure their VFDs are being fully utilized.

Another criterion of success was that these algorithms were applied in a way that is agnostic to the field equipment. By allowing the users to leverage their existing controller and VFD without requiring purchasing edge devices from us or our own controller, the barrier to entry to using these algorithms was reduced and testing and piloting the autonomous control algorithms was simpler as was iterating on ways to improve the algorithms.

DESCRIPTON AND APPLICATION OF EQUIPMENT AND PROCESSES

We identified variety of wells across multiple US basins to enroll and pilot the autonomous VFD setpoint optimization. The wells were monitored while they made changes and observations were made on key metrics such as, runtime, fillage, speed, and production.

Initially, multiple rounds of VFD optimization algorithms were necessary before the wells saw any benefits from the self-governing VFD setpoint optimization. Nevertheless, it was discovered that a host software solution could optimize wells with undersized designs, poor fillage, and poor runtime. Wells that experienced poor runtime due to improper fillage and speed setpoints saw an increase in their runtime. Additionally, wells with VFDs that had poor fillage were considerably optimized, resulting in an increase in fillage and a decrease in speed cycles on the VFD equipment. This also made the VFD speed more uniform. In these instances, the well was optimized by utilizing the existing field equipment and a host software algorithm. Undersized designs were identified and were pushed to run faster as long as the equipment was capable. The optimization of VFD setpoints in wells resulted in improvements in production, pump fillage, and runtime.

PRESENTATION OF DATA AND RESULTS

The algorithms were deployed on over 150 wells for the initial pilot. Through this sample set, three use cases stood out as the results were collected. Most wells followed a pattern that they were either running optimally or they needed to improve the fillage, increase the capacity, or optimize the runtime. Some case studies exemplifying this will be discussed below. The end goal of these algorithms is to increase production, reduce failures, and reduce electricity cost where relevant to make sure that the VFD is being utilized to produce the wells in the most efficient, safe, and reliable way.

Case Study 1:

A well with a VFD was running on average 14 hours per day. This was due to suboptimal VFD setpoints, specifically the maximum working speed. Initially the well was running at a max speed of 5.2 SPM and cycling up to twenty times per day and the pump fillage was averaging around 60%. The optimization gradually changed the max working speed down to 3.1 SPM which resulted in the well running 24 hours per day. The average fillage increased to 90% and the most surprising result is that production increased around 5%, which means this well was losing some production due to the downtime. By implementing the logic, production and fillage increased and the average speed of the unit decreased. These results demonstrate that along with the production increases the system can also optimize the fillage and speed reducing failures and optimize power consumption resulting in energy savings.

Case Study 2:

This case was an example where the max working speed was too low. In this case the well had a worn traveling valve which caused the rod pumping system to run at the max speed 24 hours a day with a full pump and fluid level above the pump. The algorithm recognized this as an opportunity for improvement and utilized the predictive analytics to understand that the well could speed up. Unfortunately while the

VFD was ramping up the speed the pump was pulled and replaced and after the replacement a speed increase was no longer necessary. In this case the autonomous control algorithms were working to increase production on a well that was under producing.

Case Study 3:

The final case study shows a well that was experiencing poor fillage and the speed was cycling up and down from the max to min speed several times per day. The equipment for this well was significantly oversized causing the fillage to decrease drastically from stroke to stroke. The logic attempted to optimize this well by reducing both the speed increase and speed decrease setpoints. This successfully got the speed to normalize. After optimizing the speed increase and decrease setpoints, the speed output varied significantly less and the well was able to run near the max speed more consistently. Although this change did improve the average fillage, because the downhole equipment was significantly oversized the fillage still dropped down to 20-30% on occasion. Overall, the fillage was improved and the operating speed of the well was normalized. Which will help reduce failures and electricity costs.

CONCLUSION

The algorithms developed can optimize the VFDs that are controlling rod pump wells. By utilizing the full capabilities of the VFD, rod pump wells can have a longer run life, increased efficiency, and higher production rates. This has the added benefit of allowing operators to monitor and optimize wells in much greater numbers, leading to improved productivity across multiple sites.

Furthermore, by generating and implementing a solution like this in host software, operators can focus on wells with nuanced problems rather than spending excess time manually adjusting VFD setpoints on a large amount of wells. This allows them to address issues more efficiently, reducing downtime and maintenance costs. With generalized algorithms running in a host software application, operators can more quickly identify trends and patterns in well performance, allowing them to adress potential issues proactively and optimize VFDs accordingly.

This represents the first step in a series of advances towards true autonomous control and advanced automation for the oil and gas industry. By leveraging the latest technology, the industry can improve efficiency, reduce downtime, and improve safety. In addition, the use of algorithms can help to reduce the number of manual interventions required, allowing operators to focus on more complex tasks and increasing overall productivity.

Moreover, the use of VFD optimization algorithms provides significant benefits in terms of operational efficiency. By monitoring and optimizing VFDs across multiple wells, operators can reduce energy consumption and save costs in the long run. This not only benefits the individual well but can also have a positive impact on the wider oil and gas industry by reducing overall energy consumption.

By utilizing the full power of VFDs, rod pump wells can have longer run life, increased efficiency, and higher production rates, and operators can focus on more nuanced problems, reducing downtime and maintenance costs. With the use of host software, algorithms can be more quickly identified and optimized, allowing for greater efficiency, and reducing energy consumption. This represents the first step towards true autonomous control and advanced automation in the oil and gas industry, and as such, is an exciting development for the industry.

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FIGURES

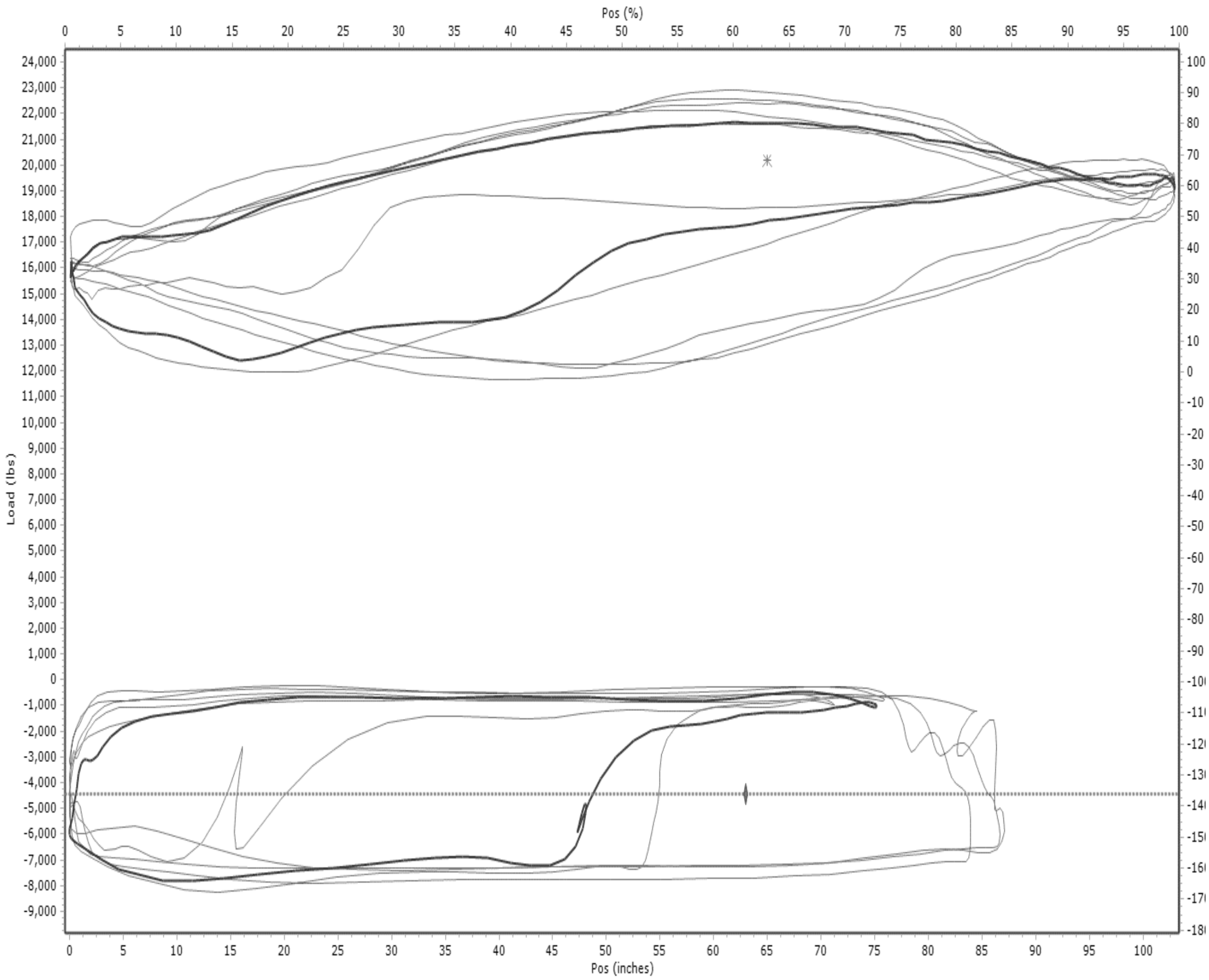
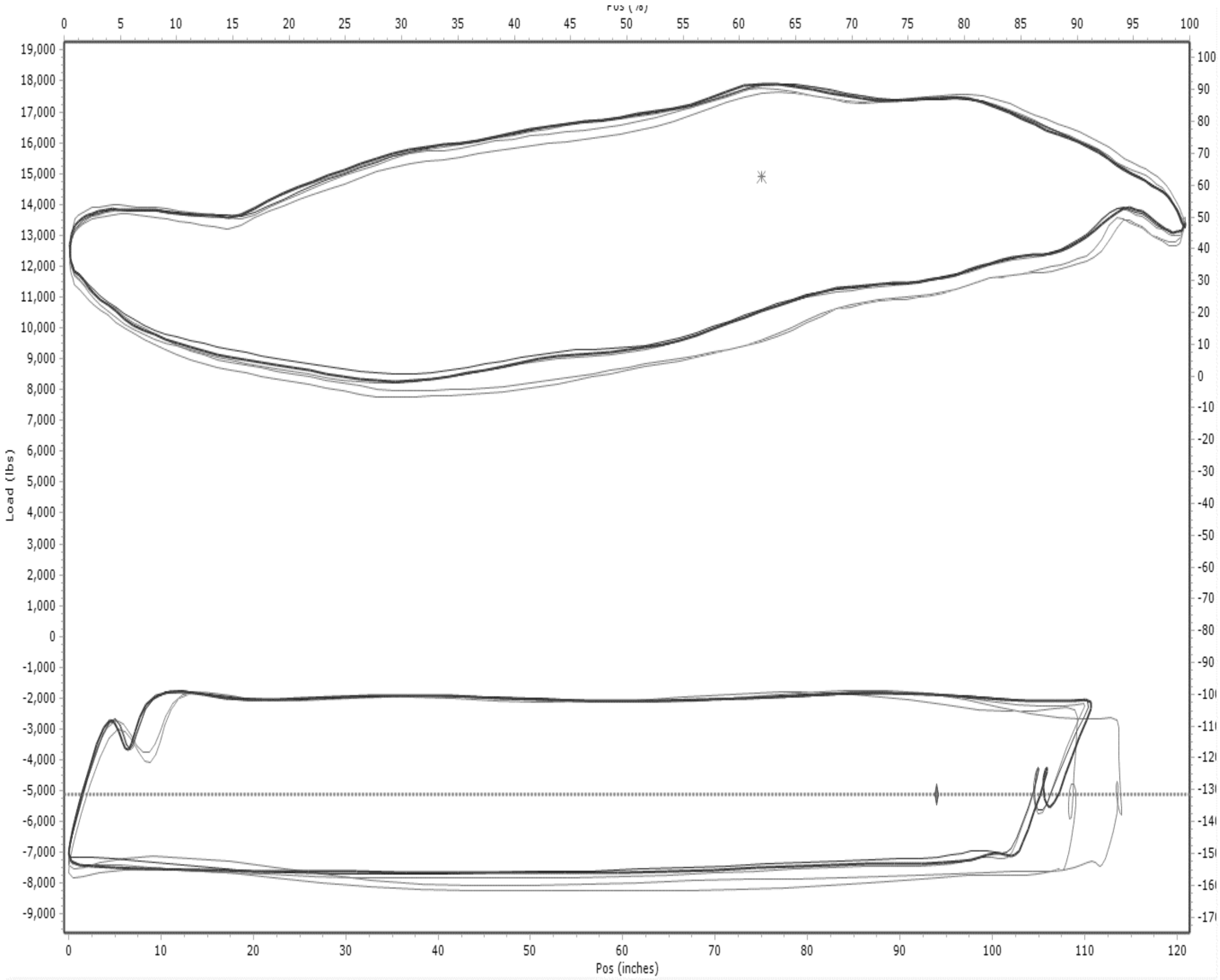


Figure 1



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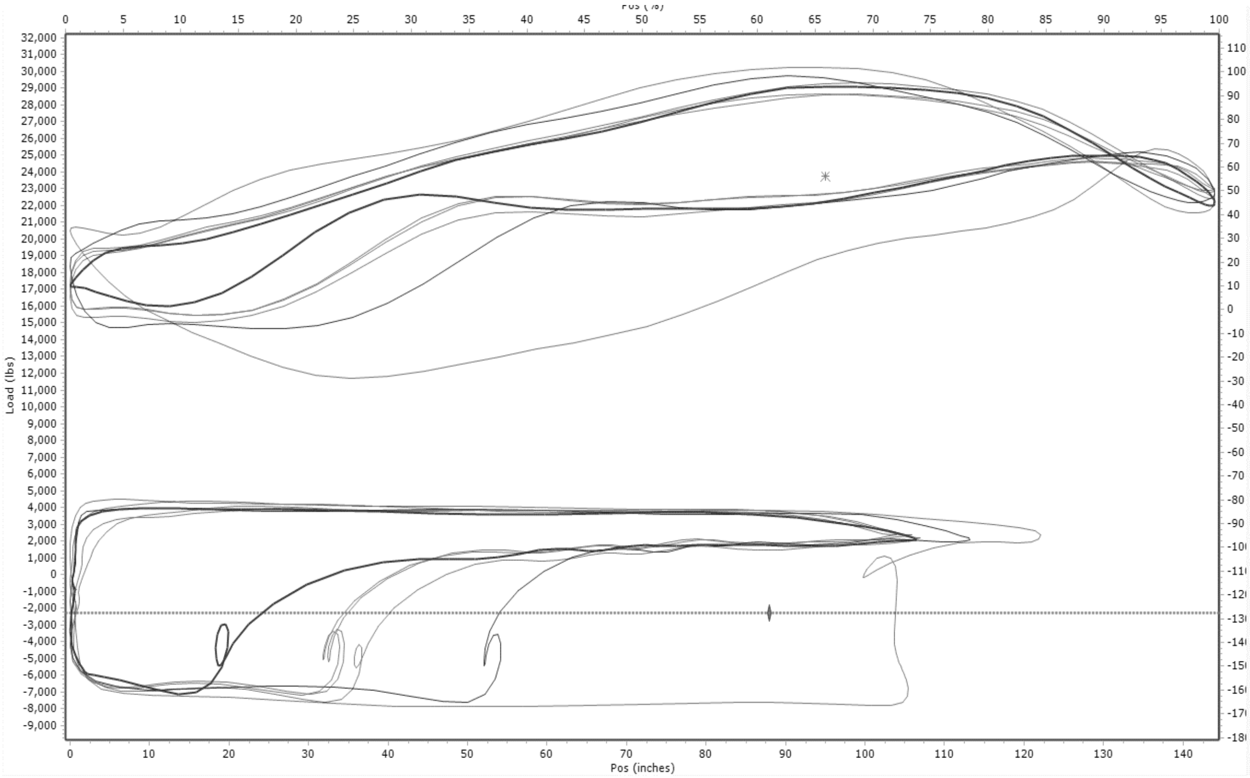

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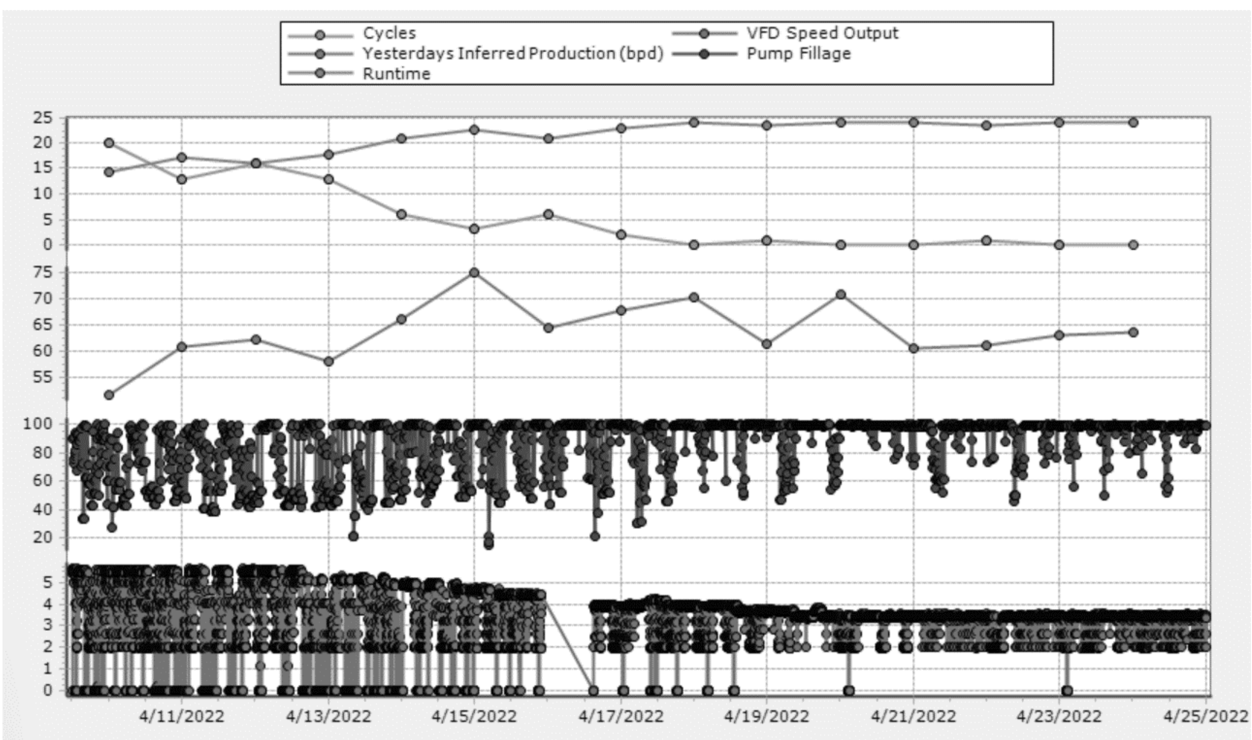

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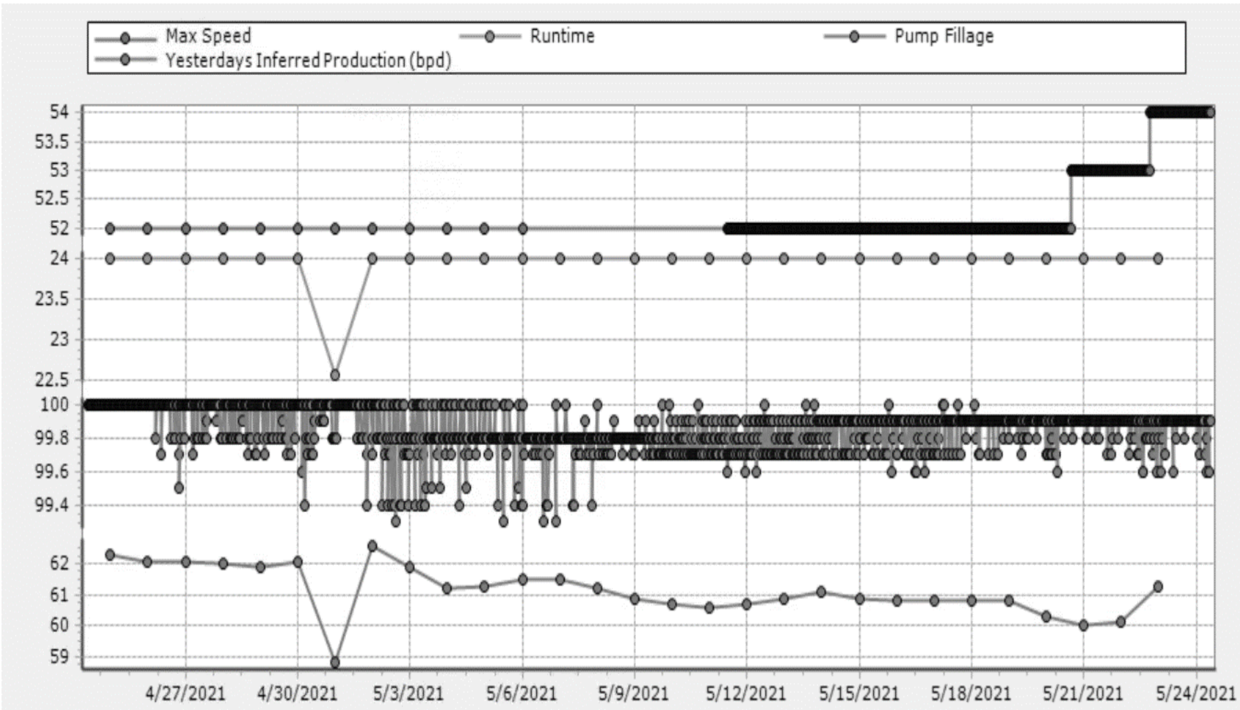

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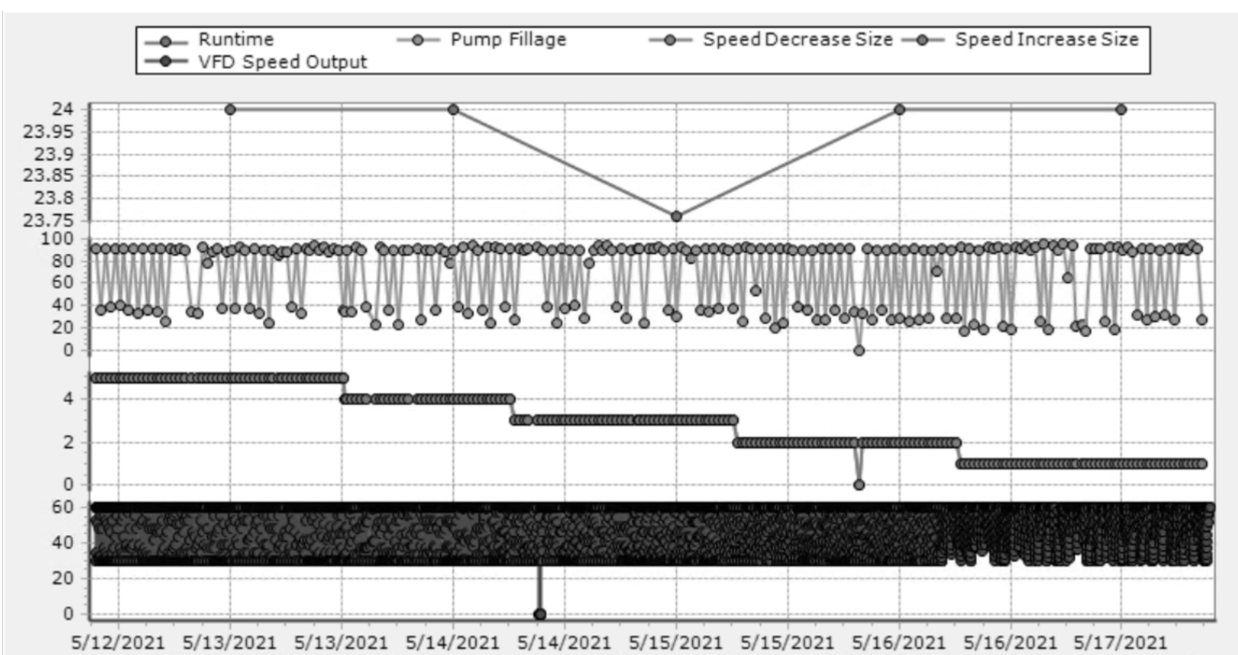

Figure 6

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