ARTIFICIAL INTELLIGENCE AND AUTOMATION FOR SURFACE ROD LIFT PRODUCTION

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OVERVIEW

Rod lift oil production primarily utilizes manually operated pressure controlling equipment at surface with long technological lifecycles compared to surrounding equipment in a producing well. While downhole technology and production units have begun to incorporate modern features such as digital monitoring and actuation, production equipment at the wellhead has not advanced in development.

Upon initial drilling of a well, the wellhead acts as the primary method of pressure control and casing suspension for the well. During production, the wellhead is modified by the installation of a rod lift blowout preventer (BOP), stuffing box, and pumping tee. The wellhead subsequently becomes the primary point of access to the rest of the well where critical performance data may be collected and utilized in real time to optimize asset efficiency throughout the life of the well.

Condition based monitoring may be achieved through a Total Production Real Time (TPRT) monitoring system. Key performance data may be gathered and analyzed in real time. An additional step may be taken by incorporating artificial intelligence and automating actions based on data gathered and compared to pre-defined performance parameters, such as actuating compression set seals to mitigate leaks on producing wells.

US SHALE COMPLETIONS TREND

Efficient oil production begins with the detailed design and execution of drilling and completions processes. In the United States specifically, a drilling rig may output two new wells per month. As of March 11, 2022, there were 663 active drilling rigs in the United States, approximately yielding 1,326 new wells per month which may fluctuate depending on down time and drilling rigs being taken into or out of service (Baker Hughes Rig Count, US Area). Upon finishing the drilling processes, these wells may be completed through hydraulic fracturing (frac). Oil production in the United States has increasingly come from wells that had been hydraulically fractured (EIA, Hydraulic Fracturing). This has exposed a phenomenon of reservoir communication where a well experiencing frac pressure may be linked to a low-pressure producing well, causing the producing well to experience a sharp, temporary increase in pressure. When the increase in pressure exceeds pressure ratings for the production equipment at wellhead, failure occurs.

Increasing frac pressure on communicating reservoirs is causing a market transition to more robust production equipment that is rated for higher working pressures in anticipation of upcoming frac operations on neighboring wells.

PRODUCTION CHALLENGES

As of 2020, there were approximately 936,934 producing wells in the United States alone (EIA, US Oil and Natural Gas Wells). While many are accessible through highly traveled roads, commutes from field offices to actual well sites vary greatly. The remote nature of certain producing wells poses significant challenges in quickly addressing failures on production equipment at the wellhead, specifically product leaks.

In an effort to combat equipment leaks and production emissions due to antiquated production equipment, government agencies have introduced significant production regulations on operating wells. States such as California, Colorado, and North Dakota have already introduced operating regulations around emissions and leaks. Other states such as New Mexico and Wyoming are considering similar regulations. For operators managing a high number of wells, costs associated with assets, equipment, and personnel become burdensome when operating with outdated equipment that does not utilize modern monitoring equipment.

DIGITAL MONITORING BENEFITS

Surface production equipment at the wellhead provides a gateway to critical performance data from a well. Whether it is through a BOP, stuffing box, rod rotator, or pumping tee, an operator may gather data on parameters including pressure, flow rate, rotation, and vibration.

Legacy production products fail to incorporate appropriate monitoring ports or controlled monitoring voids within the products themselves, thus limit operators in advancing production performance in most retrofit scenarios. Modern production equipment includes compatibility with a wide range of data acquisition devices such as linear variable differential transformer (LVDT) sensors, rotary position sensors, pressure transducers, and load cells.

While there are products in the market capable of collecting data, utilizing the data becomes challenging. Through TPRT, performance data from sensors described above may be consolidated in a single web-based application on a per well basis for a comprehensive overview on live production characteristics. Data is collected from individual well sites and transmitted via point-to-point transmission. Considering well sites may be in remote locations with little infrastructure development, data transfer occurs through cellular signal to cloud-based storage resulting in accessibility of the data on any device capable of web access.

PRODUCTION OPTIMIZATION THROUGH ACTUATION

Real time data acquisition is valuable in assessing live performance of a well. However, there exists a major shortcoming on traditional monitoring systems in that they act simply as alert systems incapable of driving an action. When this data alerts an operator of a critical failure, such as a leak, the operator is left with minimal course of action. One method of control is to incorporate a pump off controller. This often results in a complete shutdown of pumping units until personnel can travel to the problem site and correct the issue, leading to downtime and lost production.

TPRT aims to incorporate the corrective action directly into equipment being monitored by including actuators on the equipment. This is a unique approach in the space as current providers offer iron-only products or digital-only products, but not in a seamless unit that is inherently designed for iron and digital coexistence.

Average operating conditions may be defined for a producing well and ultimately input into TPRT as an acceptable operating range. This provides the upper and lower limits for which a product may operate. Upon operating outside of the set parameters, TPRT detects the deviation then drives a subsequent action. For example, if a stuffing box is to operate with approximately 250 PSI to 450 PSI but an attached pressure transducer records declining readings of 150 PSI then 100 PSI, it is assumed that there is now a leak in the compression style packing within the stuffing box. TPRT will then trigger an actuator on the stuffing box. Due to the point-to-point connectivity, an operator may update operating parameters from a remote location in real time and adjust sensitivity of their system to optimize uptime performance.

Bibliography:

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