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Research Article

Application of Industrial Internet of Things (IIoT) in Crude Oil Production Optimization Using Pump Efficiency Control

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The collapse of oil prices in mid-2014 and early 2016 was the biggest in modern history that witnessed more than a 70% drop in the price to around $40 barrel. It prompted companies to think seriously to maintain profitability. Most companies were able to survive partly by simplifying their operations. Price recovery in 2021 is only 70% of its peak value. Companies are focusing on reducing the cost of operations, increasing production simultaneously, and finding new and different strategies to survive. The current scenario is witnessing strong research focusing on the development of process control for oil and gas upstream and downstream to improve the control and preventive maintenance to reduce operating costs and increase production. This paper presents the Industrial Internet of Things (IIoT) practical solution that improves the oil production rate from the well and increases the average pump efficiency (fillage) to 90%. This paper proposes a mechanism for collecting, storing, and analyzing all required parameters to build valuable charts. These charts' data help optimize the values and parameters for controller setpoints to prevent pump gas lock problems. An artificial lift is required to lift the oil from the well. In this paper, the sucker rod pump is driven by a gas engine fed by the well's gas. At the same time, SCADAPack 535E remote terminal unit collects all pump and well parameters such as hydraulic pressure, casing pressure, tubing pressure, and pump speed in stroke per minute (SPM). The remote terminal unit sends the data through a wireless network using a 5 GHz antenna to the main control room. The IIoT platform is designed using a visual basic programming language. Microsoft DDE (Dynamic Data Exchange) and Kepware OPC server were used to work on the received data to monitor, generate charts, and apply the controllers.

1. Introduction

Intelligent oil and gas production depends on understanding all crude oil well and pump parameters. Ensure the uniform increase of liquid production rate from the crude oil well and avoid problems such as gas lock. Field operators currently record these parameters two or three times a day, giving experts a fuzzy picture. Increasing guesswork due to the dynamic behavior of these parameters, which changes minute after minute, this paper introduces an approach to thoroughly understanding the surface and downhole parameters. Using Industrial Internet of Things technology (IIoT) gives users a clear picture. It reduces the guesswork and optimizes different parameters to maximize the production for the long-term in a stable situation. Over 90% of the wells in the United States are currently being artificially lifted. Beam pumping is the most commonly used method, accounting for over 85% of artificial lift installations. The beam pumping system is mechanically very simple. It consists of a surface unit that transmits the upstroke and downstroke motion to a bottom-hole pump through a sucker rod string (Figure 1). While the system is simple, a proper design requires many factors. Over the years, formulas developed to be used in the optimum pumping design. However, a good design still depends on experience as a key.

Energy from the crude oil pumping unit is transmitted to the bottom-hole pump through a sucker rod string. Sucker rod strings operate under cyclic load in erosive and corrosive

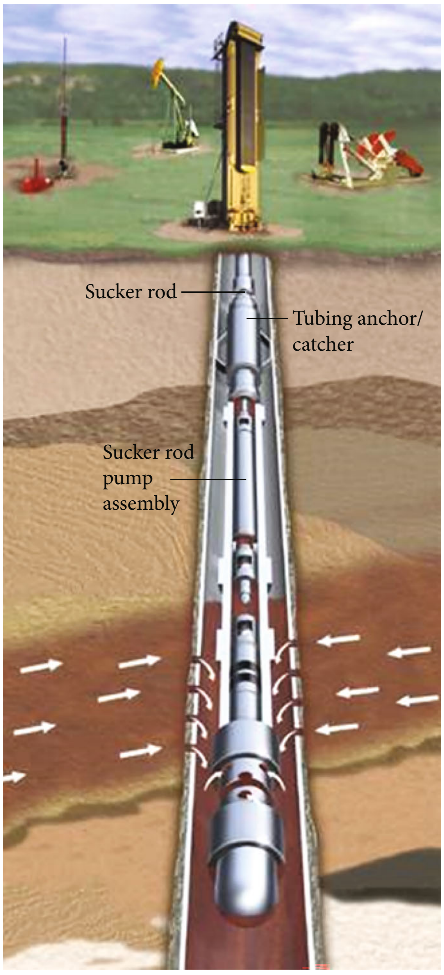


Figure 1: Sucker rod pump.

environments. At the same time, the target is a good sucker rod design is the most critical part of a successful sucker rod pumping system. It will decrease the pulling cost and increase production. The next step is the surface unit. In this paper, the surface unit is the gas engine that feeds by the well gas itself to reduce the cost. At the same time, the jack pump is driven by SCADAPack 535E remote terminal unit. It is an IIoT device to provide a local and remote controller to prevent the gas lock problem using an on-off controller and the oil well casing pressure, PID controller. It ensures the well's liquid level and pumps fillage at optimum values.

1.1. Literature Review. Our work proposes an IIoT-based strategy to control the smart sucker rod pump automatically and intelligently. The development of this strategy aims to ensure the optimization of oil well production using AI models that enable IIoT closed-loop process control. The Industrial Internet of Things found its way to the oil and gas industry via building online intelligent controllers, such as fuzzy logic or neurofuzzy, developing the management and control, centralizing the data, or digitalizing the production process for intelligent production purposes [1, 2]. The current research discussed control strategy, efficiency, optimization, multiphase, pump fillage calculation, pumping system simulation, and an expert system to develop the sucker rod pump system. On the other side, researchers focus on using the IIoT in oil and gas for management, health, and safety to reduce maintenance costs. Integrating optimization and process control with IIoT is still a gap in this field. Our work introduces the solution to integrate intelligent pump control with an IIoT system. The review of the current research discussed below:

In this work, authors describe the control strategy method for the sucker-rod pumping (SRP) system which is discussed; this method stands out for its simplicity and low cost in maintenance and investment, and it can be operated in a large range of flow rates with fluids of different compositions and viscosities. The sucker rod pump units require periodic maintenance and adjustments, whether preventive or corrective. Two common procedures are important for the sucker rod pump units: the first one is to adjust the counterbalancing of the pumping unit, while the second is to adjust the polished rod stroke length. Stopping oil well production is required to accomplish these procedures [3]. A special design for the sucker rod pumping unit using a given condition was studied and tested. A horizontal wellbore with a range of up to 90 degrees bore curvature operated by sucker rod pumping units was studied. The target was to increase the volume efficiency, reduce bottom hole pressure, and decrease the gas impact while increasing drainage speed for the best sucker rod pump efficiency. The gas impact increases in the drainage speed for the best sucker rod pump efficiency [4]. In this work, the author tunes the production potential and controls the oil well rate by understanding all parameters to face the challenge in unconventional reservoirs: the deliverability of the reservoir governing the rate changes with time. The complexity of understanding an artificial lift well's performance pushes the author to optimize the oil well production gains by changing the operating parameters and then finding the optimization and modeling approaches that affect well performance [5]. This paper discussed and developed a pragmatic and robust technique to design and apply a multiphase sucker rod pump in oil wells with high gas-oil ratios. More specifically, in the design of the sucker rod pump structure according to pump working mechanism in the presence of various liquid contents and high gas-oil ratios, effective solutions were enhancing oil production by enforcing gas evacuation. They designed a unique gas buffer to include both chamber gas and fluid inside and connected it through the slotted liner to prevent the pump from the gas lock. In addition, this gas buffer can be bypassed if the stroke is shortened as the traditional downhole pump [6]. This work shows an advanced approach to optimize the sucker rod pump. While most of the operators still depend on surface dynocards for sucker rod pump diagnostic, the author shows the value to use wave equation mathematical calculations as pump (calculated) dynocards to obtain production insights [7]. This paper shows the importance of knowing the correct value of pump fillage in the oil well control to represent the pump efficiency and optimize the production of a rod pumping well. The downhole card graphical representation is often used to know the pump fillage, which can

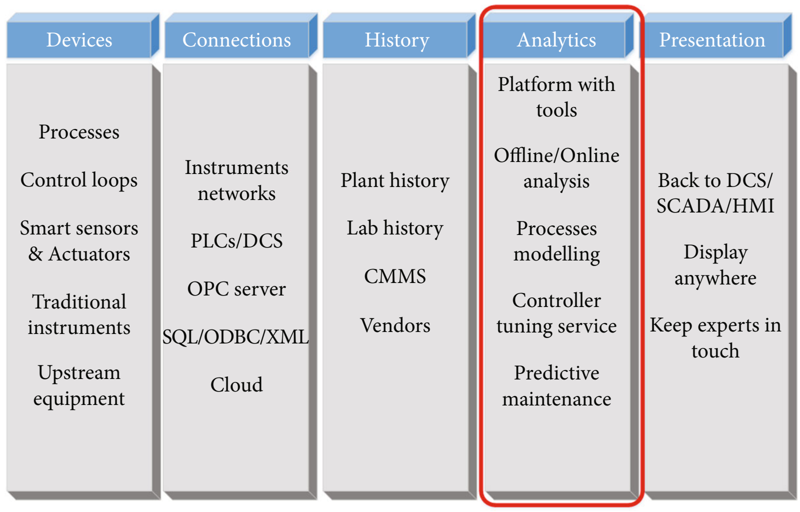


Figure 2: IIoT platform potential.

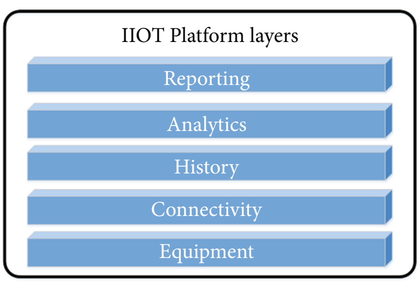


Figure 3: IIoT platform layers.

sometimes be inaccurate. The authors introduced a compute method that used the downhole position to calculate pump fillage. The pump fillage accurate calculation involves the correct location of the transfer point, and it is the point of transferring the load from the standing valve to the traveling valve: a method comprised of four algorithms to locate the transfer point introduced. Correct transfer point location extracted using a combination of these methods, the accurate value of the pump fillage optimizes well production. Application of the method over numerous data sets resulted in a wide coverage range of conditions for optimizing sucker rod pump well assets [8]. The authors discussed how a sucker rod pumped oil well increased the gas to liquid ratio, in addition to the unconventional reservoirs that have high gas to liquid ratio from the beginning of production. To improve the sucker rod pump, the gas production efficiency should be handled. Several methods are used to handle gas production, increasing the sucker rod pump efficiency. The authors focused on three areas, gas separator design, variable speed drives, and the backpressure valves [9]. This work discussed how advanced technologies could overcome many common problems in downhole and surface, such as unconventional oil wells production, high gas oil wells, and sandy oil wells. High-capacity sucker rod pumps with ultralong stroke length maximize the production from heavy crude wells with a high liquid rate with fewer problems of downhole equipment. This technology affects operation costs by reducing the OPEX maintenance and the number of operators required [10]. This paper discussed the most common artificial lift technology, a sucker rod pump, and focuses on the efficiency problems caused by incomplete pump fillage. This problem results from a pump capacity that exceeds the rate of production from the well or gas lock. High pump fillage means lower cost, and more efficient operations will result. The author also presents using the pump off the controller to control pump run time to keep the pump displacement in harmony with the wellbore volume to avoid shock loading problems that occur on 24 hours running well with pump capacity excess wellbore volume [11]. The problem of obtaining downhole data makes monitoring the hydraulic performance of the sucker rod pump difficult. These data, including gas interference, pump fillage, gas locking, sticking valves, fluid pound, equipment failure, rod downstroke compression loading, and reduced production, are difficult to diagnose from the surface. Currently, guesswork and component analysis are the base of root cause analysis. They also develop a sucker rod pump knowledge base [12]. They explained the expert technology and system applications to diagnose sucker rod pumps. This capture expert's knowledge approach is held by a few individuals and makes it available on PC to record it permanently to solve more difficult problems. The authors developed a rule-based expert system that gives users a clear picture to analyze the subsurface pump problems. The analysis information obtained by the presented system utilizes auxiliary programs available for users. The need for such a system means growth in production and reducing the maintenance cost, especially for the wells far away from the head office, to reduce the cost of delayed analysis [13]. The authors discuss the digital transformation and IIoT, and it is effective to keep the plant running, reduce the maintenance cost, and extend life time of equipment that led to increase the productivity. Also, review the IIoT-based project examples to reduce the human and equipment costs in the oil and gas field [14, 15]. They discussed the impact of industry 4.0 and operations based on data centric on oil and gas production that led to discover various scenarios about

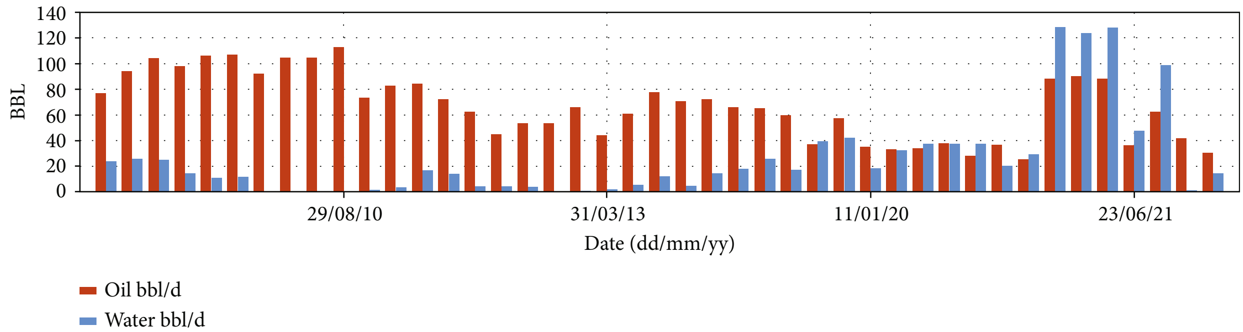


Figure 4: History of selected crude oil well tests with and water capacity.

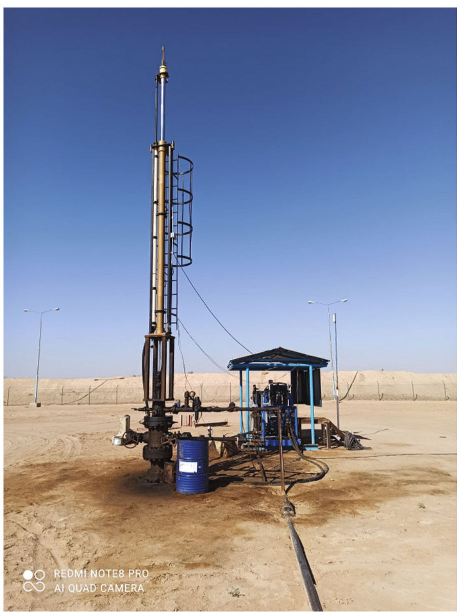


Figure 5: Crude oil pump surface unit.

the future of oil and gas industry [16, 17]. Authors discussed a cyber-physical system for an IoT-based industrial solution such as SCADA to monitor and control their critical infrastructure [18]. Data privacy and security in the Industrial Internet of Things application discussed by enabling user authentication with transfer learning empowered blockchain [19]. Authors discussed machine learning-based malware attack detection protocol in the IoT industrial multimedia environment [20]. New key management and remote user authentication scheme is proposed for securing 6G-enabled NIB deployed for industrial applications [21]. Novel blockchain-edge framework for industrial IoT networks was proposed. It ensures low latency services for industrial IoT applications and optimizes the network usage, the data integrity, trust, and security ensured by a decentralized way provided by blockchain [22].

2. IIoT in Process Control

Industrial IoT is the application of IoT in process control and manufacturing to ensure data exchange between various instrumentation and control equipment. Figure 2 shows the potential of the IIoT platform in the process control industry by providing the analysis tools for predictive maintenance through device health analysis and automated tuning recommendations for controllers through analyzing the interaction, error, variance, model, and knowing the tuning needs. Figure 3 shows the IIoT platform layers for the oil and gas plant. These layers are equipment, communications, history, analytics, and reporting.

The equipment layer includes the processes, control loops, smart sensing and actuating devices, and traditional sensing and actuating devices. In contrast, the communication or connection layer includes industrial wireless, Profinet, fieldbus, and OPC. The history layer includes all data collected from processes, maintenance management system, laboratory information system, and logistics system.

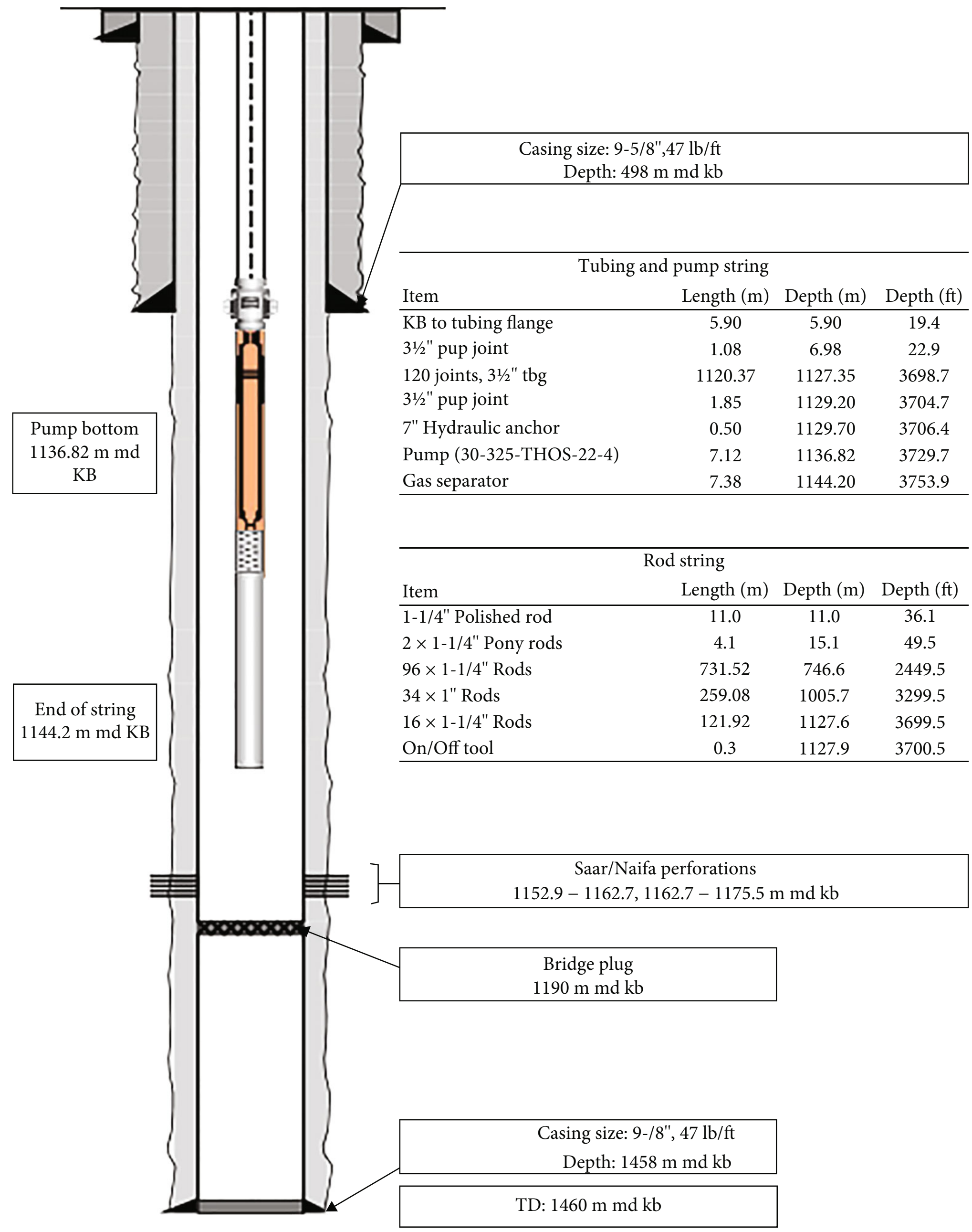
The analytic layer is the most important layer because it is the core of IIoT's strength. It gives the Industrial Internet of Things power to apply intelligent algorithms such as genetic algorithms, neural networks, fuzzy logic, and neuro-fuzzy to control the complex nonlinear and dynamic processes. The analytic layer affects the reporting layer and shows better results of production due to the smooth operation and high quality of process control and automation.

3. Crude Oil Well

This paper selected a crude oil well drilled in 2008 in Yemen for the study. We showed the effect of the Industrial Internet of Things by applying control algorithms or tuning parameters to ensure maximum production with the lowest cost.

3.1. Selected Crude Oil Well History. The oil field downstream facility has a small separator used to test every crude oil individually for 24 hours or more to know the crude oil production rate. Furthermore, it separates the oil, water, and gas from the crude oil. It measures the average daily production rate for oil, water, and gas. Figure 4 shows the crude oil well test history with 43 tests that indicate the maximum and minimum production of crude oil and water.

3.2. Crude Oil Pumping Control. The pump surface unit shown in Figure 5 includes all parts main prime mover (gas engine), and the hydraulic jack pump gives positive displacement to the pump. The SCADAPack 535E controller is used for the control unit. It links the wireless technology



Tubing and pump string

Item	Length (m)	Depth (m)	Depth (ft)
KB to tubing flange	5.90	5.90	19.4
3½" pup joint	1.08	6.98	22.9
120 joints, 3½" tbg	1120.37	1127.35	3698.7
3½" pup joint	1.85	1129.20	3704.7
7" Hydraulic anchor	0.50	1129.70	3706.4
Pump (30-325-THOS-22-4)	7.12	1136.82	3729.7
Gas separator	7.38	1144.20	3753.9

Rod string

Item	Length (m)	Depth (m)	Depth (ft)
1-1/4" Polished rod	11.0	11.0	36.1
2 × 1-1/4" Pony rods	4.1	15.1	49.5
96 × 1-1/4" Rods	731.52	746.6	2449.5
34 × 1" Rods	259.08	1005.7	3299.5
16 × 1-1/4" Rods	121.92	1127.6	3699.5
On/Off tool	0.3	1127.9	3700.5

Figure 6: Crude oil pump downhole installation and well bore data.

through the 5 GHz nanostation to the main control room. The IIoT platform is installed to collect the data, monitor the whole operation, draw the charts, and apply the control algorithms.

Figure 6 shows the downhole pump installation, including all data such as casing size, depth, tubing and pump string, and rod string.

4. Design and Configuration of IIoT System

This paper purposes novel system hardware and software setup that includes IIoT device, communication network, data acquisition, data log, SCADA, control, and valuable charts.

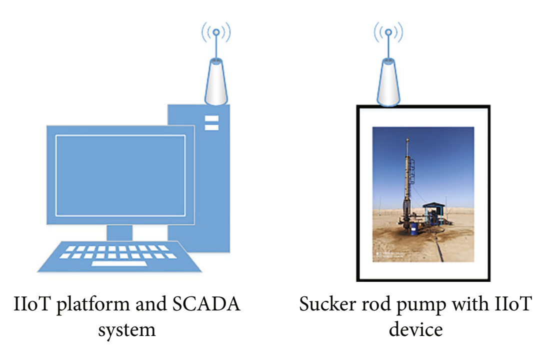


Figure 7: Proposed hardware system.

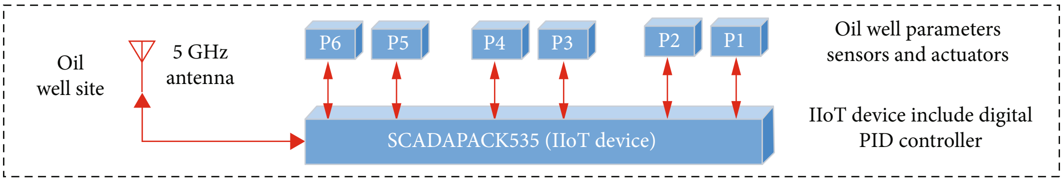


Figure 8: SCADAPack535E IIoT device.

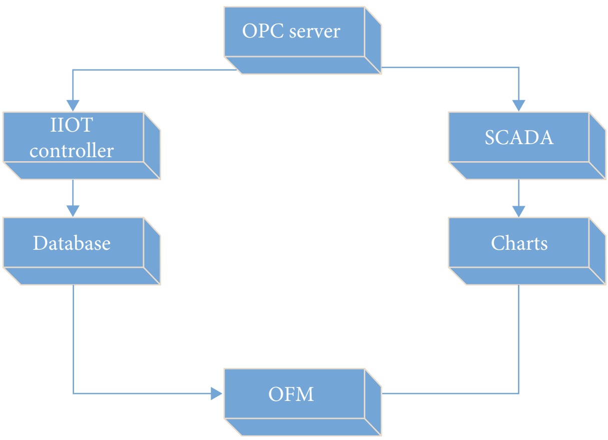


Figure 9: Proposed software system.

4.1. Proposed Hardware System. Figure 7 shows the purposed hardware system. It includes the sucker rod pump, SCADAPack 535E as IIoT device, a 5 GHz antenna, and a server in the control room that will include the IIoT platform and SCADA system. The difficult nature of the environment for oil and gas fields represents a real challenge, considering oil well scattered location and distance from the central processing facility which made the industrial wireless Ethernet the solution for data acquisition, especially nanostation M5 5 GHz antennas that provide a reliable connection for up to 10 km.

Figure 8 shows SCADAPack 535E remote terminal unit and automation controller from Schneider Electric; they are the perfect solution for IIoT applications that need high-speed time stamping and data capture. With an open standard programming environment, SCADAPack 535E supports standard industrial communication protocols such as Modbus RTU, Modbus TCP, and even DNP3 level 4 with security suit and data encryption. SCADAPack 535E works as an agent for the IIoT platform. It collects the data from engine sensors through Modbus RTU communication protocol. Also, it collects data from the rod pump and oil wellhead sensors using 4-20 ma I/O. Finally, SCADAPack 535E sends the data to the control room using Modbus TCP communication protocol through nanostation M5 5 GHz antenna.

4.2. Proposed Software System. Figure 9 shows the proposed software system; in this paper, the Kepware OPC server collects the crude oil well controller (SCADAPACK 535E) through a 5 GHz wireless link using TCP/IP network that passes it to two main branches, SCADA and IIoT platform.

The SCADA system monitors and generates valuable charts. At the same time, the IIoT platform uses these data for modeling, controlling and forecasting, and storing optimum parameters in the database. The two branches then send the data to the OFM (Oil Field Manager) software from Schlumberger, France. The visual basic programming language was used to build the SCADA system and IIoT platform. Figure 10 shows the proposed software implementation algorithm.

Figure 11 shows the proposed platform working flowchart. It clarifies the build of machine learning-based AI models that simulate the expert's responses. The proposed platform uses code to prepare training datasets by recording all expert's resonances that achieved the goals and increased pump efficiency. Machine learning builds the prediction models using training datasets.

4.3. Sucker Rod Pump Performance Calculation for Production Maximization. Because it is difficult to measure the crude oil level in the well continuously and stop the pump during the measuring process, the pump performance is needed to indicate the level and pump fillage. So, the dynamometer card is used to accomplish this job while the surface card displays the load on the polished rod over the pump cycle. The card result shape is a function of everything, such as speed in stroke per minute, PPU geometry, pump depth, and fluid load on the pump, while the wave equation mathematically models the elastic nature of the rod string (assuming a downhole friction factor) and uses the surface card data to represent what happens at the pump plunger.

A dynagraph card represents the forces acting on the pump plunger as it moves upward and downward in the well, capturing and releasing fluid with each stroke. Surface and downhole dynagraph cards measure the load on the polished rod, and this load is plotted with the polished rod position as the pump moves through each stroke cycle. A complete stroke cycle is one up and downstroke. The controller uses this data to create an x-y plot. By observing the graphs, information about the efficiency of the pump operation can be collected. Rather than being a plot of load vs. time, as shown below in Figure 12, a card is a plot of load vs. position, as shown in Figure 13. The ideal card, as shown above in Figure 13, demonstrates the instantaneous increase in load from $L_{\min}$ to $L_{\max}$. The pump plunger begins its upward stroke, and the load remains constant as it travels to the top. As soon as the pump plunger starts back down, the load instantly falls back to $L_{\min}$ where it remains constant as the pump travels to its bottom position again.

The card shown in Figure 14 shows a dynacard with an ideal upstroke and 30% pump fillage, demonstrating the effect of conditions such as fluid pound. If the traveling valve

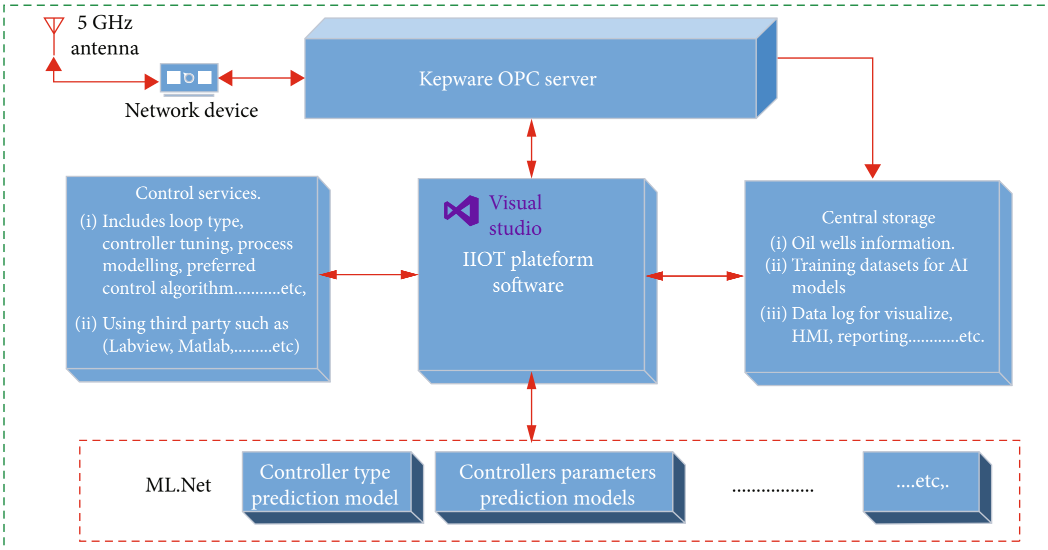


FIGURE 10: Proposed software implementation algorithm.

on the pump opens properly, the load falls instantly to L_{min} and remains constant for the entire downstroke (P_{top} to P_{bottom}), and the fluid is transferred from the pump to the tubing. When the pump plunger reaches the bottom, the barrel is empty.

The hydraulic pump begins to lift the entire fluid column to the top again, causing more fluid to be pulled in from the reservoir through the standing valve. However, when a condition such as low fluid level or trapped gas stops traveling valve from opening properly as the plunger starts downward, transfer of the contents of the pump; so, the tubing does not begin at the top of the stroke.

The fluid in the tubing descends with the traveling valve, maintaining the load at L_{max}, until fluid is encountered or the gas compresses enough to open the traveling valve. Only when the plunger reimmerses in the fluid can it use the traveling valve open, and fluid transfer occurs through the travelling valve. The maximum and minimum load can be expressed as

$$L_{Max} = S_f(62.4)D\left(\frac{A_p - A_r}{144}\right) + \frac{\lambda_s D A_r}{144} + \frac{\lambda_s D A_r}{144}\left(\frac{SN^2M}{70471.2}\right), \tag{1}$$

$$L_{Min} = S_f(62.4)D\left(\frac{A_r}{144}\right) + \frac{\lambda_s D A_r}{144} - \frac{\lambda_s D A_r}{144}\left(\frac{SN^2M}{70471.2}\right). \tag{2}$$

The liquid flow rate Q can be expressed as

$$Q = 0.1484\left(\frac{A_p N S_p E_v}{B_o}\right). \tag{3}$$

The symbols listed in Table 1.

In this paper, surface load is calculated from the hydraulic pressure and the geometry of the hydraulic system. The position is represented by the position readings obtained by monitoring the hydraulic fluid flow.

5. Results and Experimental Setup

The most important parameter that indicates the status of the crude oil well is the fluid level. It must be ensured that this level is above the pump. We determine the casing pressure's critical value in the next stage, which pushes the level down under the pump. Therefore, the first part of the experiments in this paper is measuring the level. After that, the second part is activated, connecting the dedicated IIoT platform to the crude oil well controller and showing the results. These two parts are explained below.

5.1. Measuring Fluid Level in Wells Using Echometer Device. The most important parameter is the liquid level in the oil well. It is the process variable that needs to be maintained to ensure the fillage of the pump. This parameter is measured by an echometer device that uses an ultrasound gun to measure the number of tube joints to level.

The results of the echometer instrument can be read using Total Manager software to calculate the tubing joints liquid level in the oil well, as shown in Figure 15. Figure 16 shows the raw signal recorded by the echometer mic and displays the acoustic gunshot start, tubing joint reflection and fluid level kick (appears in zoom window). Low-pass filter is applied to the signal to make it easier for the operator to read and determine tube joints kick and fluid level kick as shown in Figure 17.

Depth determination screen is shown in Figure 18, where the joints can be counted easily, and zoom tools are used to show the kicks.

5.2. Performance Enhancement by the Proposed IIoT System. Once the system is installed and commissioned, the SCADA

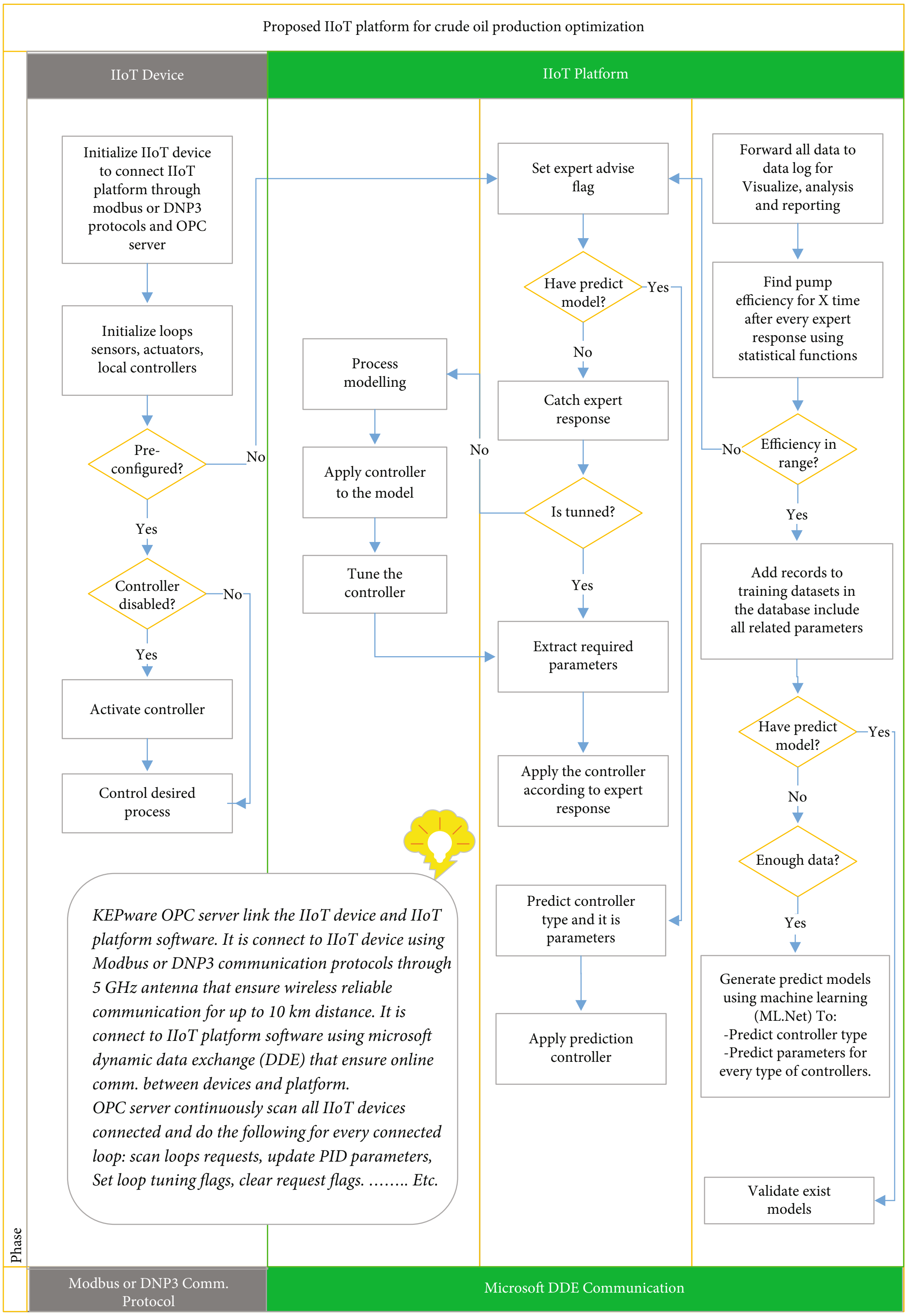


Figure 11: Proposed IIoT platform working flowchart.

system is built, and the IIoT platform is launched. The oil well chart includes fillage (pump efficiency), tubing pressure, jack pump hydraulic pressure, pump speed (stroke per minute), and casing pressure displayed. It depends on the data log recorded by the IIoT platform using a one-second scan rate stored in CSV files or ODBC database.

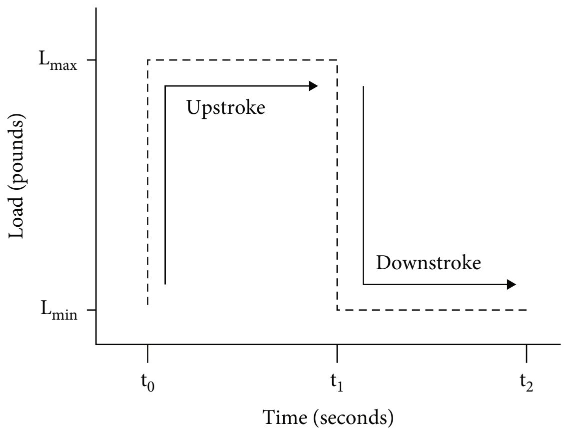


FIGURE 12: Load vs. time.

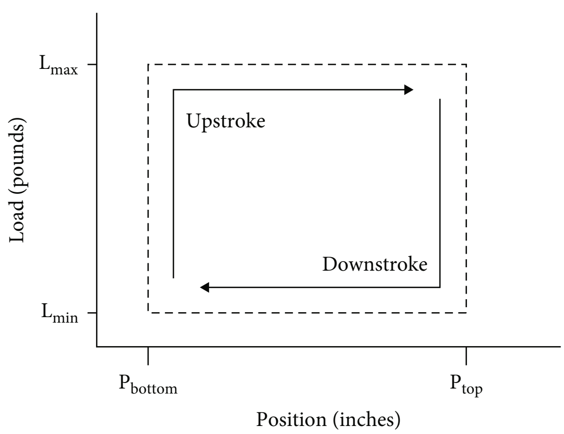


FIGURE 13: Load vs. position.

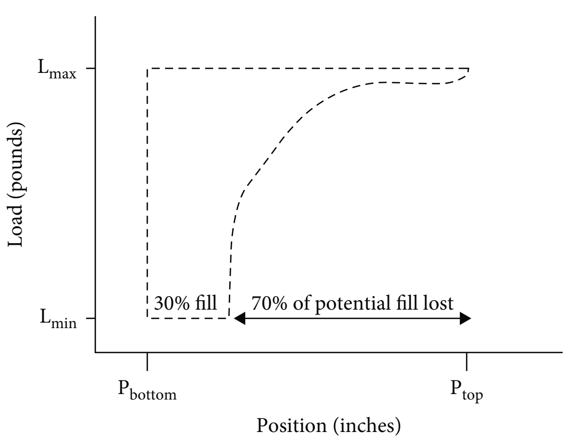


FIGURE 14: Load vs. position.

Figure 19 above shows the one-month oil well chart that indicates how the gas lock problem affects pump efficiency, which needs to be maintained. For best understanding, the higher resolution chart for 48 hours is shown in Figure 20. The pump fillage affected by gas lock without any control action is noticeable.

TABLE 1: Symbols.

Symbol	Remark
S_f	Liquid specific gravity
D	Sucker rod string length
A_p	Plunger area
A_r	Rod area
λ_s	Specific weight of steel
M	Machine factor
N	Pump speed stroke per minute
S_p	Stroke length
E_v	Pump fillage (efficiency)
B_o	Formation volume factor

Our proposed solution avoids the gas lock effect by stopping the pump for some time to give the reservoir a chance to build up again. It increases the liquid level in the crude oil well. Figure 21 shows the five-day well chart and how the on-off crude oil well pump controller affects pump efficiency.

With the proposed method for pump operation as discussed above, the pump fillage efficiency is stable at 90% as Figure 22 shows.

For a clearer picture, the higher resolution chart for 48 hours is shown in Figure 23 with continuous stability of pump fillage (efficiency) around 90% after stopping the pump for 6 hours.

The other solution to avoid the gas lock problem and maintain the oil well level is to control the casing pressure. The pressure controller maintains the casing pressure at a certain setpoint taken from the experts in real time via the IIoT platform.

Figure 24 shows the effect of casing pressure on the pump efficiency. This higher resolution chart for 48 hours is shown in Figure 25, while Figure 26 shows the higher resolution chart for 2 hours that gives a deep view of the behavior of all parameters with continuous stability of pump fillage (efficiency) under control via the IIoT platform.

With the effectiveness of our proposed system visible in the results, the oil well's production rate should be tested on other oil wells to ensure the solution's acclaim. The last three tests were done before applying the proposed technology in this paper. These tests showed a drop-in liquid production rate with unstable pump fillage after a short time from the last well workover, which means a well needs work over. The average liquid production rate was 43 BPD oil and 50 BPD water while the maximum expected is 100 BPD oil. The other test was done after applying the new IIoT system solution, especially when the pump fillage was stable at 90%, and the liquid production rate increased from 43 to 80 BPD oil. In contrast, the water increased from 50 to 110 BPD, and the increase in water rate is not an issue as it can be reinjected to a reservoir. The results have shown an improvement in the liquid production rate of the oil well, which means duplicating the production and decreasing the work over frequency with reducing work over cost and well-off

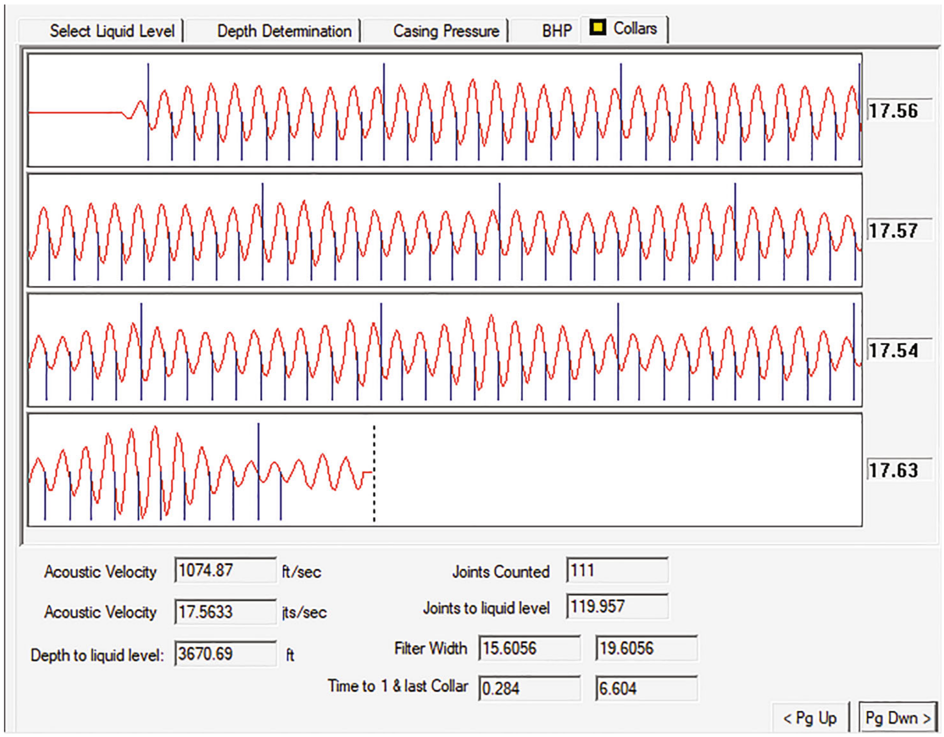


Figure 15: Echometer final ultrasound response to count the tube joints.

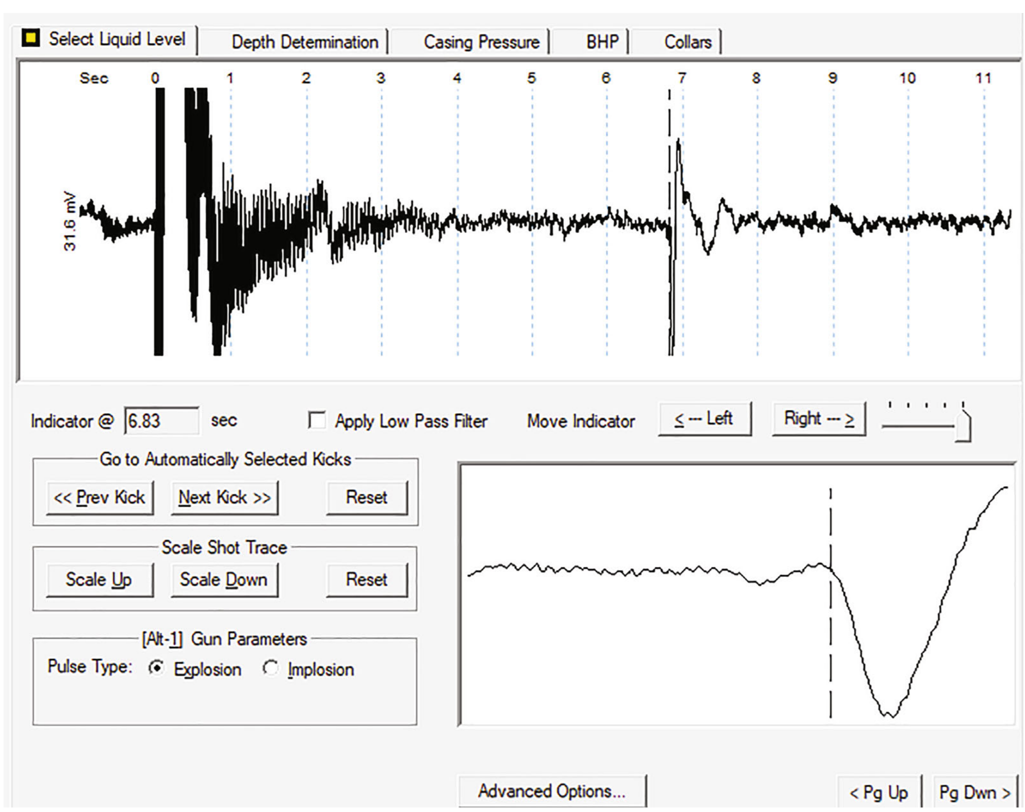


Figure 16: The raw signal recorded by echometer to count the tube joints.

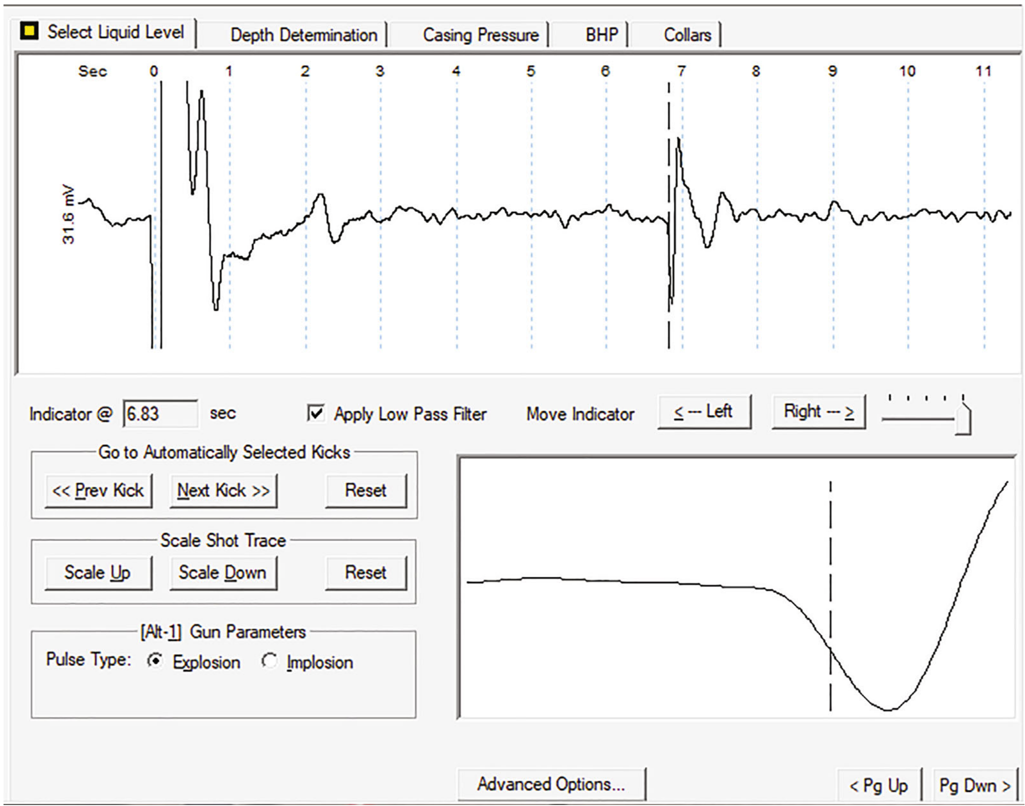


Figure 17: Number of tubing joint liquid level in crude oil well by applying low-pass filter to the signal.

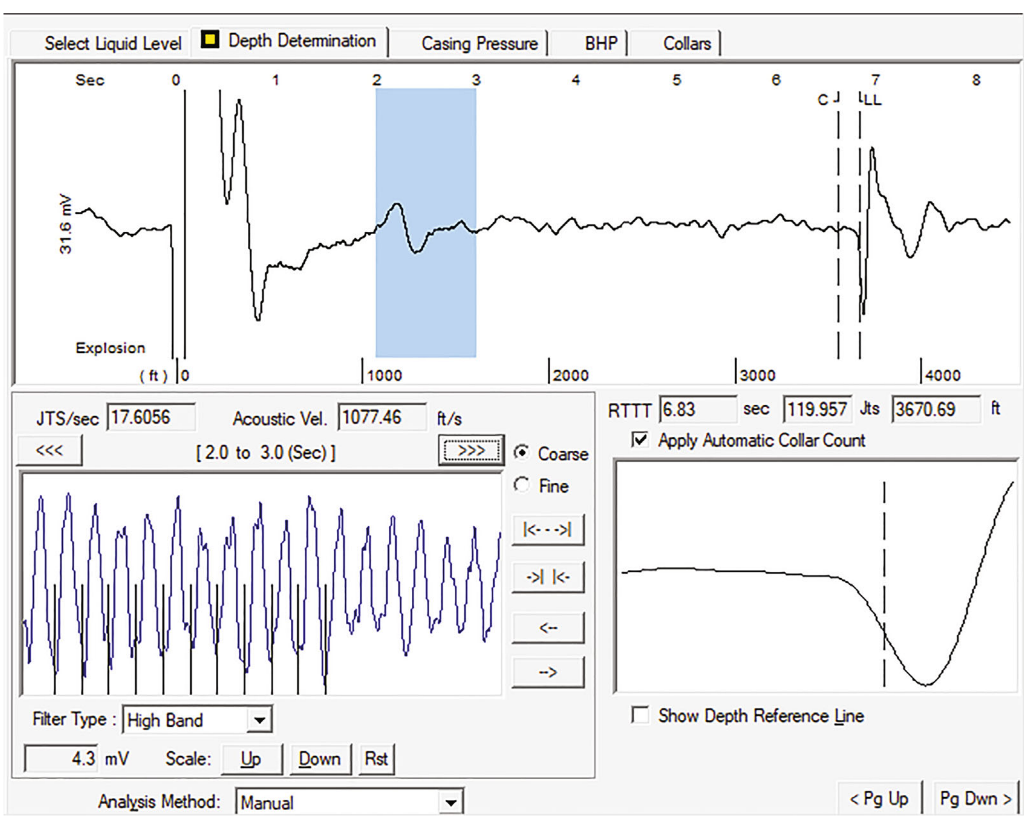


Figure 18: Depth determination screen.

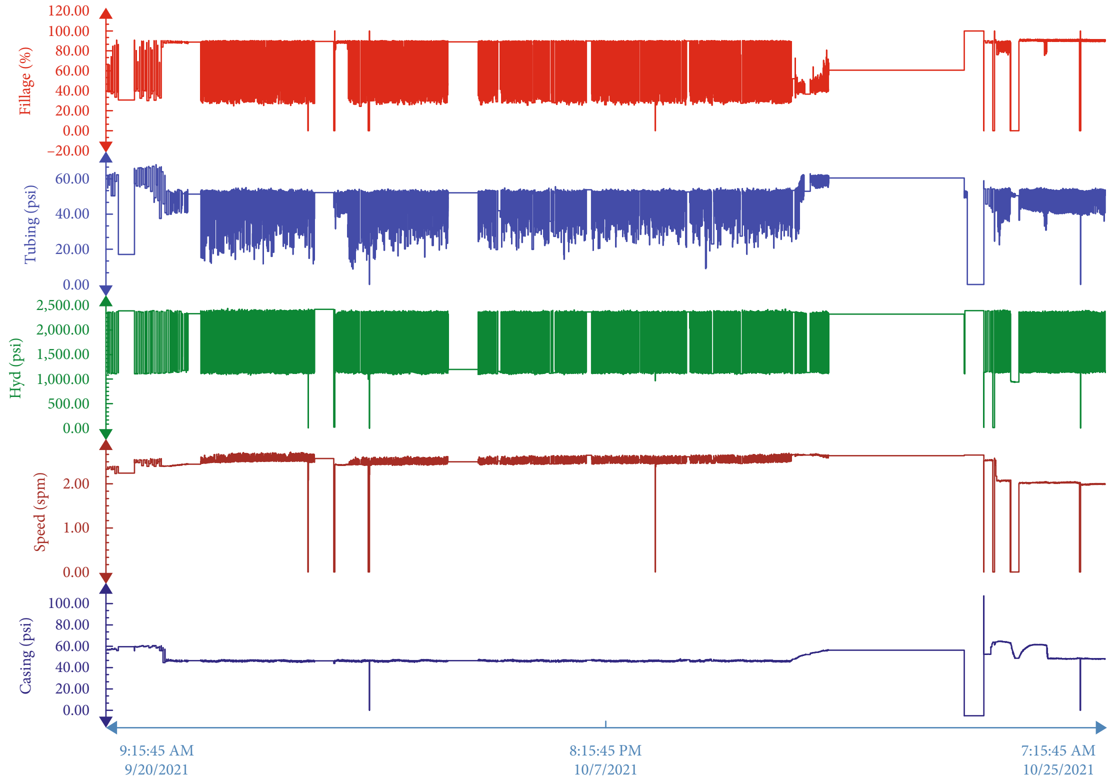


Figure 19: One month crude oil well chart showing essential parameters.

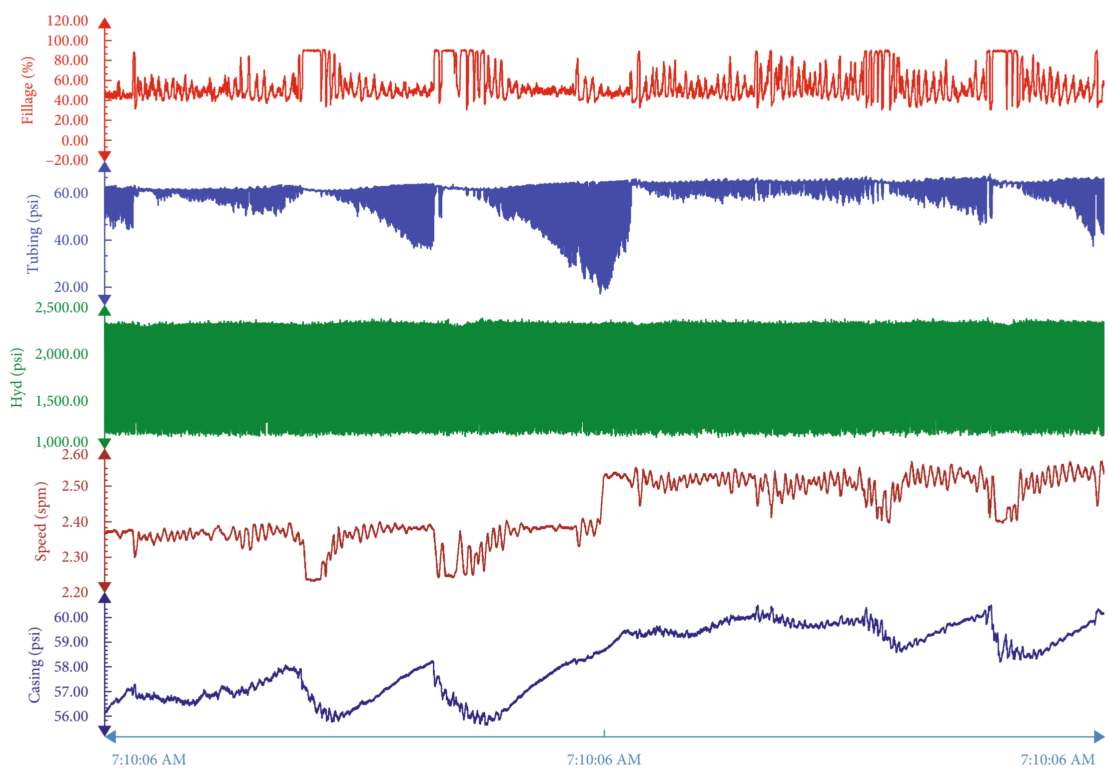


Figure 20: 48 hours oil well chart without control.

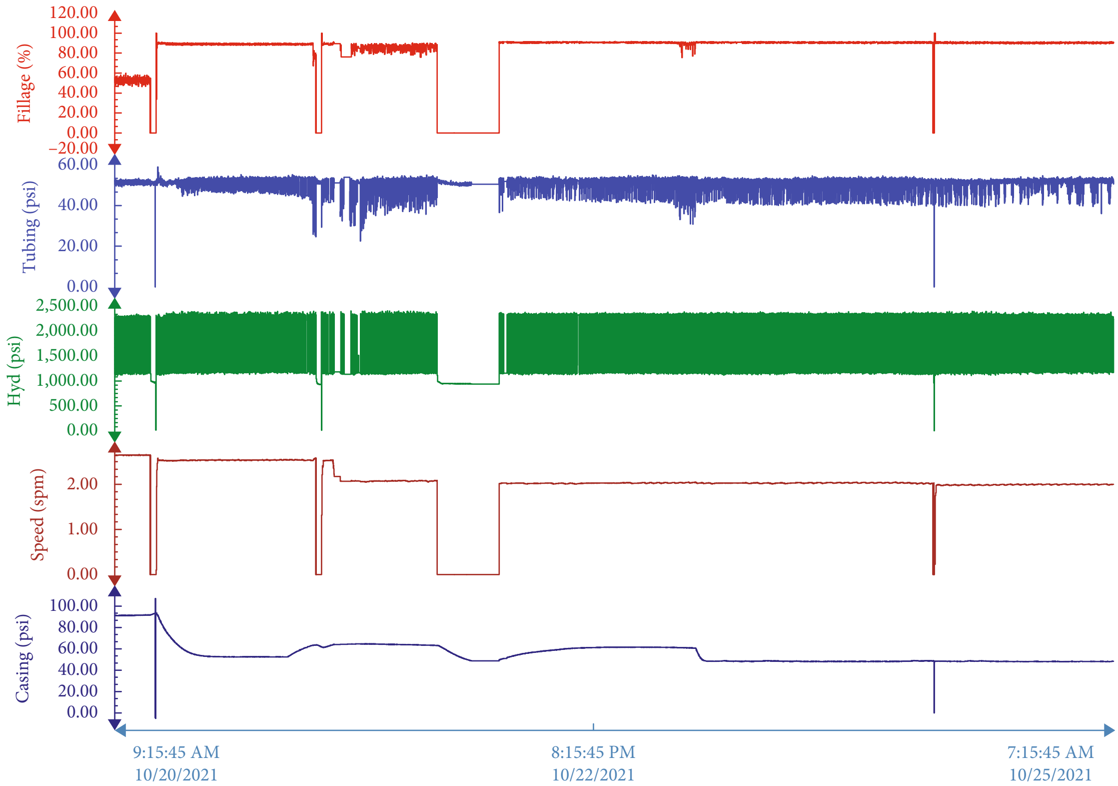


Figure 21: Five-day well chart with pump on-off control.

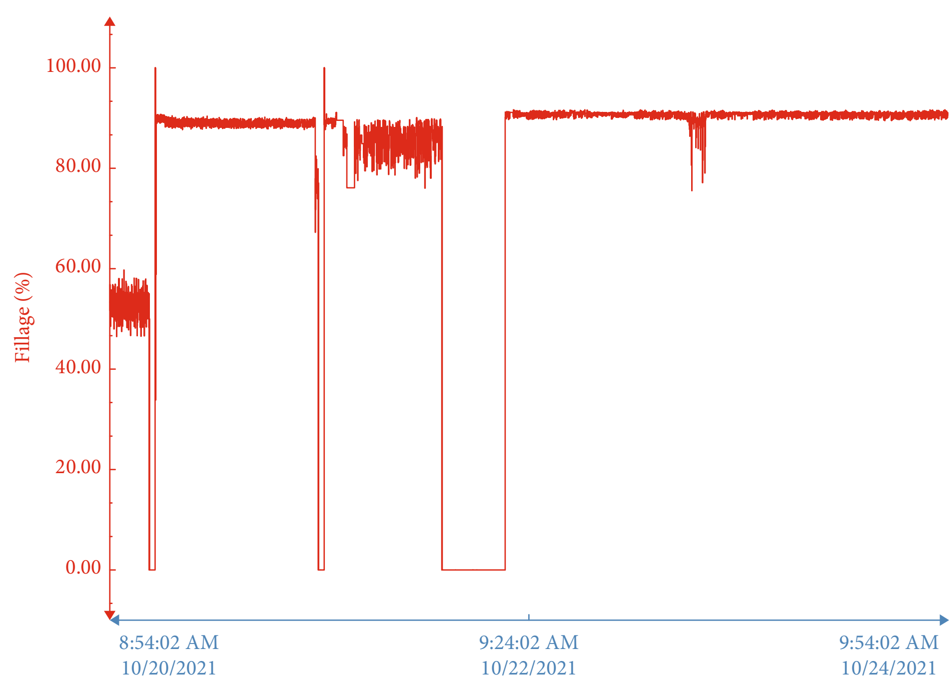


Figure 22: Five-day pump efficiency chart with pump on-off control.

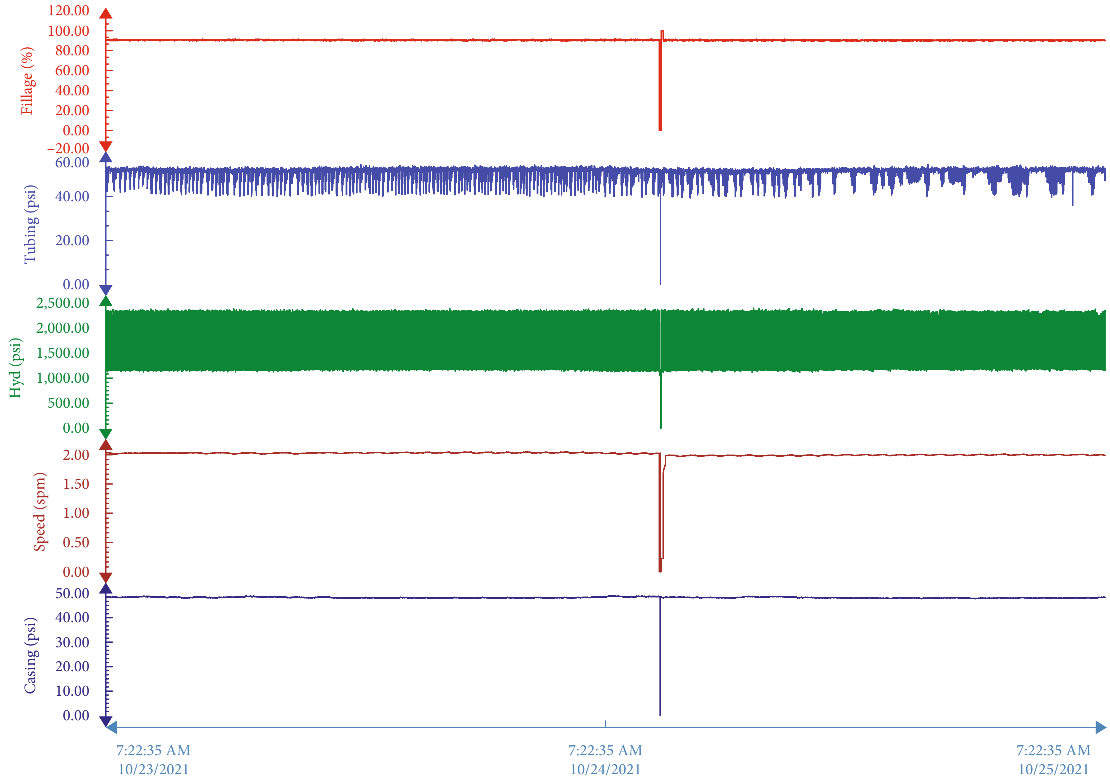


Figure 23: 48 hours oil well chart after 6 hours of shut-down.

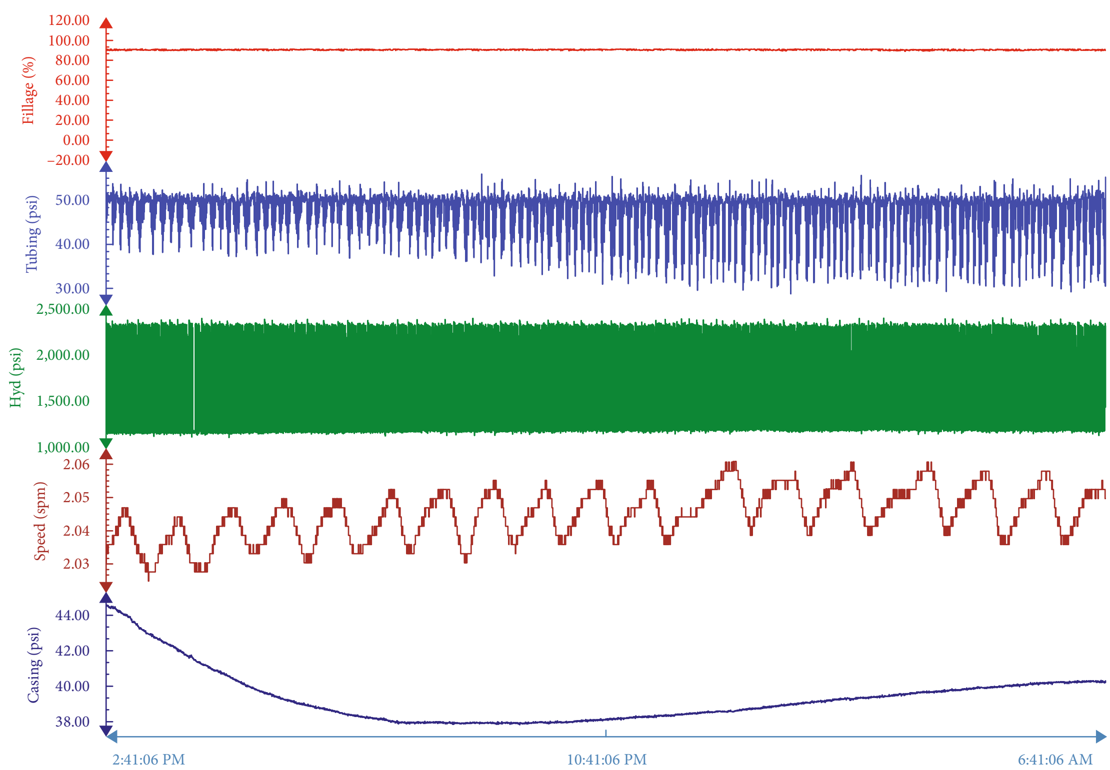


Figure 24: Effect of casing pressure controller.

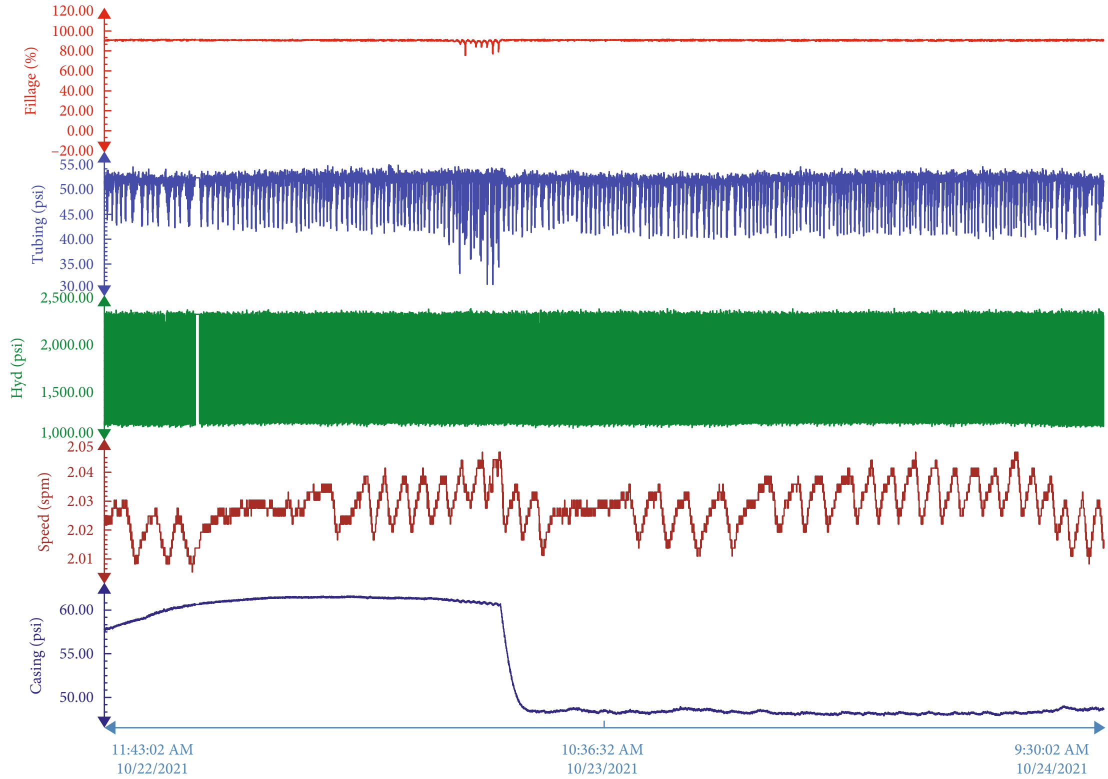


Figure 25: 48 hours oil well chart with casing pressure controller.

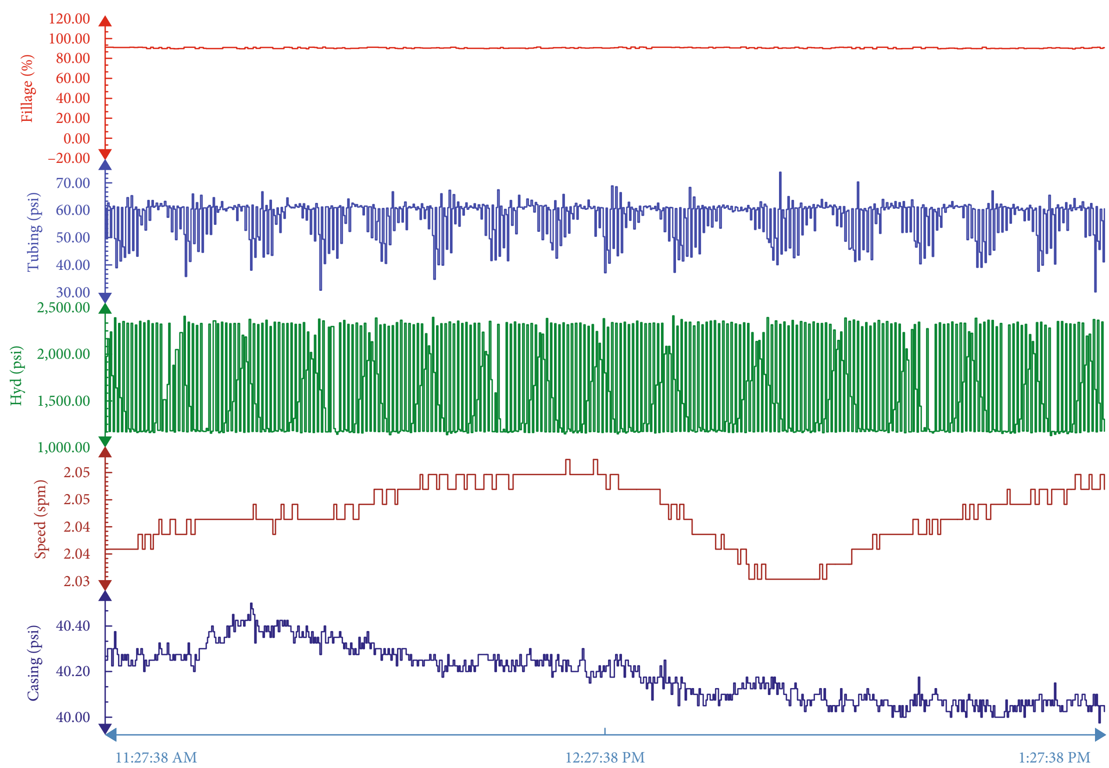


Figure 26: 2 hours oil well chart.

days. Furthermore, make the right decisions by reflecting the right picture of sucker rod pump behavior that helps experts.

6. Conclusion

Using the Industrial Internet of Things (IIoT) in the oil and gas industry means intelligent production and opening the door for a new level of optimization and cost-effective production. This paper shows how this technology successfully transferred a clear picture of the sucker rod pumping well. It introduces an approach to understand all the required parameters such as pump efficiency, pump fillage, tubing pressure, casing pressure, hydraulic pressure, and pump speed. The clear picture leads to the right expert's responses and transfers their experience to AI prediction models. The AI models predict the control parameters based on experts' responses. The production rate of the oil well studied in this paper has increased by 90% when applying this new technology. It prevents the gas lock problem by using an on-off pump controller. It maintains the liquid level in the well by controlling the case pressure using PID controller. At the same time, the experts determine the optimized setpoints for the controller and the lowest pump off-time. The future of oil and gas is the Industrial Internet of Things (IIoT) that will optimize the upstream and downstream to reduce maintenance costs, improve production, increase reliability, and more.

Data Availability

Data supporting Figures 2, 4, and 10–21 are not publicly available according to company policy. However, these datasets can be accessed on request from Mr Ali S. Allahloh, upon the completion of a Data Usage Agreement, according to policies from the Yemen Petroleum Exploration and Production Authority (PEPA).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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