

Research on Intelligent Oil Production Technology of Electric Pump Well

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Abstract

To explore the current application of intelligent oil recovery technology in electric pump wells and the opportunity for lower development pent. Through reading many literature, this paper systematically summarizes the research status of related technologies at home and abroad and establishes three hot research topics: fine-tuning optimization of pump operation parameters, real-time optimization of production process and intelligent well technology under the framework of large data. Then, according to the author's many years of work experience, the application of electric pump-intelligent gas lift string technology and multi-parameter monitoring technology of submersible electric pump in offshore oilfield is displayed in a panoramic way, providing constructive suggestions for colleagues.

Keywords

Oilfield, Electric submersible pump, Oil production, Monitoring

Introduction

The oil recovery technology of electric submersible pump has a long history. It is mature in equipment manufacturing and field application, but today, with the rapid development of big data and computer technology. The digital oil field with the development concept of intelligence will be an opportunity for the petroleum industry to take off. At present, structural optimization based on down hole tools and supporting pipe strings is often used in the innovation of oil production technology, and the traditional petroleum industry barriers of "stupid, big and rough" cannot be avoided [1]. The application of high-tech modern instrument automation technology can fully introduce the advantages of big data computer processing and fully realize the benign development of intelligent oil recovery technology. Based on the author's many years of working experience, this paper takes the intelligent oil recovery technology of electric pumps well as the research topic and carries out relevant discussions to provide constructive suggestions for peers.

Research status at home and abroad

Electric submersible pumps are widely used in the field of oil development and are often deployed in single wells with high liquid production. The working principle of the equipment is that the corrosion resistance and high temperature resistance of the conventional multistage centrifugal pump have been significantly improved after special treatment [2]. And a certain work gap is allowed to adapt to gas production, sand production, wax deposition and multi-flow transportation of high-viscosity fluid in the formation. In the aspect of power distribution, explosion-proof cables are connected to the ground through the shaft under armored protection for underground motor power supply. Finally, the quantitative lifting of oil and gas is carried out by multistage centrifugal pump. This oil recovery technology is widely used in high production areas such as Tarim Oilfield, and the energy-saving effect is remarkable because of the wide application of frequency conversion

technology in operation mode. However, the current control is still dominated by a relatively simple and stable open loop. Open loop means that the correlation between input parameters and output parameters is weak or irrelevant, and the corresponding data is not connected and has no feedback. Therefore, the corresponding system operation is a fixed value set by the design, which cannot be adjusted in real time according to the current situation and dynamic working parameters. After the production well needs to be adjusted, the pump can only be manually lifted and the choke replaced by working on it, or the liquid production can be adjusted by frequency adjustment. The time cost and labor cost are high, and the comprehensive operability is cumbersome. However, the fluid output of formation and its comprehensive properties of medium tend to change dynamically, which needs real-time monitoring and dynamic adjustment according to the current power and fluid output of pump body, to improve the service life of pump under the premise of maximizing and optimizing production technology [3]. The closed-loop regulation with real-time data feedback by using automatic instruments can optimize the system and predict the output by using relevant mathematical models under the premise of data link sharing, and the output can be obtained through the input according to evidence, thus improving the corresponding production situation and improving the system operation efficiency. At the same time, closed-loop control can also add different intelligent hardware devices and software devices, which improves the adjustment timeliness and fully realizes automatic control. Balance many parameters such as liquid production and liquid supply and prolong the service life of the equipment while ensuring the intact rate of the equipment. The following will comprehensively introduce the current situation of intelligent oil recovery technology of electric pump wells from three aspects: fine-tuning and optimization of operating parameters of electric pump itself, real-time adjustment and optimization of production

technology and intelligent well technology under the framework of big data. Theoretical support for the follow-up research.

Fine-tuning and optimization of electric pump's own operating parameters

As mentioned above, the operation parameters of the pump can be fine-tuned by manually starting and stopping the pump, replacing nozzles with different specifications and adjusting the motor frequency. However, on the premise of simplicity and practicality, we need to consider the influence of activity-based cost and missed work rate. At the same time, the manual replacement of the choke will induce the flow channel plunger because of the wax deposition of crude oil, and finally the corresponding ESP operating parameters will change over time, resulting in the adjustment failure. Therefore, the effectiveness of this process is small. However, due to the influence of power equipment, the adjustment range is often small by adjusting the working frequency, and only gear-type switching adjustment can be carried out, with limited accuracy [4].

Relevant theoretical research shows that the current frequency conversion regulation is not effectively supported by a set of mathematical theories, and it can only be approximately considered that the frequency conversion frequency and displacement are linear, but the subsequent changes will be restricted by multiple factors such as sand production, rock physical properties, formation energy and choke throttling properties. We must systematically analyze the interrelation of related factors and regard it as a grey system. Comprehensive prediction and analysis of mathematical modeling [5-7].

Real-time adjustment and optimization of production process

At present, the software/hardware combined automatic regulation technology of oil and gas fields using big data combined with mathematical algorithm has been developed, commissioned and put into production quantitatively [8]. However, how to upgrade automatic control instruments,

transmit stable data and fully analyze and utilize relevant data is still in its infancy in the field of petroleum engineering. According to relevant literature research, as early as 2001, Schlumberger Company carried out remote control of Indonesian oil and gas fields by American local control center through AAL project and conducted algorithm analysis and expert consultation based on different parameters at present. Finally, the control scheme is determined, and the production form of oil and gas fields is optimized through the mandatory adjustment of the control center. At present, all major oilfields and universities in China have carried out digital oilfield projects, among which the integration of geological engineering has been quite mature. And the corresponding regulation based on more advanced electromechanical equipment is an original leap. However, the progress of related practice links is slow due to various unexpected factors.

Intelligent well technology under big data framework

The concept of intelligent well has a long history, but the definition is different in different technical stages and field requirements. At present, the latest definition of intelligent well has risen from single well optimization to grid analysis of well pattern and oil group. With the help of real-time injection-production management network, multi-functional downhole sensor matrix is used to obtain, transmit and analyze cable-transmitted dynamic multivariable big data. The output of downhole equipment and its reservoir is comprehensively judged, which lays the foundation for subsequent computer mathematical modeling and information sharing. Make full use of information feedback mechanisms to scientifically improve the output of work area [9].

From the application category of intelligent wells, it can be divided into two modular concepts: real-time monitoring and dynamic control. As the name implies, the real-time monitoring platform can effectively obtain relevant useful measurable physical quantities, and store and analyze the data.

However, the complex environment of high temperature and high-pressure underground will bring great interference to the collection and transmission of information, so the research based on reliability instruments and equipment and data transmission methods need to be followed up. At present, the main transmission medium of field data is cable or optical fiber, and many sensors are also used underground to work under different working conditions. Usually, electronic sensors can effectively measure the relevant parameters of fluid in oil layers, and the transmission accuracy of optical fiber can reach the highest. The main core of the dynamic control module is the underground production control system, and the mechanical parts on site mainly rely on cable and hydraulic sensing to flexibly move the corresponding sealing switches of the downhole packer, throttle valve and control branch shaft. After making corresponding adjustments, the ground data center will receive corresponding feedback and effect analysis, which is convenient for technicians to make continuous adjustments in the next step [10].

According to the intelligent well system that has been used at present, the cost of downhole operation is effectively reduced. Therefore, the application of intelligent well control based on workover intervention protection principle is the main purpose of this field at present, which can produce about 20% cost savings. However, it has great potential for economic benefits to continue to develop multi-intelligent well regulation technology based on geological level.

Oilfield electric pump-intelligent gas-lift pipe string technology

Due to the limited oil and gas production area, the electric submersible pump is used for large-scale production in the oilfield, in which the electric pump-intelligent gas lift pipe string technology is used for intelligent gas lift. The process mainly covers the electric submersible pump, liquid flow reversing valve, intelligent gas lift valve and other related hardware equipment. Among them, the

liquid flow reversing valve was installed at the end of the electric submersible pump, and the intelligent gas lift valve and corresponding detection equipment were installed at the upper part of the pipe string. When this kind of string is used for coordinated production, formation gas and injection gas can be comprehensively used to realize energy-balanced lifting production. The intelligent gas lift valve can accurately adjust the air intake according to the current temperature, pressure and flow, realize predictive calibration, and judge the quality of the corresponding fixed parts in real time. This process does not need to use additional electric energy, and the process flow is simple and reliable, with wide adaptability.

At present, the main research is to improve the functionality and accuracy of coupled lifting calculation software. Ensure that the working conditions and corresponding ductility parameters of the downhole pump body are accurate. At the same time, how to realize frequency adjustment and valve opening adjustment through the control system of electric submersible pumps is also the main topic of current research. Matching analysis and adjustment of multiple measurable physical quantities are the prerequisite advantages to realize system stabilization and minimize energy consumption. Closed-loop control through computer technology can improve efficiency and ensure comprehensive solutions to the problems of short equipment life caused by excessive pump load during oil and gas simultaneous production [11-14]. The following is the working principle of this technology: Through the gas-lift coupling lifting pipe string diagram in Figure 1, the pipe string design can make full use of the gas-lift advantage to realize the dynamic regulation of electric submersible pump energy consumption, to complete the production of downhole fluid. The process design is that the oil layer and gas layer are controlled by the production sliding sleeve. If the formation pressure is sufficient, the corresponding device of the oil layer is opened, and the production sliding sleeve of the gas layer is closed.

The produced gas opens the intelligent gas lift valve through the oil collar and enters the tubing at a certain flow rate, and the produced liquid is displaced to the ground by kinetic energy. If the formation pressure is insufficient, the relevant sensors will collect and calculate the relevant physical quantities and then command the ESP to start work and complete the replenishment. Finally, the purpose of well fluid lifting production is achieved.

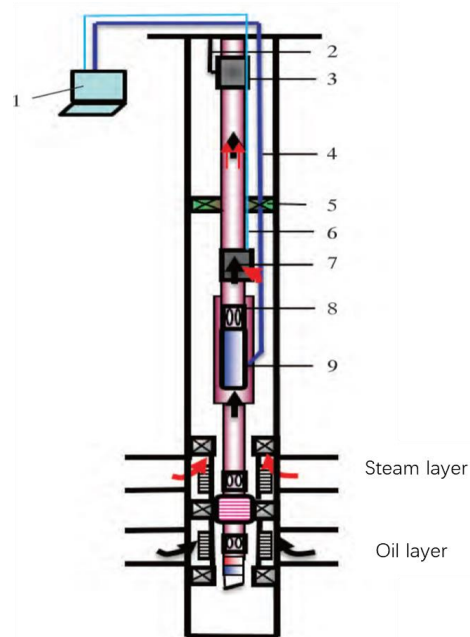


Figure 1. Schematic diagram of electric pump formation gas lift coupling lifting pipe string.

The following is Figure 2 of the lifting string for gas lift production by active surface gas injection. Similarly, the production of sliding sleeve plays the purpose of layered mining, but the difference here is that the packer is triggered to open the gas injection valve through the pressurization of the ground pipe string.

The high kinetic energy gas on the ground is introduced to the relevant position through the cable packer and finally triggers the change of the pressure system inside the pipe string to complete the lifting of the liquid column. Similarly, the underground is equipped with a certain specification of electric submersible pump to achieve the purpose of comprehensive support [15].

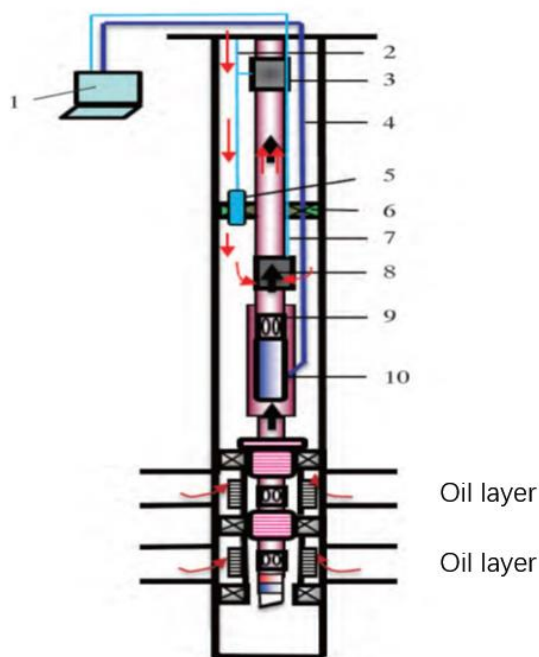


Figure 2. Schematic diagram of electric pump surface gas injection gas lift coupling lifting pipe string.

To sum up, this intelligent oil recovery technology based on electric submersible pump and simple downhole string can make full use of underground natural gas energy and complete the whole life cycle of single well. Usually, new wells are full of energy, and direct production by flowing mode can achieve good results.

However, with the deepening of development, the formation of energy plummeted. After being measured by relevant instruments and meters, the underground intelligent equipment-gas lift valve can be remotely controlled, and the mining can be continued by corresponding gas lift methods. At the same time, the opening of the gas lift valve can be adjusted based on the mining degree and related parameters during the mining process to achieve the goal of stable production. Further, with the decrease of formation energy, the electric submersible pump is started, and the combined development mode of gas lift and electric pump coupling lift is adopted for production and operation until the underground

energy is completely consumed. At this time, the gas facilities on the ground began to start to supplement energy and complete the repetitive mining in the previous stage. Through field application, it is found that this process design can extend the service life of electric submersible pumps and other dynamic equipment in an all-round way and achieve the best economic efficiency on the premise of the best development efficiency. It has a huge advantage in human resources and time cost [16].

Submersible pump downhole multi-parameter monitoring process

The basis of intelligent oil recovery is real-time data acquisition and transmission. In this underground multi-parameter monitoring equipment of submersible pump, the mechanical end and the transmission end are combined, and the corresponding measurable physical quantities are collected, transmitted and processed all the time under the integrated concept of manufacturing. The equipment has high manufacturing accuracy, can adapt to multiple downhole conditions in complex environments, and can effectively monitor the direct parameters such as motor temperature, inlet/outlet pressure, mechanical vibration, motor power and so on. Relevant personnel on the ground make corresponding analysis according to these working parameters and finally formulate practical and effective operating frequency of electric submersible pump oil production to comprehensively help production. The structure of the submersible pump downhole monitor is simple, which mainly consists of upper and lower connectors, test inner cylinder, outer cylinder, filter device (frequency converter) and test cup (functional circuit) (Figure 3). In detail, the upper joint is connected to the bottom of the downhole motor, and the lower joint is used to connect other auxiliary devices such as centralizers.

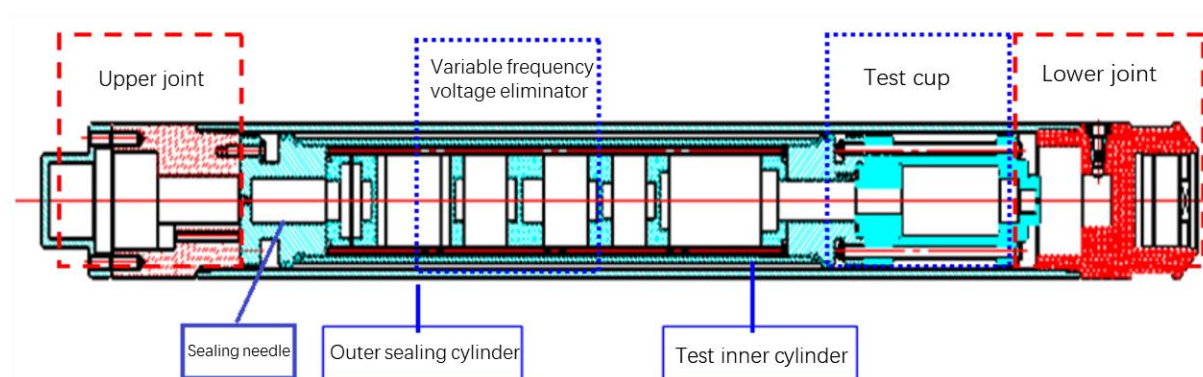


Figure 3. Schematic diagram of downhole monitor structure.

The relevant integrated test equipment is selected to the lower end of the ESP. The power supply is directly connected to the power end of the electric submersible pump for sharing, and it is equipped with a three-phase star-point equipotential standby power supply introduced from the ground. After the relevant signals are obtained, the data is transmitted back by using the principle of the current loop closed loop and relying on the metal sheath of the three-phase armored cable. Realize the full use of multiple functions on the premise of the least relevant components. To ensure the accuracy of data and facilitate computer analysis, a filtering device is set here to fully avoid the influence of common mode voltage and higher harmonics generated during the frequency conversion operation of three-phase asynchronous motor at the power supply end of electric submersible pump.

The ground control system is mainly composed of artificial star point (three-phase reactor), ground filter, data acquisition and processing unit and other core components. Among them, the artificial star point has a strong role, and this device is mainly a three-phase reactor device set artificially. During operation, the related components can cooperate with the three-phase winding at the motor end of submersible pump to form a physical three-phase star point equipment, thus achieving parametric equilibrium during operation. The related ground filter can prevent the common-mode voltage extra interference produced by the star end of the motor to the maximum extent and fully guarantee the data accuracy. The data acquisition module mainly uses MCU microcontroller and corresponding software

component system to ensure the fault tolerance of operation. Fully fit the current signals transmitted from different stages underground and finally convert them into digital quantized data. The latest wireless module can fully guarantee that the data will not be lost after the cable breaks and ensure the perfection of the large database.

Conclusion

To sum up, the intelligent oil recovery technology of electric pump well needs the scientific design of downhole string and the stable operation of multi-parameter stable acquisition and monitoring system. Achieve coordination and unity in "information" and "command". Comprehensively ensure the perfection and efficiency of the oil production process system. Among them, the description of intelligent gas lift pipe string technology as an example is limited by space considerations and does not show the relevant application results parameters. However, the principle of related components is efficient and feasible, and further basic research should be carried out based on the development of material mechanics and fluid mechanics.

Comprehensively optimize the reliability of related downhole tools. In the introduction of multi-parameter monitoring technology, the structure, working mode and hanging position of the current underground monitor are systematically displayed. The next step will be in-depth research on signal anti-jamming and data processing. Make new contributions to oil and gas field exploitation with integrated geological engineering.

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Conflicts of Interest

The authors declare no conflict of interest.

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