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Article

Research on Key Technologies of Intelligent Oil Well Pumping

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Abstract: Rod pumping is commonly used in oilfield development. In recent years, with the development of oilfield development projects, the cost of oil extraction has significantly increased. Therefore, it is crucial to adopt measures to improve the efficiency of mechanical extraction in order to improve the efficiency of oilfield development. Take targeted improvement measures to enhance oil recovery efficiency and truly improve the economic benefits of oilfield exploitation. The article introduces and analyzes the factors that affect the efficiency of mechanical extraction, using system efficiency as the starting point, introducing intelligent management methods, and conducting on-site evaluation of intelligent balance technology for pumping wells, aiming to improve the system efficiency and energy-saving level of pumping wells.

Keywords: pumping well; Intelligent oil well pumping; Efficiency

1. Factors affecting the efficiency of intelligent pumping well systems

From the perspective of the pumping well system, it is capable of continuous capacity conversion and energy transfer. The ratio of effective energy to the inlet energy of the oil well is the efficiency of the oil well production system, and the system efficiency includes surface and downhole efficiency, which is composed of four connecting rods, gearbox, belt, electric motor, etc [1]. The latter is composed of the efficiency of the tubing string, pumping pump, pumping rod, and packing box. The ground factors mainly include the characteristic of alternating load during the operation of the pumping unit, which requires sufficient margin to be left when selecting the capacity of the driving motor. The main underground factors are the power loss of the oil pipe column, which directly affects the efficiency of the oil extraction system [2-4]. The losses mainly include oil pipe leakage loss, friction loss between the produced fluid and the inner wall of the oil pipe, and elastic expansion and contraction loss of the oil pipe [5].

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2. Measures to improve the intelligence and efficiency of pumping wells

2.1 Optimize the inter well opening system of pumping units

The efficiency of a single well system is an important indicator of whether the operation of a rod pumping well is coordinated. The higher the efficiency of a single well system, the less electricity is consumed per ton of oil produced. Based on the principle of "maximizing effective stroke and minimizing production load", we will focus on carrying out inter well opening, parameter optimization, balance adjustment, and other work to improve well pump efficiency by 5.6% and system efficiency by 1.2%. By evaluating the relationship between electricity costs and benefits, the critical yield of ineffective wells is determined to be 0.033 tons/hour. Based on the recovery of the liquid level and the liquid supply capacity of a single well, the shutdown time is determined. The optimal shut in time of 5 days is determined by the liquid level recovery method. By fully relying on the existing digital construction conditions and utilizing intelligent technologies in data collection and remote control, we aim to achieve intelligent management of oil wells.

2.2 Carry out intelligent room renovation

One is to explore the intelligent room opening system. Following the principle of "demonstration and guidance, consolidation and improvement", we will explore the intelligent room opening system. The second is to carry out intelligent room renovation. According to daily liquid production ⩽ $5m^3$ The requirement for all oil wells to achieve intelligent inter opening. With the goal of improving the efficiency of the mechanical extraction system, we will continue to carry out work such as inter well opening, parameter optimization, replacement of small diameter pumps, and balance adjustment. It is expected that the oil pump efficiency of the treated well will increase by 5.9% (35.6 ↑ 41.5%), and the system efficiency will increase by 0.5% (21.9 ↑ 22.4%). Develop a comprehensive management and control platform for back-end interconnection, achieve the "four management and four use" of the company's intelligent interconnection, focus on building shared applications with the group company, create an intelligent interconnection technology model, break down front-end hardware compatibility barriers, refine and improve intelligent interconnection technology specifications, conduct distributed photovoltaic+intelligent interconnection integration technology experiments, and create a new production model of "zero carbon" and "low-carbon". The daily average grid power consumption of the applied well group has decreased from 58.5% to 36.6%, and the production of intermittent pumping wells has remained stable, with an efficiency of ↑ 10% compared to normally open pumps and a system efficiency of ↑ 3%.

2.3 Optimize pumping parameters

On the premise of maintaining stable liquid production, optimize the pumping parameters of the oil well according to the principles of "long stroke, low impulse, and appropriate pump

diameter", improve the efficiency of the pumping pump, implement a plan that is easy to construct on site, and prioritize the implementation of surface measures. Some pumping wells have the characteristics of small production parameters, low single well yield, high energy consumption, and many inefficient wells. The next plan is to implement intelligent interval drilling, and the selection of wells is mainly based on a liquid volume of less than 2 meters ³ Mainly, the interval system is based on 12 hours of operation and 12 hours of shutdown. Compared with before the interval, the single well production remained stable, the pump efficiency increased by 12.0%, and the average daily energy consumption of a single well decreased by 28.5kw. h. In order to study and explore methods for improving the efficiency of machine mining, experiments were conducted on the effects of different production parameters on the efficiency and daily power consumption of machine mining systems, and parameter adjustment and efficiency improvement tests were conducted,. On site experiments demonstrate the quantitative relationship between stroke and impulse frequency on electricity consumption and system efficiency, providing guidance for improving the efficiency of mechanical mining.
Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

2.4 Supporting energy-saving equipment

Strengthen the promotion, use, and management of energy-saving supporting equipment, such as soft start control boxes, power factor dynamic compensation devices, interval controllers, ultra-low impulse belt pulleys, and other energy-saving devices. To address the issues of screw pump blockage and insufficient long-term stability, optimization and improvement work will be carried out. Low swelling stator rubber with preferred characteristics, combined with high gas oil ratio and high aromatic hydrocarbon content, HN70 high acrylonitrile rubber is preferred to enhance its anti swelling ability. The on-site operation situation shows that the improved screw pump has achieved stable swelling after one month of entering the well, and the pump inspection shows that the rubber has not experienced excessive swelling. Carry out wide clearance design and system optimization selection for the stator and rotor, increase the clearance between the stator and rotor, reserve rubber swelling space, and avoid pump jamming due to excessive rubber swelling. In response to the pump efficiency loss caused by the increase in the clearance between the stator and rotor, it is compensated by moderately reducing the pump type and increasing the motor speed, while reducing the starting torque of the screw pump, making it more adaptable. Optimize the transmission mechanism and improve material performance. In response to the problem of pump inspection caused by some electric submersible screw pump transmission systems breaking, by optimizing the transmission system structure and improving the material, the overall operation is stable and there is no breaking fault. The diameter of the protector shaft has been increased from 22.2 ↑ 30mm, the yield torque tested has been increased from 1650 ↑ 2320N · m, the material of the spline coupling has been increased from 2Cr13 to 42CrMo, and the maximum bearing torque tested has been increased from 830 ↑ 1280N · m. The flexible shaft connection thread has been changed to a forward rotating integrated type, and the material has been improved from 35CrMo to 630 stainless steel. The tested transmission torque can reach 1200N · m. Through continuous improvement, the pump failure rate has decreased from 51% in the previous stage to less than 10%. After improvement, the average operation has exceeded 300 days, highlighting the advantages of high efficiency, safety, and intelligence.

3. On site evaluation of intelligent balancing technology for pumping wells

In response to three types of problems: high labor intensity in manual start-up and shutdown of interval wells, and interference between cluster wells, supporting interval controllers and wellhead backflow prevention devices have been introduced to effectively reduce single well energy consumption and employee labor intensity, and improve interval management level. After on-site testing, it was carried out in Changqing Oilfield. The pumping unit model CYJ12-6-73HF and the rated power of the motor were 30kW. The test results are shown in Table 1. The new technology has also changed the traditional manual balancing method, achieving non-stop pumping operations, reducing the labor intensity of workers, and improving the oil well production rate, as shown in Table 2.

Table 1 Comparison of Energy Conservation Data (Pumping unit Model: Motor power/Kw stroke/daily liquid production per stroke/m^3 current/A balance rate/% power consumption/(KW. h))

Name	Model of pumping unit	Motor power/kW	Stroke /stroke count	Daily liquid production/m^3	Current/A	Balance rate/%	Power consumption/(KW. h)
Before use	CYJ12-6-73HF	30	6/2.8	35.5	33/25	74	85
After use	CYJ12-6-73HF	30	6/2.8	37.2	33/32	98	70

Table 2 Application effect of intelligent balancing device

Economic and technical indicators	Conventional beam pumping unit	Intelligent balancing device for pumping units	contrast
Employment/Person	4	0	Intelligent adjustment
Equipment situation	1 crane/time	0	Intelligent adjustment
Balancing time/min	120	0	Intelligent adjustment
Effective pumping rate/%	98.7	100	1.3

From Tables 1 and 2, it can be seen that under the same liquid production rate, compared with traditional methods, the balance rate of the new technology has increased from 74% to 98%, and the daily power consumption has decreased from 85 kW · h to 70 kW · h. At the same time, non-stop pumping operations were achieved, and the effective pumping rate of the oil well increased from 98.7% to 100%.

4. Conclusions

In short, ensuring the efficiency of oil extraction is the key to improving the level of oil extraction in the process of oilfield extraction. The improvement of the efficiency of the pumping well mechanical extraction system involves various tasks such as surface equipment, wellbore technology, and daily management of the oil extraction system. For the improvement of the efficiency of the pumping system, it is necessary to optimize the selection of pump rods, adjust surface pumping parameters, inspect pump operations, and take corresponding measures from the perspective of technical and production management to comprehensively improve the efficiency of the pumping system.

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