Adaptability Analysis and Optimization of Oil Well Energy Saving Motor

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Abstract. Motor is the core energy consumption node of mechanical mining system, and also the key point of energy saving potential of mechanical mining system. At present, there are two main problems in the use of matching motor of mechanical oil production system: one is that the types of oil well motor are complex and the performance index is uneven; the other is that the oil well working conditions are complex and diverse, and there is no basis for motor selection.

In view of the above problems, in order to reduce the power consumption of high energy consumption motor, improve the rationality and scientificity of oil well energy-saving motor selection and matching work, effectively improve the operation efficiency of mechanical production system and reduce energy consumption, the adaptability of oil well energy-saving motor is carried out. Taking the energy-saving motor of oil pumping unit as the research object, through no-load, locked rotor, pumping unit simulated load, field calibration and other testing means This paper evaluates the comprehensive quality of the energy-saving motor of oil well from the systematic point of view, and studies the optimization method of the matching between the energy-saving motor and the pumping unit.

1. Types and Characteristics of Energy Saving Motors for Pumping Units

From the perspective of oilfield scope, the energy-saving motors currently in use mainly include y (Y2) series three-phase asynchronous motor, permanent magnet synchronous motor, DC motor, ye3 (YX3) series high-efficiency motor, dual power motor, multipole multi speed motor, switched reluctance motor, high (ultra-high) slip motor, linear motor, electromagnetic speed regulating motor, gear reducer motor, AC servo motor, etc.

In order to further select energy-saving motors suitable for pumping unit operation, we have carried out classification research

(1) Ye3 (YX3) series high efficiency motor

High efficiency motor is a kind of three-phase asynchronous motor with high efficiency. By taking measures in design, material and technology, such as adopting reasonable stator, rotor slot number, fan parameters and sinusoidal winding to reduce loss, the efficiency can be increased by 2% - 8% and the average increase is 4%. It has the characteristics of high efficiency and long service life, and can completely replace the ordinary three-phase asynchronous motor. However, due to its high speed, if it is used in the oil well with low stroke rate, additional speed reduction (speed regulation) device should be added.

(2) Dual power motor

Double power motor belongs to three-phase asynchronous motor, which is different from the ordinary three-phase asynchronous motor in that each phase coil is composed of two groups, which can be
operated by one group alone or two groups, with two different power levels. After adding a specific control module, the motor operates in high power (high torque) gear during start-up and heavy load, and automatically switches to low-power gear when the load decreases. This special operation mode is more suitable for the equipment with large load start and small load operation. However, the essence of dual power motor is ordinary asynchronous motor, and its operating efficiency is lower than that of high efficiency motor with the same power.

(3) Switched reluctance motor (system)
Switched reluctance motor (SRM) is mainly composed of switched reluctance motor (SRM), power converter, controller and position detector. It is a new type of speed regulating motor. The speed regulating system has the advantages of both DC and AC speed control systems. It is the latest generation of stepless speed regulation system after frequency conversion speed regulation system and brushless DC motor speed regulation system. It has the advantages of simple structure, wide speed range, excellent performance, high efficiency and high reliability in the whole speed range. However, its cost is high, and the performance is not high at low speed. It needs to be equipped with special power electronic device control cabinet, and its stability and reliability in pumping unit well site need to be further verified.

(4) High (ultra high) slip motor
High slip motor is to improve the slip rate and rotor resistance by changing the rotor groove shape and guide bar material, so that it has the characteristics of larger locked rotor torque, smaller locked rotor current, higher slip ratio and soft mechanical characteristics. When it drives the impact load, the speed of the motor drops more, so it can release the stored functions of the flywheel of the equipment being towed. High slip motor is suitable for driving flywheel with large torque and uneven impact load, as well as many times of reverse rotation. At present, in the field of energy-saving products, the biggest application of high slip motor is oil field pumping unit system. In summer, especially in the field pumping unit well site, the temperature rise of the motor is slightly higher.

(5) Multi pole and multi speed motor
Most of the multi speed motors are cage rotor motors, and their structure is similar to the basic series of asynchronous motors. The speed regulation is realized by changing the series parallel relationship of motor windings through external switch switching. At present, domestic production has double, three, four speed and other categories. This kind of motor, in essence, belongs to ordinary three-phase asynchronous motor, and its operation efficiency is not high when it is applied to oil wells. The main energy-saving principle is that when the working conditions of oil wells change, the speed can be adjusted without the help of speed reduction and speed regulation device, so as to reduce or increase the stroke times and reduce the energy consumption on the premise of ensuring the liquid volume. The connection between the motor and the control box requires four 3-core power cables, which makes the control box slightly complicated.

(6) Permanent magnet synchronous motor
The working principle of permanent magnet motor is the same as that of electric excitation synchronous motor. The difference is that permanent magnet is used to replace excitation winding for excitation, so as to avoid excitation loss (copper loss) caused by magnetic field generated by excitation current. Compared with the traditional electric excitation motor, permanent magnet motor, especially rare earth permanent magnet motor, has the advantages of simple structure, reliable operation, small volume, light weight, high efficiency, high power factor, flexible and diverse shape and size of motor, which has been widely used in oil field in recent years.
At present, the number of low production liquid wells in the oilfield is increasing. In order to improve the displacement coefficient of oil well pump, it is necessary to reduce the oil well stroke. To meet this demand, the technology testing center has developed a multipole low-speed permanent magnet motor (16 pole, 24 pole), with the minimum speed of 250r / min. without any speed control device, the oil well stroke can be reduced to 1min-1 without any speed control device The energy saving effect is remarkable.

(7) DC motor
DC motor is a rotating device that converts DC electric energy into mechanical energy. According to the configuration of common brush commutator, DC motor can be divided into two categories,
including brushless DC motor and brushless DC motor. The biggest advantage of DC motor is good speed regulation performance, which can realize uniform and smooth stepless speed regulation under heavy load conditions, and has a wide range of speed regulation. However, with the continuous development of AC motor speed control technology in recent years (such as frequency conversion technology), the advantages of DC motor are gradually weakened.

(8) Linear motor
The linear motor changes the rotary motion of the motor into a linear motion, and the motor bracket replaces the pumping unit. The motor directly drives the rod of the pumping unit to move up and down, eliminating all the deceleration transmission equipment and occupying a small area. The disadvantages are that the efficiency of the motor itself is low, the control circuit is complex, the harmonic component is large, which causes the voltage waveform distortion of the transformer, and the price is high.

(9) Electromagnetic adjustable speed motor
The electromagnetic adjustable speed motor can realize the stepless regulation of the speed, and can adjust the speed of the motor conveniently according to the needs, so as to achieve the purpose of controlling the oil well stroke and production. Because it is very simple and fast in adjusting the punching times and controlling the output, it can save a lot of workload and cost of replacing the belt pulley. However, the electromagnetic speed regulation system consumes a part of electric energy, resulting in low overall efficiency of electromagnetic speed regulating motor, which belongs to high energy consumption elimination motor.

(10) Gear motor
The reducer gearbox is installed on the end cover of the motor, and its shape is basically the same as that of the ordinary motor. According to the different speed of the motor equipped, its output speed is 180-300 rpm. Advantages: the rated power of the motor is greatly reduced by 4-5 power levels, the gear transmission efficiency is higher, and the use efficiency in the wells with low liquid production rate is particularly improved; and the volume is small, the weight is light, and the price is low. Disadvantages: there is a mechanical gear reducer, there is lubricating oil in the gearbox, there is a certain amount of maintenance work every year, and the efficiency and power factor are not high.

(11) AC servo motor
As a high-performance, digital and intelligent drive system of pumping unit, AC servo motor system has high control precision and dynamic response speed. The built-in motion control function improves the control level of pumping unit. Advantages: the speed adjustment is convenient, combined with the pumping unit monitoring system, the variable speed operation control of the pumping unit can be easily realized, and the high power factor can be maintained under different load rates. Disadvantages: the test efficiency of control cabinet and motor is not high, the control circuit is complex, and the anti overload ability of the whole system is poor.

Through the research on the types and characteristics of energy-saving motors in oil wells, the electrical characteristics, advantages and disadvantages of various types of energy-saving motors are preliminarily mastered. According to the special working conditions of oil well production, it is recommended to select permanent magnet synchronous motor, ye3 series three-phase asynchronous high-efficiency motor, multipole multi speed motor and high slip motor for pumping unit load. The specific working conditions (site conditions) of which energy-saving motor is selected need to be verified in the next step.

2. Selection Principle of Energy Saving Motor for Pumping Unit
(1) Motor selection principle
① The motor selection follows the principle of reliable performance and moderately advanced performance, and meets the requirements of grade 2 energy efficiency standard requirements of "energy efficiency limits and energy efficiency grades for small and medium-sized three-phase asynchronous motor", so as to avoid the risk of backward elimination in the near future.
② Motor selection should be combined with relevant historical data, use and other comprehensive consideration. On the premise of meeting the requirements of mechanical load, the type and rated
power of the motor are determined economically and reasonably, and the characteristics of the selected motor and the mechanical load being driven are matched.

③ The locked rotor torque, maximum torque, minimum torque, speed and its regulation range of the motor shall meet the requirements of the load driven by the motor under various operation modes.

④ The motor with high operation efficiency, high power factor and good power saving effect is verified in laboratory and field.

⑤ For the mechanical load that needs speed regulation, the motor suitable for speed regulation mode should be selected according to the factors such as speed regulation range, efficiency and long-term economic benefits.

(2) Motor selection method
On the premise of meeting the requirements of mechanical load, the type and rated power of the motor are determined economically and reasonably. The selected motor matches the characteristics of the mechanical load being driven.

In principle, high-efficiency three-phase asynchronous motor (ye3 Series) and permanent magnet synchronous motor are the main motor renewal methods. Under the condition of low liquid volume and low load, the low-speed motor is preferred, and the comprehensive consideration should be given to the well condition and the motor in use. The specific methods are as follows, as shown in table 2-8

① Under normal working conditions, permanent magnet synchronous motor is preferred for oil well (pump displacement coefficient ≥ 0.45), followed by ye3 series high efficiency motor;

② For wells with insufficient liquid supply (pump displacement coefficient < 0.45), low-speed permanent magnet motor is preferred;

③ For oil wells with large liquid production variation (such as steam huff and puff wells), multipole multi speed motor or ye3 series high efficiency motor matching frequency converter is selected;

④ High slip motor with good starting performance is preferred for the well with deep hanging depth and heavy load.

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