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Selection method modelling and matching rule for rated power of prime motor used by Beam Pumping Units

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ABSTRACT

The energy consumption of prime motors used in oilfields is the one-third of the total energy consumption of beam pumping unit wells. In order to keep initiating and operating the prime motor smoothly and safely, its actual rated power is high much more than the needed. With the intention of improving the efficiency of the prime motor and decreasing the cost of rod-pumping, a set of rated power calculated methods and a set of matching templates was built up under the regarding conditions such as the changing rule of the system load, the heating of the prime motor and the overload torque in the initiate processing. The tested data indicated that, after replacing the prime motor with lower power, the active power, the inactive power and the suspended polished-rod load were all decreased substantially.

1. Introduction

Oil and gas are one of the main energy resources that are difficultly replaced in the modern society. They are called black gold to economic and are the main materials for the petrochemical industry. With the development of economy, the target of energy-saving, emission-reduction, green and low-carbon production are our goal (Pang and Liu, 2004; Feng, 2006). Oilfields are great customers for power consumption, and had the responsibility to design the beam pumping units in order to improve their performance. The total consumed power of the Daqing oilfield is 99 hundred million kilowatt-hours, where the artificial lift occupied one-third. The “big motor drive small rod-pumping” always existed in the past, which was constantly denounced (Bai and Zhang, 1999; Bai et al., 1999). Power-reducing of the beam pumping units is a big issue needed to be solved.

In 1993, Tang et al. (Tang and Zhang, 1993) considered the oversize rated power of the prime motor was one of the main reasons for the low efficiency of rod-pumping systems. The authors regressed the grand efficiency function of the beam pumping unit by using tested data, and analyzed the reasonable selection methods for the rated power of the prime motor. In the end, the investigators drew the conclusion that the utilization ratio of the nominal rated power was not higher than 35%. The grand efficiency of rod-pumping units was in the scope of 65–75%, while the utilization ratio of the nominal rated power was in the scope of 20–35%.

In 2009, Duan et al. (Duan and Zhang, 2009) analyzed the running mechanical characteristic of the prime motor and the load characteristic of the beam pumping units, setting up a selection motor template though the stroke, the frequency of stroke and the polished-rod load ratio. Sixty-eight oil wells were optimized by this motor selection template. The tested results indicated that the power of motor decreased 2.3 kW averagely, and the power consumption per day was decreased 4.2 kW h on average. Actually, the current documents for selecting motor in oilfield are not enough. With all kinds of energy-saving motors had been applying in the oilfields, the guiding theory and method of optimized selection motor is needed urgently.

According to the calculated model of the prime motor output torque and the motor working pattern, a set of selecting method of the motor rated power was set up with the considering of polished-rod load change rule, heat of motor, initiate power and overload of torque. A set of motor matching template was also set up, which is suitable to be applied in the oilfields. The tested results indicated that application of this paper's motor selection method could decrease the rated power of the prime motor and could improve the efficiency of the prime motor.

2. Selection method of the prime motor of the beam pumping units

The prime motor of the beam pumping units undertakes the variable loads and continue period working manner. Therefore, the selection of the prime motor must be conducted in the follow principles:

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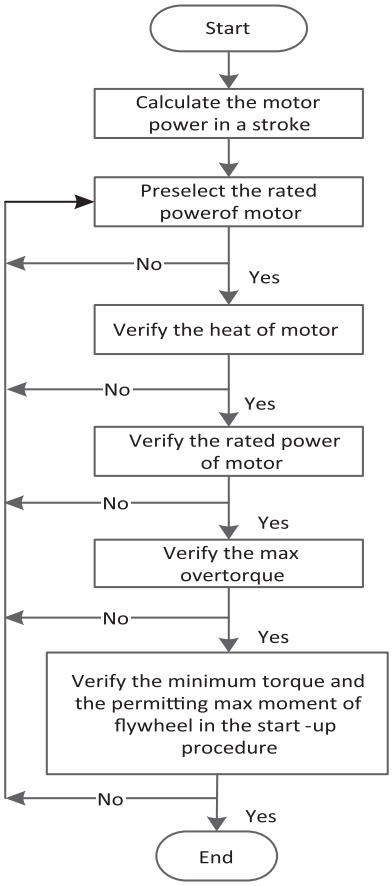

Fig. 1. Selection process of rated power of motor.

1) The rated power of the prime motor must be utilized as substantially as possibly;
2) The maximum running temperature of the prime motor must not exceed the allowable value;
3) The overload and the initiate capacities of the prime motor must be satisfied to the demand of load.

2.1. Selection program of the prime motor of the beam pumping units

The selection program of the prime motor of the beam pumping units in the oilfield is shown in the following: (Fig. 1).

2.2. Predictive selection of the rated power of the prime motor of the beam pumping units

The motor load of the beam pumping units is changing continually and belongs to continua period working pattern. Therefore, the prime motor must be predictively selected at first. Then, the heating and overload of the predictive motor must be verified. If the verified results indicate that the rated power of the prime motor is not enough for the corresponding working conditions, the predictive selection of the prime motor must be remade.

The formulas for the predictive selection of the prime motor are expressed as follows:

$$p_e = k \cdot \overline{p} \tag{1}$$

p_e the rated power of the prime motor using in the oil well;
$\overline{p}$ the equivalent averaged output power of the prime motor using in the oil well, kW;
k the heat growing coefficient of the prime motor, in general, it is in the scope of 1.1–1.6.

$$p = \frac{n \cdot T}{9549} \tag{2}$$

p the transient power of the prime motor, kW;
T the output torque of the prime motor, kN m;

$$\overline{p} = \frac{\int p dt}{t} \tag{3}$$

t a stroke time of beam pumping units, s;
$\overline{p}$ the equivalent averaged power of the prime motor, Kw.

Within a given condition of construction parameters of the beam pumping units and the swabbing parameters of the oil well, the transient output torque of the prime motor could be calculated by the follow formula (4):

$$T = \frac{1}{i\eta_m^m}\left[\eta_b^m\left[W - B + \frac{J_b}{A}\varepsilon_b\right]\overline{TF} - M\sin(\theta + \tau) + J_p\varepsilon\right] \tag{4}$$

i the total transmission ratio from the motor axis to the output

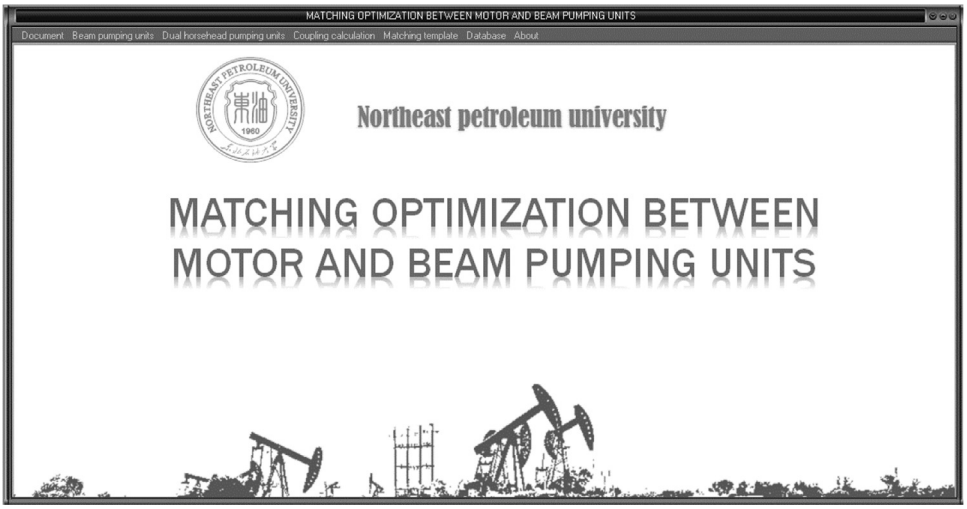

Fig. 2. Interface of the reasonable matching optimize program.