

APPLICATION OF BEAM PUMPING UNIT ENERGY SAVING TRANSFORMATION TECHNIQUES IN DAQING OILFIELD

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Abstract:

Daqing oilfield has been developed for 49 years. The conventional pumping unit(BPU) is the main artificial lift method which has been applied in more than 30,000 wells in the oilfield. Therefore, the overall power consumption each year of beam pumping units is a considerably high which resulted in heavy pressure on the development cost of the company. After years of study, a series of innovative transformation techniques based on the conventional BPUs have been developed to improve the system's mechanical properties. These innovative techniques have been proved to an inevitable trend for energy-saving and reducing consumption of oilfield. This paper presented these transformation technologies including: 1) conventional pumping unit transformation, 2) Y series motor transformation, and 3) cabinet panel transformation. In this paper, both technical feasibility study and economic benefit were introduced. Application indicated that, after using these energy saving technologies, the operating status could also be improved as well as the running life be prolonged considerably.

Keywords: beam pumping unit; motor; cabinet panel; energy-saving transformation

1 Introduction

The pumping system consumes about 3 billion kilowatt-hour every year in Daqing Oil-field. If we can improve the system efficiency by one percent increments, we can save at least 100 million kilowatt-hour every year. We must precipitous upturn the system efficiency to found an energy saving enterprise. Recent time, for saving energy and decreasing consumables, every institute and manufactory take a large number of research and development in principle of pumping structure, electrical motor dynamic characteristics and electric control technology. In order to reduce the production cost which is the result in model changed, we transform the conventionally pumping system for saving energy, including pumping unit, electrical motor. The transformation is generally used in crude

oil exploitation. It is one important means to save energy, decrease crude oil cost and improve economic efficiency of oilfield.

2 Energy-saving transformation for conventional beam pumping unit

There are more than 30,000 Conventional beam pumping units in Daqing at present. Due to its simplicity, reliability and durability, beam pumping unit has been the dominant lift method in Daqing Oilfield. But due to structural limitation, load fluctuation range is large. It makes energy efficiency slow down, resulting in a waste of energy. Take a Daqing production factory as an example: There are 1996 pumping units now, including 975 conventional pumping units which occupy a total installed capacity of 49.6 percent. If every conventional pumping unit saves 1 kilowatt-hour, we can save 975 kilowatt-hours in total every day, and 356 thousand kilowatt-hours in total every year. It can not only save a large number of energy, but also alleviate the tension situation of using electricity on oilfield. It can get both economic benefits and social benefits.

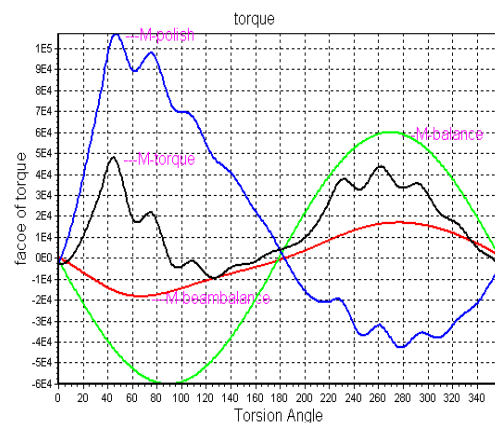


Figure 2 Torque Curve of Lower Barbell Pumping Unit

In the beam pumping unit's operational process,

whether the counterbalance effect is good plays an important role in energy consumption. At present, both conventional pumping unit and bias pumping unit use the principle of crank balanced. The pumping unit which uses the principle of crank balanced cannot take complete balance except the crank circles to a certain angle. In order to reduce energy-saving inputs and improve the conventional pumping unit counterbalance effect, we actively explore the energy-saving transformation of conventional pumping unit. Now the main machine models which have small changes in the models, are easy to take effect and good at saving energy are lower barbell pumping unit and dual horse head pumping unit.

2.1 Transformation of lower barbell pumping unit

We use the principle of compounding balanced in the lower barbell pumping unit. When the horse head of the pumping unit accesses the maximum polished rod load, the actuating arm of beam balanced core is the longest; when the horse head of the pumping unit accesses the minimum polished rod load, the actuating arm of beam balanced core turn shorter, for the purpose of adjusting the actuating arm. It makes the pumping unit have better counterbalance effect.

The transformation to lower barbell pumping unit is based on the structure of the conventional pumping unit. We fix a barbell which has a certain weight and a certain angle on the beam tail of the beam pumping unit. It makes full use of the space which is surrounded by connection rod, cross beam, supporting frame and reducer gear box.. The barbell is constituted

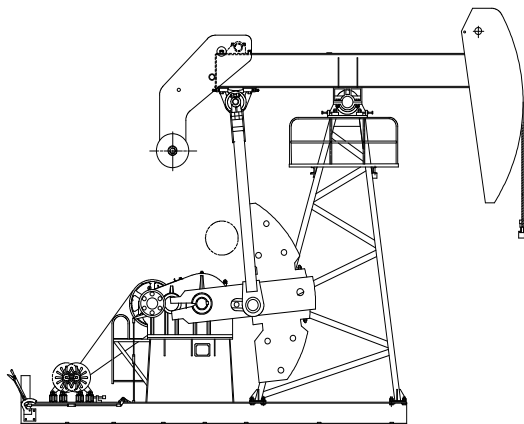


Figure 1 Modified Lower Barbell Pumping Unit

by many circular castings, which can adjust the barbell weight. It is affixed on the steel plate across the balance beam and joined with the balance beam. And in the transformation process, we should make use of the original components and structure as more as possible for reducing the transformation amount of work and decreasing the transformation cost. Structure as shown in Figure 1

In the Figure 2 of the torque balance curve of lower barbell pumping unit, it shows that crank balancing torque curve is a poid which is symmetrical distributing. If the crank balanced is not bias, the peak value at the up stroke position occurs when the crank street corner reaches 90 degree and the peak value at the down stroke position occurs when the crank street corner reaches 270 degree. The peak value of loading torque curve does not correspond to the peak value of crank balanced torque curve, which results in fluctuations of torque curve, the bias peak value at the up stroke position and existence of negative torque. After fixing lower barbell, torque curve generated by the moving of balance beam lower barbell make the peak value of the torque curve produced by the reducer casing take-off spool slow down. This alternation makes the fluctuation more stable and the counterbalance effect of pumping unit much better, which can prolong the using time of reducer casing.

2.2 Transformation of dual horsehead pumping unit

The dual horse head pumping unit improves counterbalance effect by altering the changed law of pumping unit torque factor. When the dual horse head pumping unit works, it can be in the state that counter balance arm of force becomes longer as the load increases and counter balance arm of force becomes shorter as the load decreases, so as to achieve to save energy.

The transformation to dual horse head pumping unit is as the followed Figure 3. When the dual horse head pumping unit works, the alteration of load torque

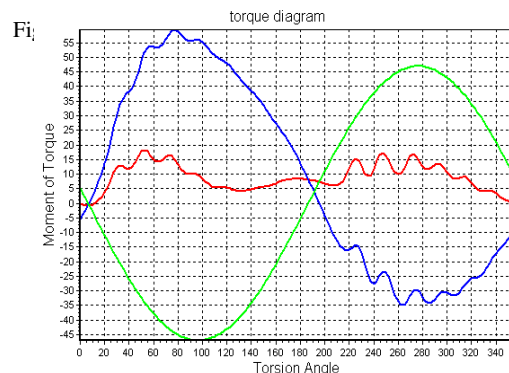
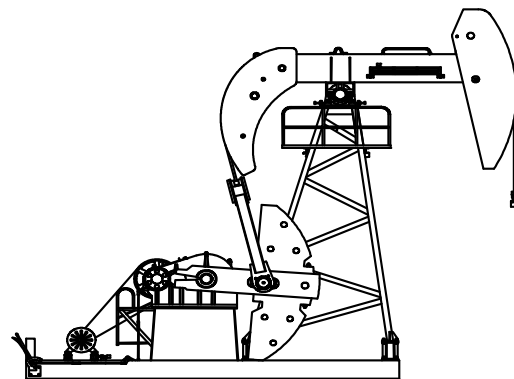


Figure 4 Torque Curve of Dual Horsehead Pumping Unit

curve is close to law in changes of sine function. And the alteration of crank balancing torque curve is close to law in changes of cosine transformation. The two peak values offset each other, which reduce the torque crank fluctuation and decrease installed efficiency. Then we achieve to save energy. Show the torque characteristic curve in the followed Figure 4.

For the two energy-saving transformation of pumping unit, the development of the lower barbell pumping unit is base on beam pumper, Its main features are: Energy-saving effect of significantly、durable and high-reliability; Simple structure, easy for the adjust parameters; Low maintenance costs.

Although the dual horsehead pumping unit has a good energy-saving effects, but there is the shortcoming which hoist cable of the behind horse head is easy to fatigue failure, there is poor reliability in the behind horse head connects with the beam. This shows that under the lower barbell pumping unit will become the preferred method of energy-saving transformation,

3 Energy Saving Transformation for Y serial Motor

Pumping unit is the lifting equipment of the sucker-rod pumping system, the sucker-rod is transmitting equipment of the force. When the sucker-rod up going and down going, its load is periodic changed, it makes large waviness of the pumping unit torque and the motor current. When Y serial motor works in the periodic changed load, the motor efficiency is between 40 percent and 60 percent, the motor power factor is between 0.3 and 0.5, the energy consumption is severe consumptive. If we exchange a new energy saving motor directly, it will increase manufacturing cost, so the motor transformation for energy saving will be an important means to reduce manufacturing cost. At the moment the proven technique contains three schemes in Daqing oil-field: the high torque transformation、the magneto motor transformation and the double capacity transformation.

3.1 High torque transformation for Y serial motor

In order to increase the rotational magnetic field intensity and improve motor torque, we take the high torque transformation for Y serial motor by decreasing motor coil number of turns and increasing sectional area of the traverse line. But because of the decreasing of the number of turns, which makes the excitation current larger, energy-saving effectiveness of the motor drops in a certain degree. Although this means becomes mature in the technology and the transformation cost is low, energy-saving effectiveness is not good in contrast. A statistics of 42 wells in Daqing oil-field shows that the average energy-saving rate is 9.85%.

3.2 Magneto motor transformation from conventional Y serial motor

In the course of the magneto motor transformation, we should exchange the original rotor to the magneto rotor which makes the rotor have high intensity magnetic field for improving power factor and decreasing the stator current and the resistance loss .In order to achieve the stator and the rotor to be suitable, the original carcass is discarded, the motor cage is used finally. So The magneto motor transformation cost is high.

The changed magneto motor has high efficiency and power factor. It has a large driving torque and high overload capability. But it cannot match exactly with the pumping unit load and the motor torque. Its starting property is not flexible, the motor easily shocks when it starts. The motor is easily demagnetize.

3.3 Dual power motor transformation for conventional Y series motor

The process of the transformation to dual power motor is simple and the cost is cheap. When the motor switches on, we connect the switched wending for the sharp of Δ so as to meet the requirement of the high torque. After switching on, the motor starts failure-free operation. When the motor operates in normal, the load drops, The motor power drops to operational power in the means of motor power's switch from the original coil to the operating coil. In the entire operation process, the running power is decided by the load.

As we achieve the exactly match between the operating load and the output, which ensure that the motor always operates efficiently, the process of the automatic control is simple、operates stable and save energy significantly. The active energy-saving rate is about 19 percent.

Based on the above analysis, the energy-saving transformation to dual power pumping unit is the best means for some time because of its low cost and significant Energy-saving.

4 Energy-saving transformation for conventional cabinet panel

At present in Daqing the energy-saving transformation of the cabinet panel divided into two kinds: one is the transformation for variable voltage control box which can regulate the input voltage; the other is the transformation for wattles compensating control box which can improve the power factor and the quality of the power supply.

4.1 Regulating voltage and saving energy transformation for conventional cabinet panel

We divided the control box of regulating voltage and saving energy into two: one is making the port-voltage turn less as the load turning more, which can make the electric motor work in good condition; the other is using the microprocessor drawing of sample and non-contacting reversing switch ,which makes the electric motor work in Y and Δ . The energy-saving principle is that when the electric motor light running it declines input voltage、decreases magnetic flux、decline wear and tear and improves availability ration. In addition, when light running, we decline input voltage, but the rotate speed not change and the output torque turns short, so we improve charge rate.

4.2 The wattles compensating transformation for conventional cabinet panel

We divided wattles compensating control box into two kind: quiescent control box and dynamical control box. The composition of the quiescent wattles compensation is simple. It across a capacitor or a batch capacitor at the input header. Dynamical wattles compensating across a batch capacitor at input header. According to the change of the load microprocessor controls the capacity put in by capacitor. Doing as above can improve not only the power supply quality, but also the power factor.

5 Application

5.1 Energy-saving transformation for beam pumping unit

Up to the end of 2007, there are 340 lower barbell pumping units used in Daqing. Because the transformation for the dual horsehead pumping unit is complex and the failure rate is high, we don't use this transformation elementarily. The comparison of transformation to lower barbell pumping unit and before in one oil production factory in Daqing as followed.

Table 1 Effect comparison of the transformation to lower barbell pumping unit

<i>pumping unit type</i>	<i>measure</i>	<i>real power (kW)</i>	<i>P.F.</i>	<i>current (A)</i>	<i>Electricity saving rate (%)</i>
six molding	before	4.01	0.25	26.96	16.87
	after	3.33	0.24	24.37	
ten molding	before	8.04	0.3	39.57	21.99
	after	6.28	0.25	34.72	

5.2 Energy-saving transformation for Y serial Motor

Because there are some malpractices in the transformation to high torque pumping unit, we don't use this kind of transformation at moment. According to the statistics of 138 magneto synchronous motor which are reformed from conventional motor, we can save 50.1kwh every day on average, overall efficiency of energy-saving reaches 20.9%. If payout 13187 RMB for transforming one electric motor, we can save expense 25RMB every day, and after 17.6 months we can take back the transformation expense.

According to the statistics of 230 transformed double winding electric motors used in one oil production factory in Daqing, the brownout rate reaches 16.9%,we can save 40.6kwh every day. If payout 9061 RMB for transforming one electric motor, we can save expense 20.3RMB every day, and after 14.8 months we can take back the transformation expense.

Shown as the data above, the transformation to double winding electric motors can take back benefit ahead 3months compared with the transformation to magneto synchronometer. Magneto synchronometer may demagnetize, which increases maintenance cost. So we should take the transformation to double winding electric motors the first choice way in next period.

5.3 Energy saving transformation for conventional cabinet panel

There are almost 4000 energy efficient control boxes using in Daqing now. According to the scene test result, the brownout rate can reaches 5-8% if we use energy efficient control box. We can save electricity 10~30kwh one well every day on average, and 4000kwh one well one year, Amounts to saving 1485.2×104 kwh one year.

6 Conclusions

The means of the transformation for pumping unit and ancillary equipment are many, but the means that can both achieve to run easily in technical and gain profit in short time are less. At present the better plans of energy-saving transformation are as followed:

- 1) There are two means to take energy-saving transformation, the better one is the transformation to lower barbell pumping unit.
- 2) There are many means to take energy-saving transformation for motor, the best one is the transformation to dual power motor.

In short, we should use the original components as much as possible in the energy-saving transformation process. The technical plan should be simple and easy

to operate. The initial investment and the repayable period can match each other exactly. With the level of scientific research improving constantly, the structure of the pumping unit will be more reasonable. The new means of the transformation will be more simple. I am willing to cooperate with colleagues to improve petroleum engineering and technology.

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