Monitoring of the operation of surface-driven screw pumping units using expert control systems

A Yu Davydov

Ufa State Petroleum Technological University, Branch of the University in the City of Oktyabrsky, 54a, Devonskaya St., Oktyabrsky, Republic of Bashkortostan, 452607, Russian Federation

E-mail: alex-dy@yandex.ru

Abstract: The article deals with screw pumping units with a surface drive. A hardware system combined with a control expert system was developed. It can be used to monitor and control the operating modes of screw pump units.

1. Introduction

Under the late or final stage of field development in Russia, well fluid has high viscosity due to an increase in asphalt-resin-paraffin deposits in its composition. Deposits with non-Newtonian and high-viscosity oil and low reservoir pressure are developed which increases the number of low-yield wells [1–4].

A promising way to operate low-yield wells with high-viscosity oil is the use of screw pump units. Reduced life time of screw pump units with a submersible electric motor due to the high speed of rotor rotation causing rapid equipment wear should be taken into account. As a result, it is more promising method to use a surface drive to rotate the pump screw using a rod column that has a low rotor speed.

At the same time, the areas of increased curvature and slope of the profile of production wells complicates operation of these wells. Wear of rod strings and tubing in areas of strong curvature of the well reduces the turnaround time between installations [5].

2. Research

On the basis of the analysis of statistical data on commercial operation of the anti-personnel trap generator, the following conclusions were drawn. Upper rod failure was frequent. This is due to the fact that the upper end of the column of rods is rigidly fixed which increases rigidity of the upper rods, and they become less resistant to fatigue failure [6].

During the use of the pump, torsional oscillations of the “screw-string” system arise due to the falling characteristic of the friction coefficient depending on the speed of the rubbing surfaces of the stator and rotor rubber cage which causes premature wear of the rotor surfaces and the stator rubber casing, fatigue wear of the rods, lapel tubing, etc. [7]. The studies show that in order to improve reliability of the pump, drive rotation frequency should be above critical rotation frequency, given that the critical rotation speed depends on the configuration of the screw pump unit and operating conditions, as well as on the operating parameters of the installation and properties of the pumped fluid [8].

3. Hardware system
A hardware system (Figure 1) equipped with sensors and using modern information technologies — an expert control system based on a programmable panel controller with the Linux operating system [9], was developed to control the pump operation.

The electric motor installed on the pump has a power of 5 kW and requires a power of 380 V 50 Hz. But the unit is not equipped with a gearbox to change the engine speed. To eliminate this drawback, a frequency converter is installed (hereinafter referred to as the FC). It changes the frequency of the network to reduce the number of revolutions and controls the frequency of revolutions of the engine by reading the EMF at one of the phases. Another emergency function is current control used to prevent jamming of the gearbox [10].

In order to control the revolutions of the polished rod, a turn-on sensor is use. It is based on the use of an instrument to monitor the metal approximation. The controller records the time between half revolutions. A torque meter with a pressure sensor to monitor torsional vibrations is also installed [11].

A flow meter and pressure and temperature sensors are installed on the flowline.

The control is performed by a program-logic controller (PLC) installed in the control cabinet. All sensors are connected to the control cabinet.

The PLC is connected to the computer via the Modbus TCP protocol. A special Scada software is installed on the computer to control the operating modes of surface-driven screw pump units by changing the operating parameters of the unit (engine speed, cut-off limit values, etc.) [12].

The control system is used to monitor and quickly control the operating modes of a screw pumping unit with a surface drive, thus increasing its reliability and efficiency, turning it off in emergency situations, and also controlling the parameters of the produced fluid.

In order to work offline, it is proposed to use an expert system for the unit (Figure 2) [13].

The expert system is based on the results of studies of the mathematical model of the “screw-string” system, and the resulting dependencies of torque non-uniformity on the rod diameter, rod string length, screw diameter, screw length, screw preload, pump operating pressure, etc., for operational control of operating modes of screw pump units.
Figure 1. The system controlling screw pumping units with a surface drive: 1 - torque meter; 2 - rod column; 3 - column head; 4 - screw pump; 5 - electric motor; 6 - gearbox; 7 - stuffing preventer; 8 - power; 9 - programmable controller; 10 - computer; 11 - pressure sensor; 12 - frequency converter counting revolutions; 13 - rev sensor.
4. Conclusion
The hardware system applied along with the control expert system allows for monitoring and controlling operating modes of the screw pump unit with a surface drive, increasing its efficiency and reliability eliminating emergency situations, and monitoring the parameters of produced fluid.

References
[1] Mukhametshin V V 2018 Bottomhole formation zone treatment process modelling with the use geological and geophysical information IOP C. Ser.: Earth Env 194(2) 022024
[2] Yakupov R F, Gimazov A A, Mukhametshin V Sh and Makaev R I 2018 Analytical method for estimating efficiency of oil recovery technology in case of bottom water-drive reservoir, verified on the hydrodynamic model Oil Industry [in Russian – Neftyanoye Khozyaystvo] 6 66-69
[3] Kozikhin R A, Daminov A M, Fattakhov I G, Kuleshova L S and Gabbasov A Kh 2018 Identifying the efficiency factors on the basis of evaluation of acidizing of carbonate reservoirs IOP C. Ser.: Earth Env 194(6) 062013
[4] Mukhametshin V Sh, Kotenev Yu A and Sultanov Sh Kh 2018 Assessment of the Need to Stimulate the Development of Hard-to-Recover Reserves in Carbonate Reservoirs IOP C. Ser.: Earth Env 194(8) 082027
[5] Konnov Yu D, Sidorkin D I and Khabibullin M Ya 2018 Mechanization of technological process of round-trip operations in well servicing and workover SOCAR Proc. [in Russian – Naychnie Trudy] 2 15-24
[6] Suleimanov R I, Zainagalina L Z, Khabibullin M Ya, Zaripova L M and Kovalev N O 2018
Studying heat-affected zone deformations of electric arc welding *IOP Conf. Ser.: Mat. Sci.*
*327*(3) 032053

[7] Gabdrakhmanov N Kh, Davydova O V and Valeyev M D 2018 Studying gas separation at the
inlet of the oil well bottom pump *IOP C. Ser.: Earth Env.* 194(8) 082011

[8] Suleimanov R I, Gabdrakhimov M S, Khabibullin M Y, Zaripova L M and Vasilyeva E R 2018
The study of hydraulic hammer device in drilling tool assembly in hydraulic rotary drilling
*Int. J. of Engineering and Technology* 7(2) 28-30

[9] Bailey M P and Ondrey G 2015 Twin- and triple-screw pumps for a variety of fluids *Adv. Eng.*
*Res.* 122(10) 40

[10] Brandt J U, Lewerenz J, Müller-Link D, Reichwage M 2015 Development of a multiphase down-
hole twin-screw pump and its use in multiphase-operated transport networks *Oil Gas-Eur. Mag.*
*41*(3) 153-156

[11] Muhammed A and Childs D.W 2016 Vibration modeling and experimental results of two-phase
twin-screw pump *J. Eng. Gas Turb. Power* 38(9) (092601)

[12] Bi H, Wu M and Zhang X 2016 Design of parameters optimization system for screw pump well
*Int. J. of Simulation: Systems, Science and Technology* 17(25) 6

[13] Duque J L R, Nakashima C Y and De Oliveira Junior S 2016 Modeling and simulation of a twin
screw multiphase pump, considering gradual last chamber opening and liquid recirculation
between suction and discharge *Proc. of the Int. Offshore and Polar Engineering Conf.* pp 279-290