Monitoring of Carrying Cable in the Well by Electric Drive of Winch at the Logging Works

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Abstract. Emergency situations during logging operations are considered. The necessity of monitoring of the carrying cable in the well was shown, especially at the jet perforation and seismic researches of wells. The way of monitoring of logging cable and geophysical probe by means of the electric drive of tripping works of the logging winch is offered. This method allows timely to identify the wedges of geophysical equipment and the tension of the cable in well without interfering into construction of logging installation by means of algorithmic processing of sensors of electric drive. Research was conducted on the simulation model; these results indirectly confirm the possibility of using of electric drive for monitoring of downhole equipment.

1. Introduction

The logging is the most common type of geophysical research of well. Logging represents detailed research of structure of cut of well by means of descent and rise of geophysical probe in it. Tripping works are conducted with using of the logging winch [1, 2]. The logging winch is used at carrying out perforation of well and at seismic researches of wells and crust, thus perforators fall on carrying logging cable.

In the process of construction, exploration and exploitation of oil and gas wells the emergencies occur associated with breakage of the logging cable, the fall of downhole equipment, etc. [3].

Very often these accidents occur during cumulative perforation and seismic researches of wells. The source of seismic fluctuations is lowered into the well at the seismic exploration; it makes a series of explosions there [4]. There is a need to carry out the rescue and recovery operations because of complications at conducting of logging operations; this causes by downtime and additional costs. Basic operations at the elimination of such accidents are the fishing operations which follow the preparatory works (shutoff of well; determining of location of break and fall of downhole equipment and its condition; milling of emergency tool, etc.).

For monitoring of the condition of logging cable and downhole equipment the logging installations can be fitted with different systems of control and registration of parameters, such as the tension of the cable, the depth and speed of movement of the geophysical probe, etc. The main part of similar registrars is intended for collecting and initial processing data received from the downhole equipment. It allows increasing efficiency of carrying out geophysical works. However, the imposition of additional methods of monitoring the condition of the logging cable and geophysical probe are the urgent task, because the cable breaks with consequent loss of downhole equipment are the common problems [3]. This problem is especially relevant at the seismic researches, when the gas-dynamic source of fluctuations is used (*GDSF*).

In this paper we propose to use the electric drive of hoisting winch as a monitoring tool. Currently a large part of the logging winch is equipped with an asynchronous frequency-controlled drive, which already contains the current sensors, voltage and encoder mounted on the reel of winch. This set of sensors allows making the additional monitoring of the logging cable. The proposed method does not require additional investments and changes in the design of the winch; it requires only a software algorithm for processing information, which you can lay into microprocessor-based control system of electric drive.

2. Research object and method

Functional scheme of logging winch is shown in figure 1. The scheme works as follows. Electrical transducer 1 receives power from three-phase AC power. The converter supplies the power to the induction motor 2 after the command for the movement of the operator. The motor rotates the gear 3 and the reel 4. The cable 5 is placed (wound) on the reel by using the cable layer 7. The geophysical probe 9 is fixed on a cable and it is lowered into the well 8. The position sensor (encoder) 6 is mounted on the shaft of the reel. Information from this sensor is fed to the frequency converter 1.

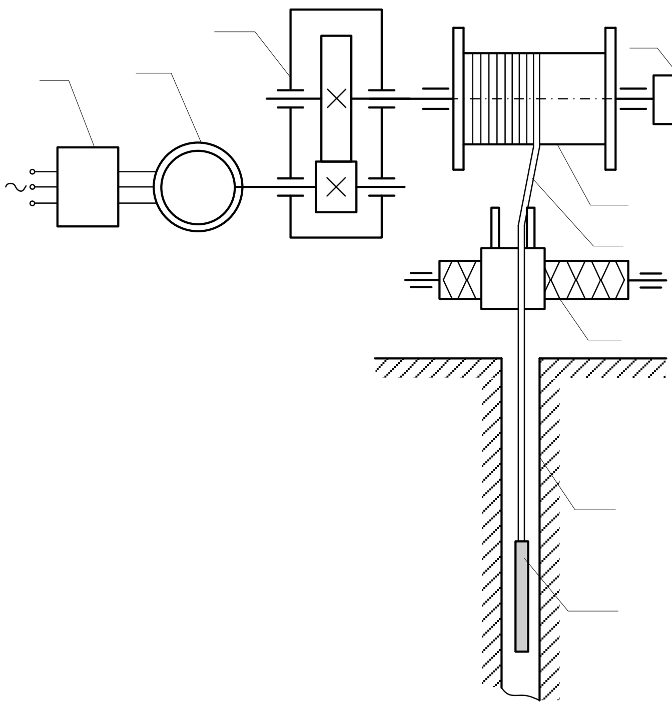

Figure 1. Functional scheme of logging winch: 1 – electric transformer; 2 – electric motor; 3 – reducer; 4 – reel; 5 – cable; 6 – position sensor; 7 – cable layer; 8 – well; 9 – geophysical probe.

The possibility of monitoring of logging cable and geophysical probe during tripping works on the logging installation is shown below. Electric AC drive typically contains three of the current sensor in each phase, three voltage sensor and encoder for feedback [5, 6]. The rise of geophysical probe with continuous recording of parameters is produced using a special above-ground electrical at conducting of geophysical research of well at a low speed. At rising of probe the subwedges and jams are possible at which the probe stops the movement. Thus the motor continues to rotate, the tension of the cable occurs. Indirect definition of load of the motor by means of current sensors can serve as alternative to the cable tension sensor. Phase currents of the motor are increased during the jamming of probe; it corresponds to increase of load, the subwedge of probe occurs. Timely shutdown of process of tripping works can save the geophysical equipment.

Deformation of the logging cable can be identified at the qualitative processing of the marks from position sensor. Descent and rising of probe have to happen evenly. The manifestation of vibrations, disruption or acceleration can be interpreted as the appearance of deformation and damage in logging cable. For detection of such faults it is need to install the position sensor as close as possible to the output link of the mechanism in this case on the reel and not on the motor.

The possibility of monitoring of logging cable and geophysical probe during seismic researches on the logging installation is shown below [7, 8]. The gas-dynamic source of fluctuations is used as a probe. The electric drive is switches-off after lowering of *GDSF* to certain depth and the series of explosions are produces with simultaneous registration of seismic fluctuations on the earth's surface. The probability of breakage of the logging cable is especially great due to shock fluctuations of the device *GDSF*. In this case, the use of electric drive as the tool allows not only to monitor the situation inside the well, but to soften the shock loads. Some researches of shock loadings are considered in [9, 10].

Alternative options at various executions of electric drives are shown below.

It is necessary to use a vector control system of the motor with feedback on speed with using of system "the frequency converter – the asynchronous motor" as the drive of the rise mechanism. Thus the zero speed of set is established at the set depth. The motor makes work with retention of a cable and the device in a motionless state. The fluctuations of device are at the explosion. In this case the electric drive is a damper; the coiling and uncoiling of cable are depending on the applied load on the motor during fluctuations of the device. Thus the resource of a cable increases; the probability of breakage of geophysical probe decreases. The coefficient of damping will depend on settings of regulators of current and speed of microprocessor control system.

It is necessary to enable a dynamic braking at carrying out the blasting operations with using of system "thyristor voltage regulator – the asynchronous motor" as the drive of the rise mechanism. It is possible to achieve a motionless condition of mechanical part due to use of a direct current. The value of DC current must be sufficient to hold the cable and the device in a stationary state, but the motor should not overheat. It can achieve by selection of accurate angle of system of pulse and phase control. This angle is formed automatically by the encoder on the motor shaft or reel. The electric drive is a damper at the explosion. In certain degree the processes will be similar to the process of electric drive with system "the frequency converter – the asynchronous motor".

3. Results and considerations

Researches of simulation model with help of the software MatLab were conducted for check of possibility of monitoring of logging cable and geophysical probe. The block diagram of the mathematical model of the electric drive of winch is presented on figure 2 [11].

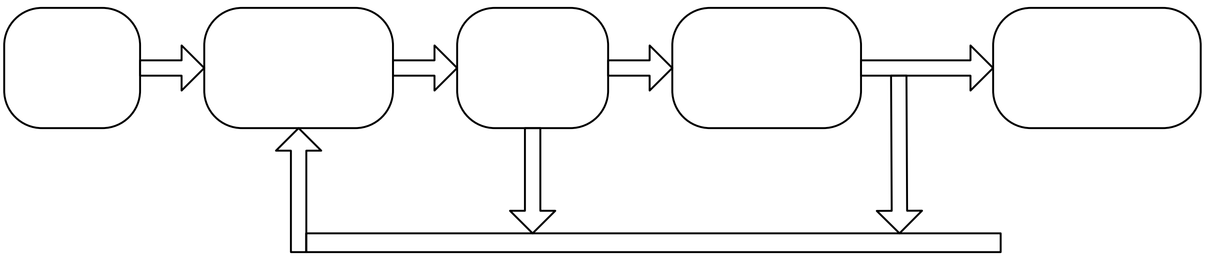

Figure 2. Block diagram of the mathematical model of the electric drive winches.

The simulation model includes a source of electric energy (three-phase alternating current network), the electric converter which transforms the variable voltage of one frequency to tension of other frequency, the asynchronous motor and two-mass mechanical system. The mechanical system consists of a first mass: motor, reducer, chain transmission, reel, etc. The device and a cable are the second mass, which is lowered into the well. The cable is the elastic element. Cable length, stiffness, and other mechanical parameters vary depending on the position of the cargo. The model allows dynamically monitoring the start processes, the stop of logging winch, reset and pounce of load, which may correspond to the real process of subwedge of the device.

Electrical converter receives the signals from the current sensors of the motor and the speed sensor. The speed sensor can be installed on the motor shaft and the shaft of reel, which is preferable from the point of view of diagnosis of subwedge of device in the well. In the electric converter the control system provides the necessary voltage to the motor depending on the condition of sensors and a set algorithm of control. In turn the motor sets in motion the device in a well.

Figure 3 shows the transient processes of the electric drive of logging winch at the jamming of the device during lifting of the device from the well.

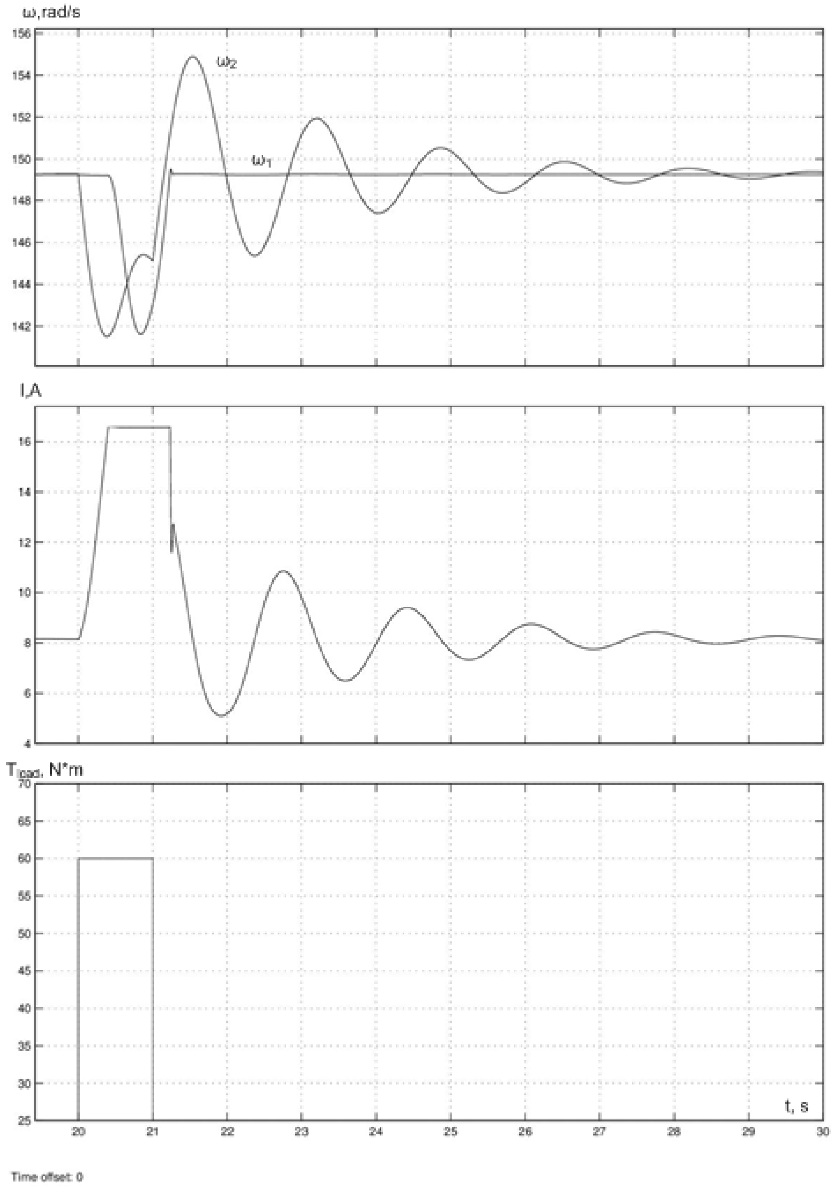

Figure 3. Transient processes of electric drive of logging winch at subwedge of device in well.

The notation adopted In figure: ω_1 – frequency of rotation of the motor (the first mass), ω_2 – frequency of rotation of the second mass, I – stator current of the asynchronous motor, T_{load} –torque of load. Jamming of device is simulated with the load increase, i.e. with increasing of

T_{load}. In this case T_{load} increases from 25 to 60 *N·m* at time of 20 *s*. Accordingly, the speed of the device ω_2 begins to decrease. At this time the rope is pulled, the motor current is gradually increased; the motor speed does not change. After 0.5 *s* the motor speed decreases; the current reaches a maximum value of 16.25 *A*, increasing from 8 *A*. The contour of current is in a saturated state. At time of 21 *s* the load reverts to the original state; the current, speeds of motor and device are leveled after the oscillatory process in the electromechanical system.

This example shows the possibility of monitoring the process of logging operations by means of the electric drive. Subwedge of device or complete jamming of the device in the well can be diagnosed in advance if information of stator current and speed of rotation is known. Thus, there is a possibility of change of the mode of operation of electric drive and the full shutdown of system can be executed.

4. Summary

1. The way of monitoring of logging cable and geophysical probe by means of electric drive of tripping works of logging installation is offered.
2. It is shown that use of electric drive at seismic researches allows reducing shock fluctuations of the device, thus, the cable resource increases, and the probability of geophysical probe break decreases.
3. Research of imitation model was conducted, and it was indirectly confirmed the possibility of using of electric drive for monitoring of downhole equipment.

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