On The Problem of Operation of Self-Propelled Drilling Rigs in the Harsh Winter Conditions of the Far North

D.M. Tatarinov, N.G. Timofeev, R.M. Skryabin

Abstract: In the North-East and Arctic regions of the Russian Federation, self-propelled drilling rigs of various modifications are in high demand for drilling of various purpose wells during exploration and engineering works. Due to the geographical inaccessibility of the production sites during the warm season, the bulk of drilling work is carried out in winter.

The drilling fleet of exploration companies is becoming obsolete due to the lack of stable production of new generation drilling equipment by domestic plants, so now the process of purchasing imported equipment with higher technological capabilities, but not enough adapted to work in the harsh climatic conditions of the cryolithic zones of the northern and arctic regions, has begun. Besides, the enthusiasm for imported equipment, as we know, leads to constant dependence on foreign companies - suppliers of spare parts, technological means and materials and providing maintenance of drilling rigs.

Keyword: Due to the geographical inaccessibility of the production sites during the warm season, the bulk of drilling work is carried out in winter.

I. INTRODUCTION

All this is not in line with the recent import substitution policy of the country in the context of sanctions.

In the regions of the North and the Arctic the tasks of scientific and technical progress and introduction of innovative technologies in well drilling become especially important. There is a need for modern drilling equipment of northern design and special technologies, taking into account the geocryological and natural-climatic features of the region.

Powerful thicknesses of permafrost with complex structural composition are typical of Yakutia’s fields, where the temperature in winter months reaches - 50 °C, and the average annual temperature does not exceed minus 10-15 °C. This predetermines very unfavorable conditions of the drilling process, maintenance of drilling rigs and operation of related mechanisms of geological exploration and mining production. The main reason for the complications is the lack of consideration of the temperature factor, violation of the normal temperature regime of the well, at which the intensity of heat exchange processes between the frozen rocks and the cleaning agent circulating in the well, causes violations of the aggregate state of ice as a binder cement of the frozen rock mass.

II. PROPOSED METHODOLOGY

Many years of experience in drilling exploration and engineering wells in winter shows a number of problems associated with negative ambient temperatures. Thus, in winter core drilling at temperatures below -30°C, the drilled rock (core) freezes instantly to the inner wall of the core while lifting the projectile from the well. This is explained by the fact that the process of mechanical destruction of the rock is accompanied by the release of thermal energy and heating of the drill bit and core on the bottomhole. The positive temperature between the core and the core pipe during the drilling process is maintained until the end of the well bottomhole deepening, i.e. until the lifting operations, when the rotation and heating of the core pipe due to friction against the well wall are stopped. After extraction of the full string pipe from the wellbore, the process of freezing of the drill bit and instant freezing of the drilled core takes place [1,2].

One of the most common complications in the operation of self-propelled drilling rigs in winter (domestic and foreign) at extremely low temperatures (below -40°C) is the freezing of high-pressure hydraulic hoses (HPH) [3], resulting in their subsequent rupture at bending points during lowering and auxiliary operations, the flow of hydraulic fluid and termination of drilling operations, with the creation of uncomfortable situations for maintenance personnel Fig.1. [5,6]
High-pressure hoses are flexible pipes, which are nested rubber (plastic) tubes with connecting fittings, Fig. 2. Such products are especially strong due to metal winding or braiding. By means of PHP - hoses of reinforced high pressure - force is transmitted in machine mechanisms, hydraulic and motor fluids, water and oil emulsions are transported [8].

Fig.2. High pressure hose (HPH). Flexible part of the pipeline, which is used in hydraulic communications to connect moving elements and supply them with working fluids (machine oil, lubricants, etc.)

The design of the high-pressure hose is based on its purpose, the operating conditions under which it is exposed to aggressive media and significant pressure.

The drilling rig tank filled with hydraulic fluid is constantly exposed to temperature fluctuations with frequent fluid heating and cooling and is covered with condensate from the inside, which increases with each freeze-thaw cycle. As a result of this phenomenon, an unacceptable amount of water is formed in the hydraulic system of the drilling rig, which leads to the seizure of hydraulic connections and the system crane, with emergency consequences.

Further increase in the frequency of such emergency situations leads to premature failure of the main kinematics units of the unit, frequent repair of equipment, high costs of spare parts, etc., which makes it extremely difficult for drilling personnel to operate drilling equipment efficiently and achieve high technical and economic performance of drilling operations in winter.

The operating personnel have to constantly monitor the working conditions of the hydraulic components of the drilling equipment regarding:
- of excessive bending;
- defect of hydraulic system high pressure hoses (HPH);
- seasonal change of hydraulic system working fluid;
- preheating of the hydraulic system before operation;
- ensuring constant circulation of the working fluid in the hydraulic system when stopping the drilling process.

Most drilling organizations, due to the lack of special technological shelters and protection of the main components of the hydraulic system of self-propelled drilling rigs, have to stop the working process at ambient temperatures below -40 ° C, which leads to the failure of production plans.

Existing tent drilling shelters are designed for stationary and mobile drilling rigs (type A-50, well workover rig), especially for oil and gas drilling rigs. For year-round operation of drilling rigs, oil companies like GAZPROM, ROSNEFT, etc. order special drilling shelters for operation in winter conditions.

These shelters for shallow self-propelled drilling rigs have some disadvantages due to frequent movements:
- the use of deep hole drilling only on stationary deep hole drilling rigs;
- difficulties in installing and dismantling the shelter structure;
- the impossibility of using self-propelled drilling rigs;
- necessity of additional heating in winter conditions;

In this regard, in the North-East and Arctic regions of the Russian Federation, research and development of innovative methods to improve working conditions for workers and technology to protect the hydraulic system of self-propelled drilling equipment, taking into account the harsh climate of the region, is an urgent scientific and technical task of the entire drilling production of large regional companies.

One of the possible ways to solve this difficult problem is to consider ways of insulating the hydraulic system of a self-propelled drilling rig in winter. To minimize the risk of freezing and rupturing of high-pressure hoses by providing a constant optimum oil temperature and hydraulic hoses.

We propose the idea of creating a thermal protection device for the hydraulic system using self-regulating heating cables and insulating material [7].

III. RESULT ANALYSIS

The choice of self-regulating cable is based on its ability to "self-regulate" the resistance of semiconductors depending on the ambient temperature. The lower the temperature, the lower the resistance and therefore the higher the current and heating power. An important useful feature of such a cable should be considered that it can be cut into pieces of any length, starting from 20 cm, which allows it to be easily increased and shortened.

The tank of the drilling rig is wrapped around the whole area of the walls with cable (Fig. 2, a), then it is covered with dense heat-insulating material. The heating cable from the tank is routed further along the high-pressure hoses, over the winding, and the thermal insulation material is attached for thermal insulation. (Fig. 2, b).
To increase the insulation of the hydraulic hose and equipment, along with the heating cable, it is recommended to use heat-insulating material from the company "Sahatent" [9], the structure of which consists of four layers (Fig. 3):

IV. CONCLUSION

1. The outer layer is one of the varieties of "Oxford", a European metal-plated material. Its uniqueness lies in the fact that it is completely impenetrable, heavy-duty, sun-proof, moisture-resistant, lightweight and compact. It is used in the manufacture of parachutes, hang-gliders and sails. Another important feature of this material is that the snow does not stick to it when assembling.

2. Waterproofing layer: polyethylene film - a thin layer of material made of polyethylene. Packing polyethylene possesses such properties as elasticity, moisture resistance, frost resistance and hygiene.

3. The middle layer is the South Korean bamboo fiber as insulation, which is very similar to the Soviet cotton wool. But in comparison with it, it is 10 times lighter and, unlike other insulators, it retains heat 5 times better. The structure of bamboo fiber is porous; it is perfect as a filler. Micropores and microholes penetrate the entire thread. Bamboo stems do not lose their unique properties in the process of processing; on the contrary, they acquire new positive qualities. Good breathability and ventilation, fabric and filler made of bamboo fibers give coolness in summer and warmth and comfort in winter. After soaking the fibers quickly dry out, the moisture absorbs the fabric immediately. The mechanical properties of the fibers are very strong in dry and wet condition, and their wear resistance is also to the height.

4. The inner layer - Oxford metal-plated fabric - is the best option, for example, for a mobile garage, as according to the law of physics, the silver color reflects the heat back inside, thereby allowing the car to stand longer with the engine off at the lowest temperatures.

REFERENCES:

1. Alekseev V.V., Startsev O.I. Analytical model of specific energy consumption for drilling wells // Izv. vuzov. Geologiya i razvedka (Bulletin from Universities. Geology and Exploration). 2006. -No. 4. -P.54-58.
2. Alekseev V.V., Startsev O.I. Fuel consumption by internal combustion engines in self-propelled drilling rigs // Izv. vuzov. Geologiya i razvedka (Bulletin from Universities. Geology and Exploration). -2006. No. 5. -P.59-66.
3. Vorob'ev A.E., Lyashenko V.I., Kislyy B.P. Hydraulic mining equipment - the dictate of time // Tezisy dokladov XIII mezhdunarodnyy konferentsii «Resursosproizvodstvoschastie, maloookhodnye i prirodookhrannye tekhnologii osvoeniya nedr» (Theses of reports of the XIII international conference "Resource Reproducing, Low Waste and Environmental Technologies of Subsoil Development") (Tbilisi, Gruzija,15-21 sent. 2014 г.), V. 1. - M.: RUDN publ., 2014. - P. 153-155. ISBN
4. Kirsanov A.N., Zinenko V.P., Kardys V.G. Burovye mashiny i mehanizmy (Drilling machines and machinery). -M.: Nedra publ., 1981. -448 p.
5. Tamofeev N.G., Skryabin R.M., Tatarinov D.M. O probleme bureniya skvazhin samokhodnymi burovymi ustanovkami v usloviyakh kraynego severa (On the problem of drilling wells with self-propelled drilling rigs in the extreme north)/ Burenie skvazhin v oslownennih uslovyyakh: II Mezhdunarodnaya nauchno-prakticheskaya konferentsiya 30 oktyabrya - 1 noyabrya 2017 g. Tezisy dokladov (Drilling of wells in complicated conditions: II International Scientific and Practical Conference 30 October - 1 November 2017 Theses of
6. Timofeev N.G., Petrov V.L. Sposob sokhranenie rabotosposobnosti samohodnykh burovykh ustanovok v zimnee vremya (A way to maintain the operability of self-propelled drilling rigs in winter)/ Geonauki: problemy, dostizheniya i perspektivy razvitiya: materialy Vserossiyskoy molodezhnoy nauchno-prakticheskoy konferentsii, 27-28 aprelya 2018 g. [Elektronnyy resurs] (Geosciences: Problems, Achievements and Development Prospects: Materials of the All-Russian Youth Scientific and Practical Conference, 27-28 April 2018 [Electronic resource]). – Yakutsk: Izdateelskiy dom SVFU publ., 2018. P.219-222

7. Primenenie samoreguliruyushchikhsya nagrevatel'nnykh kabeley (Use of self-regulating heating cables) http://electrik.info/main/fakty/335-primenenie-samoreguliruyushchikhsya-nagrevatelnh-kabeley.html

8. https://ru.wikipedia.org/wiki/%D0%A0%D1%83%D0%B2_%D0%BE%D1%81%D0%BE%D0%B2_%D0%BE%D0%B3%D0%BE_%D0%B4%D0%BD%D0%B2%D0%BD%D0%BE%20%D0%BD%D0%B8%D1%8F

9. https://hotutent.ru