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Analysis of permafrost conditioning in the oil field

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Abstract: Based on model concepts, the technique of maintaining the stability of the permafrost layer is analyzed. An injection well is considered as a reference channel for injecting a mixture of liquid and gas. The purpose of this technology is to control the flow of heat. The development of hydrocarbon deposits in the extreme north requires the preservation of perennial frozen soils in a stable solid state. Stable condition of frozen soils is a guarantee of well operability. An injection well is used to inject refrigerant into the frozen soil zone. When using packers to separate said portion, the injection process to maintain reservoir pressure may continue in the usual manner. Permanent frozen soils are conditioned using a mixture of liquid and gas. This mixture allows you to control the parameters of temperature, pressure and heat capacity over a wide range. The directions of the mixture are formed using a packer system. Packers are installed in the tubing and in the annulus. The formation of a coolant agent is organized directly in the well above the working formation. The technique of ejector pumps is used. The ejector is a device for controlling the parameters of the mixture. The components of the mixture are fed through columns (pipes). The organization of the movement of components is considered as an additional degree of freedom. The proposed technology allows you to use an additional option for the operation of the existing layout of wells in the oil and gas field. The usual practice of the operation of the fishery may remain unchanged.

1. Introduction

When developing oil and gas deposits in areas of the Arctic zone with a thick stratum of frozen rocks, special requirements are imposed on technological support [1-8]. Deposits of the permafrost zone have significant differences. This is a temperature factor that determines the course of destruction processes and changes in the phase state of frozen rocks [2-4]. In the process of development, heat release leads to permafrost melting. Thawing of the rock in contact with the equipment of the well requires preventive measures to maintain the working capacity of the development.

Improving the efficiency of flushing wells in a frozen bed is achieved through the use of treatment agents with low thermal conductivity. Currently, there is an increase in the rate of well drilling in complicated conditions. There are abnormal reservoir pressures (both low and high), unstable rocks, rocks of high hardness, permafrost. Permafrost is widespread in Russia in various regions. More than 50% of the country's territory is covered by permafrost rocks. A significant territory of Alaska (USA) and part of Canada are also characterized by permafrost. Most of the oil and gas fields are confined to these regions.

This circumstance entails an increased interest in the development of well drilling technologies and field development in such conditions. The depth of permafrost can reach 1400 m (Markha well in the northwestern part of Yakutia). Basically, the permafrost thickness does not exceed 600-700 m. The permafrost temperature can reach -8 ° C, but more often ranges from 0 to -2.5 ° C. Of interest is the analysis of domestic and foreign experience in the development of hydrocarbon deposits in permafrost.

Well construction flushing with various treatment agents is an important element of these technologies. Special attention is paid to technologies for maintaining permafrost and cooling adjacent soils. Drilling experience using traditional technologies indicates that thawing and destruction of permafrost leads to a number of complications. Special attention is drawn to the arrangement in the wellhead zone. Violations in this zone are most often manifested, which generally negatively affects the quality of the wells. Cleaning agents such as chilled air, gas-liquid disperse systems and flushing liquids are contemplated.

Currently, all of the most promising oil and gas fields in Russia are located in the zones of distribution of frozen rocks of various types. The primary cause of increased accident rate are long shutdowns of production wells or their conservation. After stops, cases of casing collapse in the interval of perennial frozen rocks were noted. During well operation, the thermal effect on permafrost becomes extremely intense. Ice turns into water and takes up a smaller volume. As a result, the thawing and cavern formation zone turns into a thermal karst funnel. The breed loses its bearing capacity. For this reason, landslides occur. Conditions are formed for the collapse of frozen rocks when the funnel reaches a certain critical length of the well support. Wellhead craters and subsidence of wellheads are formed. This leads to a shortening of the column, a break in the wellhead piping, open fountains and emissions into the environment. These complications lead to a complete loss of the well. The control of pressure and temperature in the annular space during the flow of liquid and gases seems relevant.

The use of compressed air instead of washing liquid is effective in solving the problems of developing hydrocarbon deposits in permafrost. Compressed air does not freeze at temperatures and pressures during drilling. Gas differs from liquid washing solutions in lower heat capacity. The complications associated with freezing the flushing medium are eliminated. Simplified minimization of heat flow in the summer.

Mass air flow per unit time is an order of magnitude smaller compared with any flushing fluid. The specific mass heat capacity is four times less. Therefore, at the same initial temperature of the flushing medium injected into the well, the air carries a hundred times less heat than the flushing liquid. This significantly reduces the risk of complications. The probability of thawing and loss of stability of frozen rocks is reduced. In this respect, air as a washing agent is much more effective than saline. A solution of sodium chloride in water does not freeze in the well. But because of the greater heat capacity, it can disrupt the natural state of the constituent walls of a frozen well bore.

Summarizing various circumstances, we pay attention to the use of sparkling water as a flushing agent and coolant. Consideration of the structure of geological formations and permafrost zones leads to the need to block the access of fluid flows. It is proposed to make locks using a set of packers.

2. Thermal insulation technique for injection wells

Model representations of the heat flux problem were considered in our earlier work [9]. The technical solution in [10] is achieved by the use of internal and external columns.

Columns are lowered concentrically into the well. At the same time and separately deliver liquid and gaseous phase to the well. Their mixing is carried out directly near the reservoir using an ejector. Carbonated fluid is pumped into the reservoir. The inner pipe string is equipped with a valve nipple at the bottom. The ejector is made in the form of a block of several jet pumps with rarefaction chambers. The cameras communicate through the central and side channels.

The ejector is lowered into the well at the end of the outer pipe. The pipe is equipped with an external packer. A packer is installed above the formation and lowered into the outer pipe string. The inner pipe string is installed before the tight connection of the nipple with the central channel of the vacuum chamber. The mixture of liquid and gaseous phase is produced in the rarefaction chambers of the jet ejector pumps. Fluid is supplied through the outer pipe through the side channels under pressure. Gas is supplied through the inner pipe through a nipple. Soda liquid is injected into the reservoir due to the pressure of the injected carbonated liquid. The amount of carbonation is controlled by changing the volume of the rarefaction chambers of jet pumps. The chamber volume is controlled by the input and output of the nipple into the central channel. Thus, a change in the degree of carbonation is produced by lowering or raising the inner pipe string. The presence of a packer provides increased pressure in the space under the packer. Avoids the release of gas from a carbonated liquid. The inefficient costs of aerating liquids are reduced. The creation of increased pressure in the well is simplified when soda fluid is injected into the reservoir.

The method of injecting carbonated liquid into the formation improves the efficiency of injection into the formation. The effect is achieved due to the controlled process of mixing liquid and gas in the ejector and reducing losses during the injection of carbonated liquid into the reservoir. And it also creates the possibility of regulating the amount of carbonation of the fluid injected into the reservoir. Adjustment is made by changing the location of the lower end of the nipple in the vacuum chamber of the ejector.

Another implementation of the technology is a solution [11]. Prevention of thawing of frozen rocks is achieved by dividing the flow of produced gas into two streams. A larger flow is directed into the gas pipeline. A smaller gas stream is cooled and directed into the annular space. Then it is returned to the gas pipeline. The return of a smaller gas flow from the annular space into the gas pipeline is carried out under pressure. The pressure is equal to the pressure of the reservoir gas at the point of separation of it into two streams. The pressure in the gas pipeline is reduced before returning to it a smaller cooled stream. The pressure is reduced by an amount greater than the hydraulic loss along the path of small flow.

In the method [12], liquid water acts as a heat carrier. Water is injected through injection wells. Water is heated by heat exchange with rocks.

When opening the zone of frozen rocks in the injection wells lower tubing. A packer is installed in the annulus and frozen rocks are blocked. Below the packer, a packer is installed in the annulus in the tubing. Closer to the bottom, a shut-off packer is installed in the annulus. Water is pumped into parts of the barrel with lower temperatures through a tubing. In the part of the barrel with elevated temperatures, water is pumped through the annular space of the tubing. Water is being pumped continuously. Adjustment is made according to the established permissible lower temperature limit.

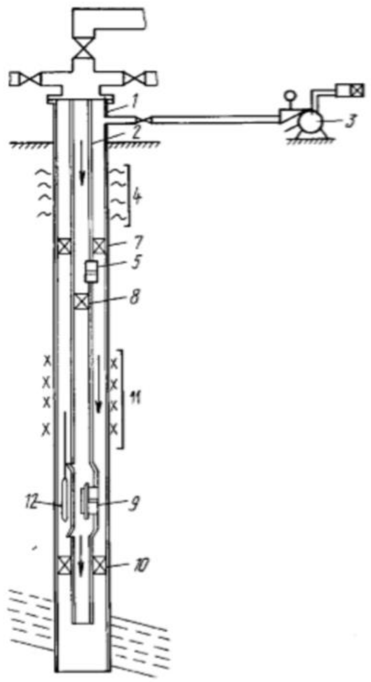

Figure 1. Packers installation diagram (packers marked with crosses 7,8,10).

To develop oil saturated with paraffin, a grid of production and injection wells is chosen [9]. Determine the temperature of the reservoir, the temperature of saturation of oil with paraffin (temperature of paraffin deposition). By section of the well determine the temperature profile in depth. In this section, sections of the well with reduced temperatures are distinguished.

The passive thermal insulation method [13] can be used in the production of highly viscous oil. At the same time, heat is constantly removed from the heat-emitting zone. A packer is installed at the lower end of the tubing. The pipe is lowered into the well before the packer is placed above the reservoir. An insulating layer forms above the packer. The latter is formed as a result of injection from the wellhead of a heat insulating agent between the casing and the tubing. A separation tube is installed concentrically, the lower end of which is positioned above the packer. The heat insulating agent is pumped through the annular channels formed by the separation tube. Inert or associated gases, flushing liquid, oil can be used as a heat insulating agent. Combined technology is illustrated in figure 1.

Based on the specified operating mode, an option is proposed for providing thermal insulation of the injection well. The supply of the working agent and preparation are carried out in the area above the reservoir. The injection process is carried out using conditioning equipment of a conventional working agent supplied to the formation. The working agent is a mixture of water and gas. The components are piped through the columns and prepared in the well in an ejector device. The ejector is located in the area above the reservoir.

3. Discussion

A variety of methods are used to create thermal insulation for oil wells. The coolant substance is supplied to the annular space. Provide heat dissipation by forcing or circulating this substance. Special technological regimes are created for supplying these substances to the annular space and their circulation. Such technical solutions create additional difficulties in the operation of the well. Because placement of additional systems for injection and circulation of these coolants in the well is required. It is necessary to install equipment for supplying and preparing the substances themselves. As a result of this, well operation costs are increased. The whole workflow is getting complicated.

An inert or associated gas, flushing liquid, water and other substances can be used as such a substance, which allows creating sufficient thermal insulation of the permafrost zone.

In injection wells, the supply of additional substances is organized. Such heat transfer agents provide heat dissipation in the permafrost zone. On the other hand, this technological solution may cause additional difficulties. The mode of operation of the well is complicated. Sometimes the creation of such a mode of operation to ensure sufficient thermal insulation can be economically inefficient.

In injection wells, water or a water-gas mixture is often used as a working agent supplied to the formation. In this case, the injection mode does not provide sufficient thermal insulation, since the temperature of the working agent must correspond to the conditions in the well itself. There are ways to prepare a working agent in the well itself. The supply of the agent to the well and the preparation of the injected mixture by the ejector device are localized in the zone above the formation. This method does not imply thermal insulation of the injected agent. Weakening of thawing of frozen soils does not occur. To achieve the desired effect, it is necessary to create a thermal insulation layer using special technologies.

4. Conclusion

A dynamic method for controlling the permafrost layer is considered. A combined technique for conditioning the state of permafrost is proposed. Permafrost stability is the key to the stable operation of the oil field. Heat transfer occurs when the cleaning agent is circulated. As the latter, a combination of liquid and gas is considered. Sparkling water allows you to vary a number of physical and technical parameters. The key parameters are heat capacity and thermal conductivity. Control of the parameters of the flushing agent mixture can significantly reduce the thermal effect of well equipment on permafrost soils.

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