Hydromechanical devices to prevent paraffin deposits

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Abstract. The focus is on paraffin deposits on the walls of the tubing. Devices will be analyzed to prevent them. The conditions of hydrocarbon deposits in Eastern Siberia are considered. Hydrocarbon fluid is in critical condition. Small changes in physical parameters lead to the launch of phase transitions. Such changes take place in the process of lifting the liquid to the surface. There is a drop in pressure and temperature. Natural gas is released and, as a result, conditions are formed for the precipitation of paraffin crystals. The adsorption capabilities of the tubing wall contribute to the initiation of paraffin deposits. Among the units designed to prevent this problem stand out hydrodynamic devices. Due to the creation of cavitation zones, local formation of crystallization centers is provoked. Moreover, these lacunae are in the stream, i.e., separated by a moving fluid from the pipe wall. These circumstances contribute to the removal of the resulting paraffin crystals up to the surface. At times, labor costs for cleaning the pipe walls from paraffin deposits are reduced. An important advantage of hydrodynamic devices such as swirlers, cavitators is the absence of moving parts. This ensures reliable operation and ease of modernization. Of interest is the property of device casings to keep clean from paraffin deposits. This circumstance is associated with concomitant vibration. Permanent shaking off of the rudiments of deposits occurs.

1. Introduction

Extensive viscous hydrocarbon reservoirs exist around the world. These reservoirs contain very viscous hydrocarbons. High viscosity makes hydrocarbon recovery difficult and expensive. Each oil reservoir is unique and reacts differently to the various methods used to extract the hydrocarbons in it. In general, heating of heavy oil in a formation is used to reduce viscosity [1-4]. Some of these viscous hydrocarbon reservoirs are located beneath the cold tundra or permafrost layers, which can extend to a depth of 600m. Steam cannot be injected through these layers, since heat can potentially spread in permafrost. Risks of wellbore stability and significant environmental problems are created when permafrost is melted.

In addition, when operating with modern methods, heavy oil reservoirs encounter other problems. One such problem is the deposition of paraffin in the wellbore as oil rises from the reservoir to the surface. This problem is compounded with an increase in the depth of the reservoir.

There is a method of developing oil fields containing paraffin oil, and which consists in the injection of heated water into the reservoir [4]. There is also a method of developing deposits in the permafrost zone, providing for the heating of water in the well [5]. The implementation of these methods is associated with the organization of a complex energy economy.
There is a whole class of oil fields located in the zone of permafrost, the oils of which are saturated with paraffin. Oil deposits occurring in the permafrost, as a rule, are in reservoir conditions in a saturated state. The reservoir pressure and the saturation pressure of oil with gas are close or equal to each other. The paraffin contained in the oil is also in a saturated state. For example, in a number of fields in Eastern Siberia located in the permafrost zone with abnormally low formation temperatures. The paraffin content in oils is in the range of 1.41 ÷ 2.52% by weight [6].

The rise of oil through the tubing is accompanied by a decrease in pressure below the saturation pressure. The gas phase is released from the oil, while the total volume of the liquid phase decreases. The amount of solid paraffins per unit volume of the liquid phase increases.

This mechanism of changing the content of components dissolved in oil will continue with a decrease in pressure, regardless of the amount of "paraffin" contained in the oil. A solution of solid paraffin in oil will always become oversaturated from saturated.

Thus, oil with a high content of paraffins and gases, when it rises to the surface, will decompose into solid, liquid and gaseous fractions. In turn, the solid fraction will be deposited on the walls of the pipe.

2. Hydrodynamic devices

The processes of formation destruction and removal of mechanical impurities into the wellbore occur as a result of a number of geological, technical, technological, physico-chemical and mechanical factors. The loss of salts takes place. And also asphaltene-resin-paraffinic components of oil fall out. Very dense clay-sand plugs are formed with partial or complete overlapping of the perforation interval.

To solve this problem in [7], an ejector pump is used. A functional insert is installed at the base of the ejector pump housing, inside of which at least four cavitation generators are located at an angle of 30°. They form a jet of working fluid eroding sand plug. This is due to the hydro-monitor effect, the erosive ability of cavitation jets. Amplitude and frequency oscillations occur during the expiration of high-pressure cavitation jets. In the process of excitation of cavitation, the liquid medium under pressure enters the cavitation generator. Having passed the inner cylindrical surface, the fluid flow accelerates and enters the conical surface with an opening angle of the channel of 6-7°. This achieves a very sharp increase in the flow rate of the working medium with the occurrence of a local discontinuity in the flow continuity. Voids and cavities are formed filled with steam and gas. As a result, the flow carries these cavities beyond the washing device. The cavities collapse and create hydraulic shocks. And the latter give rise to vibration in the sand and clay cork.

The crushed sediment material is carried away with the fluid flow up to the wellhead.

The creation of a device to reduce energy costs for pipeline transport of highly viscous liquids is the goal [8]. The pipeline throughput is increased. Precipitation is reduced due to mixing of the stream during transportation of media containing paraffin particles. Pressure pulsations resulting from uneven flow concentration are reduced. The viscosity of the transported fluid and precipitation are reduced. The flow is twisted by introducing a hollow cylindrical body of variable cross section. The hull has a smooth narrowing, providing the appearance of developed cavitation. Next is a section of a bent pipe and a continuous diffuser. The diameter of the wide part of the diffuser is equal to the diameter of the pipeline.

The influence of cavitation forces intensively destroys intermolecular bonds in a liquid and reduces its viscosity.

The device [9] is equipped with rings with conical contractions and disks with sector windows. A horizontal hole is made in the housing. The breaker is made in the form of a cam and is placed with an axis in a horizontal hole. Process liquid through a tangential inlet channel enters a horizontal hole and carries the cam along with it. The cam periodically blocks the tangential and axial channels, causing pressure pulsations. Intermittent fluid flow rinses. Then the vibrational flow moves up.

The flow of process fluid drives the device. Fluid vibrations are created. Deposits are destroyed and carried to the surface.

In a utility model [10], the problem of preventing paraffin deposition during oil production from a well including a fitting is solved. According to a utility model, the fitting is made in the form of a washer with a calibrated hole in which a cone is placed with a sharp end. The cone is mounted in a cylindrical
housing with the possibility of axial movement. The housing is closed with a washer with holes. The maximum diameter of the cone exceeds the diameter of the calibrated hole (figure 1).

When oil is produced in a well, pressure and temperature decrease. As a result, paraffin falls out of the oil and is deposited on the walls of the well. In this case, the cross section of the well and its flow rate are reduced. A device is installed in a well in the zone of the beginning of phase transitions of dissolved paraffin from oil to solid state [10]. Prevent paraffin deposits during oil production. Facilitate the passage of oil flow through the pipe. The flow is coupled and the pressure is reduced. Centers of crystallization and growth of paraffin crystals appear in the stream. Particles of paraffin are carried out with a stream with almost no deposits on the walls of the well. The pressure drop across the nozzle needed to isolate paraffin is 0.017-0.032 MPa.

Local conditions are created for the condensation of paraffin in the liquid stream. Granules of paraffin are carried away by a stream.

The processes described above occur repeatedly, instantly and, as a rule, through equal periods of time. Sound waves, hydraulic shocks lead to harmonic vibrations, resonance with a large destructive force. Cavitation fluid outflow helps prevent clogging of hydromechanical devices. The effect is achieved by crushing solid particles. This facilitates the lifting of the sludge to the surface. As a result, formation of deposits is prevented.

A local drop in pressure and temperature contributes to the controlled formation of paraffin crystals in the fluid stream. Consequently, the concentration of paraffins in the solution volume decreases and deposits on the pipe walls decrease.

3. Discussion and conclusion
Various approaches to the task of ablation of sediments in a fluid stream should be taken into account.

There is a direct ordering of the Brownian (thermal) motion of the liquid or gas in the vortex bundle. The random vectors of thermal motion of the molecules line up strictly parallel to the axis of rotation. Like bullets or shells in a rifled barrel. Spinning logs in Schaubberger’s patents [11] and shells in the gun’s barrel move according to exactly the same laws! The flow of liquid or gas during rotation in the...
pipe becomes more mobile along the central axis. Increased axial flow stability. This effect has been well studied with pudi flight examples.

![Figure 2. Fluid swirling devices [11].](image)

By centrifugal forces, a vacuum zone is created right in the center. Most of the fluid flow meets reduced hydrodynamic drag. The central axis of the vortex in the pipe is the flow acceleration zone. The flow temperature in the center decreases slightly. Twisting of the flow can lead to a displacement of the places of formation of crystallization centers. It is possible to reduce the number of crystallization centers on the inner surface of the pipe.

The use of hydromechanical devices to prevent the deposition of paraffins on the walls of the pipe is characterized by high reliability. These devices are simple. Their functioning is controlled by the pressure of the fluid flow. Some [8, 10], do not have moving parts. The effectiveness of the application was tested in a working well [10]. The interval between downtime for cleaning paraffin deposits from the pipe walls increased by 3 times. Important physical and technical characteristics of hydrodynamic cavitation devices can be summarized as follows:

- Destroy solid precipitation.
- Induce the controlled formation of centers of crystallization of paraffins in the liquid stream.
- Reduce the concentration of paraffins in the oil fluid.
- Promote the removal of solid particles of paraffins in the fluid flow to the surface.
- Due to vibrations eliminate forming deposits on the elements of the device.
- Save resources on tubing cleaning activities.

The physical conditions for creating hydromechanical devices to prevent the deposition of paraffins on pipe walls leave a wide range of design possibilities. A twist element must be provided. Examples are given by various cavitators. The cavitation area must be in the stream. It should be separated by liquid from the elements promoting adsorption, the formation of precipitation. The performance of this class of devices can be checked using desktop laboratory models.

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