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Wax Accumulation Prevention Method in Tubing

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Abstract. The article describes a wax accumulation prevention method in tubing using micanite or ceramic ring heaters. A ring heater is installed on the outer surface of tubing. To supply the ring heater with electricity direct current is used. The ring heater operation mode is periodic, with the power-on time equal to the intensity of wax accumulation.

1. Introduction

The development of wax control technology and methods has had a long history. Today, as decades ago, to control wax accumulation oilmen apply the following methods: thermal, physical, chemical, mechanical and use of coatings [1-6].

Chemical methods are based on adding chemical compounds in the produced products, which reduces and sometimes completely prevents from the accumulation. Adsorption processes occurring at the boundary between the liquid phase and the surface of pipe metal are the basis of the action of wax inhibitors.

Chemical agents are divided into wetting, modifiers, depressors and dispersants [7].

Wetting agents form a hydrophilic film on the metal surface which prevents from wax crystals adhesion to the pipes; this creates a possibility of their carryover by fluid flow. These include polyacrylamide (PAA), IP-1;2;3, acidic organic phosphates, silicates of alkali metals, aqueous solutions of synthetic polymeric surface-active substances (surfactants).

Modifiers interact with wax molecules, preventing from crystal growth. This helps to keep the crystals in suspension during their movement. These properties are intrinsic to atactic propylene with a molecular weight of 2000 to 3000, low molecular weight polyisobutylene with a molecular weight of 8000-12000, aliphatic copolymers, copolymers of ethylene and compound ether with a double bond, a triple copolymer of ethylene with vinyl acetate and vinylpyrrolidione, a polymer with a molecular weight of 2500-3000.

The action mechanism of depressors is adsorption of molecules on wax crystals, which hinders their ability to aggregate and accumulate. The known depressors are "Paraflow, AzNII", alkylphenol ИПХ-, "Dorad-1A", BEO-504 TymII, "Isolyat-7" [8].

There are several best known methods dealing with asphaltene deposits (AD) actively used in oil industry. But the variety of conditions of field development and the difference in characteristics of the produced product often require an individual approach and even development of new technologies.

Dispersants – chemical agents – which provide formation of a supracolloidal system carried over by oil flow, prevent from wax accumulation on pipe walls. These include metal salts, salts of higher synthetic fatty acids, silicate-sulfanol solutions, sulfated alkali lignin [9].

Use of chemicals to prevent AD is in many cases combined with:
- the process of destruction of stable oil emulsions;
- protection of oilfield equipment from corrosion;
- protection from scaling;
- the formation of optimal gas-liquid flow structures.

A wide range of chemicals to control AD has been developed.

Along with high cost, a significant disadvantage of the chemical method is a difficulty of selecting an efficient agent because of permanent change in operating conditions of field development.

Physical methods are based on the mechanical and ultrasonic vibrations (vibration methods), as well as electric, magnetic and electromagnetic fields impact on the produced and transported products.

Vibration methods allow to create ultrasonic vibrations in the area of wax accumulation, which affect wax crystals, causing their micromovings, which prevents wax accumulation on pipe walls [8].

The magnetic field effect should be attributed to the most promising physical methods. Use of magnetic devices to prevent AD in oil production began in the fifties of the last century, but due to low efficiency did not become widespread. There was a lack of magnets for long-term and stable work under well conditions. In recent times use of magnetic fields to affect AD has become of great interest due to the occurrence of a wide range of high-energy magnets based on rare earth materials on the market. Currently, about 30 different organisations offer magnetic dewaxers [10].

It has been found out [11] that under the influence of a magnetic field in a moving fluid there occurs destruction of aggregates consisting of submicronic ferromagnetic particles of iron compounds in the concentration of 10-100 g/t in oil and associated water. Each aggregate contains a few hundreds to a few thousands of micro-particles, so the destruction of aggregates leads to a sharp (100-1000 times) increase in concentration of crystallization nuclei and salts, and to formation of micron-sized gas bubbles on the surface of the ferromagnetic particles. As a result of the aggregate destruction, the wax crystals precipitate in the form of fine, voluminous, stable suspension; and the accumulation growth rate reduction is proportional to the mean size reduction of the wax crystals precipitated as solids along with resins and asphaltenes. The formation of gas microbubbles in crystallization nuclei after magnetic treatment provides, according to some researchers, gas-lift effect, leading to some increase in well production.

Currently they use hot oil or water as thermal fluids; superheated steam; surface and borehole electric furnaces; electric dewaxers (induction heaters) operating inside boreholes; agents leading to exothermic reactions when interacting [12, 13].

[1] There are innovative wax control technologies [14].

These methods, with slight variations, and sometimes without them, are used in wells with various types of operation.

2. Research

Thermal methods are based on the ability of wax to melt at temperatures above 50°C and flow down from the heated surface.

Currently there are applied the technologies which use:
- hot oil or water as thermal fluids;
- superheated steam;
- surface and borehole electric furnaces;
- electric dewaxers (induction heaters) operating inside boreholes;
- agents leading to exothermic reactions when interacting.

The thermal fluid technology provides heating fluids in special heaters (portable boiler) and delivering them to the borehole by means of normal or reverse circulation. Reverse circulation is more preferable because it prevents formation of wax plugs that often occur during normal circulation.

The disadvantages of these methods are their high energy output, electricity and fire risk, unreliability and low efficiency.

To create the required temperature a special heat source is required, which can be placed directly into an accumulation zone; or a heat- containing agent is to be developed at the wellhead.
These methods have certain disadvantages. Thus, the use of hot oil and water or superheated steam leads to heating the tubing section from the wellhead to the wax accumulation zone, in other word, to thermal fluids energy losses. To provide the temperature of over 50°C in the wax accumulation zone thermal fluids have to be heated at the surface to the temperature 3-4 times exceeding the required one to melt wax. This method requires stopping the well. This method is expensive and energy consuming with low efficiency.

A more efficient method is creating the required temperature in the very wax accumulation zone. For this purpose a special heat source that can be placed directly in this zone is required.

Induction heaters are used as such sources. The induction heaters design involves the use of high frequency currents (HFC) to heat the tubing wall. This is achieved by using an inductor installed in the wax accumulation zone. A generator is installed at the wellhead. The method is not electrically safe, and requires careful HFC source insulation from the well metal structures.

The authors [15] suggest a method of creating the required temperature in the very wax accumulation zone using ceramic or micanite in-line ring heaters.

Ceramic or micanite in-line ring heaters (Fig. 1) are suggested to be installed on the tubing outer surface at the wax accumulation zone. Ring heaters are ideal for heating tubes and cylinders. Ceramic ring heaters have a high specific capacity for heating, so they can be used at higher temperatures.

Рис. 1. Design of a ring heater

1 – resistance tape; 2 – magnetic core; 3 - stainless steel case; 4 – micanite layer; 5 - electrical input; 6 - clamp

The rings rim diameter is equal to the tubing external diameter; the width should be equal to the interval of wax accumulation on the inner walls of the tubing. If the interval of wax accumulation exceeds the width of the ring resonator, the latter is made compound.

Permissible specific load of the ring heater with micanite insulation can reach 4.5 W/cm², and with ceramic insulation – up to 8 W/cm².

The operating temperature generated by the ring heater with micanite insulation can reach 350°C, and with ceramic insulation - 600°C.

The production technology allows to reduce energy consumption by 30% and greatly increase the heater useful lifetime.

The heat transfer from the heating element to the tubing heated surface is performed by the contact method.

Wire or high-resistance alloy tape are used as the heating element in the ring heater.

The insulation materials are micanite or ceramics. In heaters with micanite insulation the resistance
tape (Fig. 1, 1) is wrapped around the core (2) of the required shape and placed in a stainless steel case (3). A layer of micanite (4) is laid between the core and the case, which provides complete electrical insulation of the heater. Then, the heater is shaped into a cylinder, and the electrical input is installed (5). The reliable contact of the heater with a heated tubing surface is provided with a clamp (6) with tightening screws.

Ceramic ring heaters are similar to micanite ones, but are applied at higher loads and temperatures up to 700°C (Fig. 2).

3. Conclusion
Energy-conserving ring clamp heaters save up to 20% of electricity. When installing and operating ring clamp heaters it is required to provide maximum contact of the heating part of the heater and the heated surface for long and reliable service. For this purpose high temperature mounting paste is often used.

Heating control is possible due to a program, providing a periodic electricity supply through a controller.

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