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## MAGNETIC FIELD INFLUENCE TECHNOLOGIES ON HIGH-PARAFFIN CRUDE OIL IN THE PIPELINE WITH DIFFERENT CALIBER

*Influence technology of constant magnetic field at high paraffin oil is enhanced to prevent the formation and wax deposition in the tubing and during oil transportation by pipelines of different calibres. Action mechanism determination of directed static magnetic field on high- viscosity paraffin oil wells in Boryslav deposits was investigated by conducting laboratory tests of samples. For Botyslav field conditions the construction of magnetic recovery equipment (MRE) regarding the influence of magnetic induction on heavy oil deposits is designed.*

**Key words:** *paraffin, oil, magnetic induction, well, oil field.*

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## ТЕХНОЛОГІЯ ВПЛИВУ МАГНІТНОГО ПОЛЯ НА ВИСОКОПАРАФІНІСТУ НАФТУ У ТРУБОПРОВОДАХ РІЗНОГО ДІАМЕТРУ

*Удосконалено технологію впливу дії постійного магнітного поля на високо парафінової нафти з метою запобігання утворення і відкладення парафіну у насосно-компресорних трубах (НКТ) та при транспортуванні нафти нафтопроводами різних діаметрів. Визначено механізм дії спрямованого постійного магнітного поля на високов'язкі парафіністи нафти свердловин Бориславського родовища шляхом проведення лабораторних досліджень їх зразків. Спроектовано, для умов Бориславського родовища, конструкцію антипарафінового магнітного пристрою (МАУ) щодо впливу його магнітної індукції на поклади високов'язкої нафти.*

**Ключові слова:** *парафін, нафта, магнітна індукція, свердловина, родовище.*

**Introduction.** Flow rate large losses during the operation of oil production wells derived from oil deposition of asphalt-resin-paraffin deposits (ARPD) in the tubing.

Asphalt-resin-paraffin deposits (ARPD) are known as paraffin - buttery or solid masses of dark color. Formation of paraffin deposits reduces oil production, decreases turnaround time of wells, increases labor, material costs and the cost of produced goods. The concept of the formation and control technology with ARPD in oil production is still relevant scientific, technical and practical problem, since this factor directly affects the final performance and well productivity.

**Review of the last researches.** Researches of scientists and experts have shown that pipeline crystallization of paraffin deposits is not constant criterion. The development of technology and equipment to control asphalt-resin-paraffin deposits has a long history.

However, it cannot be said that all the difficulties are associated with the problem preventing the formation of asphalt-resin-paraffin deposits (ARPD) in the tubing are resolved.

A.A. Abramson, Yu.V. Antipin, G.A. Babalyan, N.F. Bohdanov, D. M. Bohdanov, N.R. Ibragimov, N.N. Neprimerov, A.V. Zguba, A.N. Pereverzev, N.I. Tayusheva, V.P. Troniv, K.R. Urazakov, Z.A. Khabibullin and others had great contribution to the solution of theoretical and practical issues of paraffin deposits.

The researchers also established some regularities of paraffin deposits formation in wells that affect on paraffin deposition under the following conditions:

- reducing pressure in the bottom hole, and thus violation of the hydrodynamic gas-liquid equilibrium system;
- intensifying gas emission;
- decreasing of temperature in the reservoir and borehole;
- speed change of the gas-liquid mixture and its individual components;
- hydrocarbon composition in each phase mixture;
- volume ratio of phases.

**Uncertain problems.** Today the theoretical and practical issues of paraffin crystallization at various surfaces of pipelines, features and profiles of deposits in tubing while oil transportation by pipelines are not enough studied. The influence of magnetic field on the highly paraffin oil are generally considered selectively and without systematic approach.

**Aim of research.** Influence technology of constant magnetic field at high paraffin oil is enhanced to prevent the formation and wax deposition in the tubing and during oil transportation by pipelines of different diameters.

**The main material presentation.** Transportation of oil by pipelines of various diameters and variety of conditions for oil field exploration of high paraffin produced oil requires individual approaches to prevent technology of paraffin deposits in pipelines.

Today, as many decades ago, there are following dominated oil methods: thermal, chemical, mechanical, application of coatings, physical.

These methods with minor modifications, and sometimes without them are applied in wells with different operating. Therefore, in the description of technologies concerning particular way will include only significant differences characteristic of the operation present method.

The above methods are used in different production wells (free-flow, pumping and its varieties), as well as oil transportation by pipelines.

There are many factors that either hinder or contribute to the intensive formation of paraffin deposits.

To the most significant of them we can refer:

1. Flow rate. As the studies have shown, the intensity of the deposits increases at the beginning, with the increase in speed due to the growth in mass transfer, and then decreases, as tangential stresses which increase the bonding strength of paraffin to the equipment surface.

2. The gas factor and the process of gas evolution itself during the pressure decrease. With release and expansion of gas, temperature is lowered, and gas presence in the flow enhances mass transfer, as a result, the proportion of paraffin hydrocarbons crystallizing on the surface of the equipment increases substantially.

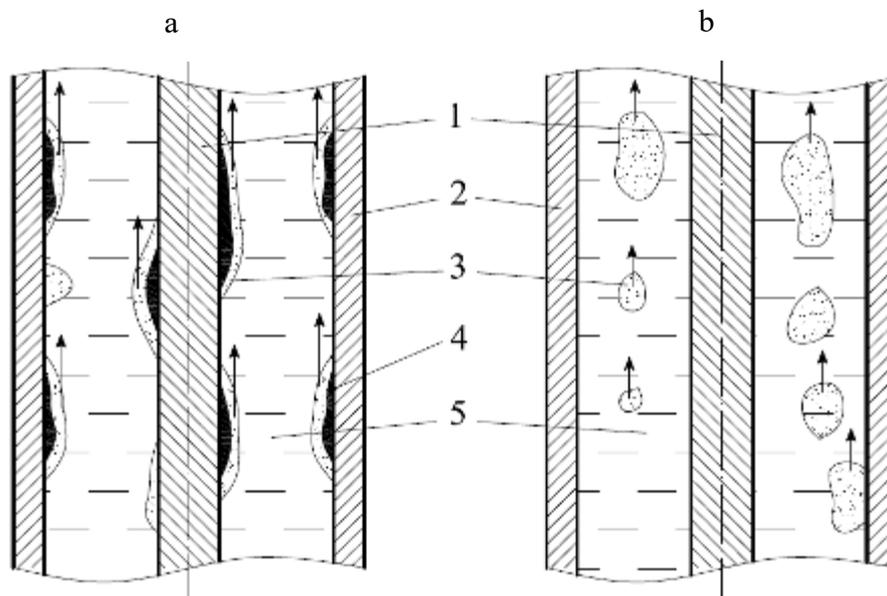
3. The presence of mechanical impurities, which are active centres.

4. Crystallization can lead to decrease in the intensity of paraffin deposition by reducing the state of oil super saturation and increase its share of crystallization in the volume.

5. The state of equipment (substrate) surface of has significant effect on deposits strength, in particular, substrate material polarity and surface quality (smoothness). The higher the value of the material polarity and its smoothness, glossiness (purity of treatment), the less is adhesion, and therefor at lower flow rates, paraffin formations will be broken from such surfaces.

6. Water cut of well production. It has twofold effect. First, with a small water amount in oil and other equal conditions, a slight increase in the intensity of paraffin deposits is observed, and then with increasing of water content in the flow, the intensity decreases both due to increase in the flow temperature (the heat capacity of water is 1.6 ... 1.8 times greater than oil), also due to the phase reversal, during which the contact of oil with the equipment surface deteriorates. 7. At the Boryslav field, the most intensive well waxing occurs at rate of 15 to 20 tons per day. With further increase in the production rate, we can observe sedimentation from the underground well equipment surface by gas-liquid mixture flows.

The oil flow sheet in the tubing cavity, at high water cut, for hydrophilic and hydrophobic surfaces is shown in Fig. 1.



**Figure 1 – Scheme of oil flow sheet in the tubing cavity with high water cut:**

a) metal surface is hydrophobic; b) surface is hydrophilic;

1 – rod, 2 – tubing, 3 – oil, 4 – ARPD, 5 – water

Therefore, during exploitation of the reservoir, the changes occur in the physical chemical composition of the oil due to several reasons: decrease in reservoir pressure and gas

release, hydrodynamic chromatographic section of the oil during its movement in the formation, dissolution of the components in the oil-flow past water and oxidation itemized to the formation with oxygen injected water. All mentioned leads to change in the thermodynamic characteristics of the formation and the fluid chemical composition, which is the main reason for the formation of asphalt-resin-paraffin deposits in oilfield equipment.

**Table 1 – The research results of APRD formation conditions**

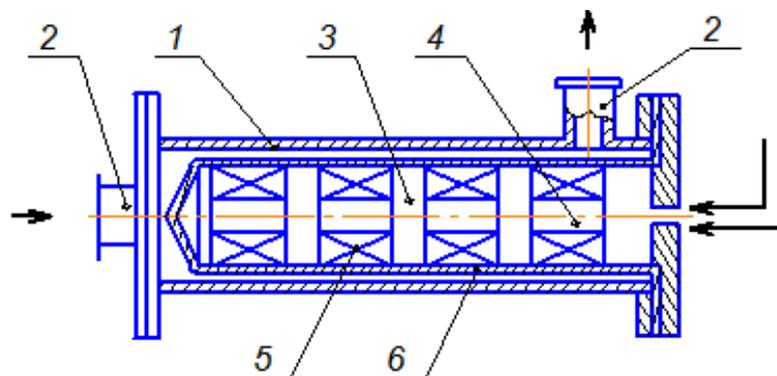
Depth, meters	Pressure, MPa	Total gradient temperature, °C/100 m	Temperature gradient caused by gas-oil mixture
1400	11,5	1,5	0,14
900	7,5	1,9	0,17
600	5,0	2,1	0,34
200	2,3	1,8	0,55

To prevent and reduce deposits growth using ASPR with the help of directly placed devices in the wells, in most cases devices with permanent magnets are used. These small devices have the best possible performance and virtually unlimited service life, they do not require significant maintenance costs, provide all the necessary range of magnetic treatment performance.

Magnetic devices that are used to prevent ARP deposition, have the most complex usually reversed field distribution, greater length of working channels, high gradient of magnetic field. Increasing of intensity and gradient are the main areas of such devices improvement.

The advantage of such anti paraffin equipment electromagnetic constructions is simplicity of increasing the duration of magnetic action, increasing the number of successively placed current windings and pole pieces. With corresponding increasing in the length of the device its consumption of power increases in proportion. However, despite the high specifications, this lack of general magnetic, closing axile surface of the pole pieces 3, leads to lower tensions of magnetic field and increased energy costs due to increased losses in the dispersed magnetic fluxes.

A scheme of development of a similar electromagnetic devices of Kharkiv National University of Engineering and Economics, with windings inside the pipe is shown in Fig. 2.



**Figure 2 – Electromagnetic devices:**

- 1 – the case; 2 – input and output flanges; 3 – pole pieces; 4 – total magnet core;
- 5 – current windings; 6 – shell of current windings

This construction has high permeability magnetic shielding outer body with input and output flanges for connection to fluid conduits but high permeability magnetic shielding pole pieces are connected with common axial cores where the current windings are. Near there are windings switched on towards each other on the treated fluid protected with nonmagnetic material covering. Annular gap between the outer surface of pole pieces and the inner surface of the body is working channel for fluid. System of current windings and pole pieces in the gap form reverse alternating magnetic field, which is used for magnetic treatment of liquid, and presence of the unifying magnetic pole piece reduces the total energy loss in scattering magnetic flux, thereby improving device energy parameters. Performance of various known devices ranges from 2 to 100 m<sup>3</sup> / h, the maximum strength of magnetic field in the working channel 96 kA / m (magnetic induction 0.12 T), the channel length of the current magnetic field of 0.3 to 3 m. To receive reverse magnetic field to 6 current windings are used, where specific energy consumption is from 6 to 35 W / m<sup>3</sup>. If the length of the gap  $g$  between the outer surface of the pole pieces and the inner surface of the outer body-tube is less axial thickness of the pole pieces, high tension  $H$  of magnetic field in the working gap of such devices can be roughly determined from the equation:

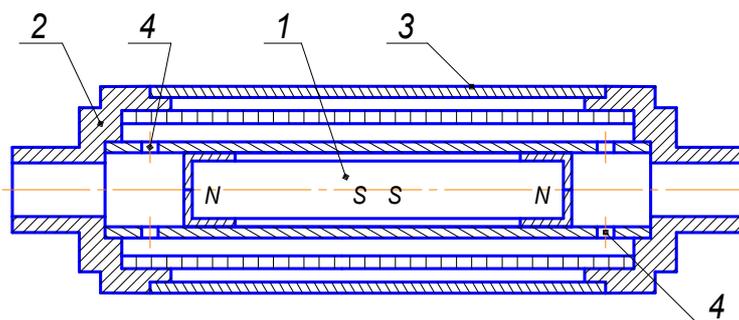
$$H_{\bar{n}\delta} = \frac{I \cdot n}{2 \cdot g},$$

where  $I$  – amperage, and  $n$  - the number of turns in each winding.

The proposed magnetic anti paraffin equipment (MAE) does not have these disadvantages. Because of usage of pipeline cores figurine-shaped magnetic the system covers only small section of the pipeline. Number of magnets is small, magnetic treatment provide effective total fluid volume that passes through the device in the same conditions of high-gradient field with sufficient treatment duration.

Permanent cylindrical chain 1 mounted in the pipeline 2, has reversible axial magnetization created so that the outer poles have the same polarity and the opposite polarity formed in the middle of its length. The working channel for the fluid is the gap cross section between the outer surface of the pipe 2 and the outer pressure vessel 3. In order the fluid enter to the channel and out of it after treatment in the wall pipe 2, near the ends of the magnet 4 holes are made.

Fig. 3 shows schematic diagram of the proposed MAE.



**Figure 3 – Magnetic anti paraffin equipment (MAE) for liquid magnetizing:**

- 1 – reversible magnetized permanent magnet; 2 – the pipeline;
- 3 – outer casing; 4 – holes for fluid input and output.

When using high permeability outer casing 3 in a device of this type, reverse magnetic field can be obtained (with a small reverse number) that predominantly is perpendicular to the direction of fluid flow force lines with high intensity and gradient. However, it is difficult to obtain large areas of high gradient length fields. Devices of this kind are easy to implement by

means of the pipe 2 sequence of magnetization directions, alternating axially magnetized magnets. Significant increase number in field reverses number does not represent difficulties. As it can be seen further, on this principle very large number magnetizing devices are made. For all these devices the main purpose are magnetic water treatment and water systems. Obviously, the consistent deployment of any other above magnetic devices with permanent magnets, they can be converted to multiblock where many reverse magnetic fields can be received. Due to this fluid duration, treatment is significantly increased.

**Conclusions.** Therefore, influencing technology of magnetic field at high paraffin oil by magnetic anti paraffin equipment (MAE) proposes figurine-shaped magnetic cores use. Number of magnets is small, but it ensured the effectiveness of magnetic treatment of fluid entire volume passed through the device in the same conditions of high-gradient field with sufficient treatment duration.

The equipment (MAE) can work in pipelined of different diameter thus providing the necessary magnetic field strength and magnetic induction. It has small magnet mass, requires lower cost, comparatively to other similar devices.

The equipment (MAE) differs from other magnetic devices for fluids treatment that there is no need for any power supply to the unit, as it is based on permanent magnets.

Magnetic field influencing technology usage at high paraffin oil by magnetic anti paraffin equipment (MAE) shows the necessity to use such equipment either in free flow wells with high content of asphalt resin paraffin particles (especially in winter), or at the operation of deep- centered rod and diaphragm pumps, as well as oil transportation by pipelines of different diameters.

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