



## EFFECTIVE TECHNOLOGIES OF DISSOLUTION OF ORGANIC DEPOSITS IN THE BOTTOMHOLE ZONE OF OIL WELLS REGISTRATION FORM

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### ABSTRACT

Article deals with problems of oil production on Kazakhstan's fields. The necessity of search for more effective ways of restoring the initial permeability of bottomhole zone of the formation was established. The assessment is given to methods of removal and decrease in asphaltic-resinous and paraffin deposits in a bottomhole zone of oil layer. A new technology of treating the bottomhole zone of a layer with oil-based solvents is offered and ways of increasing well flowrates are considered. Experimental studies have been carried out to determine the ability of the recommended new oil reagents to dissolve asphaltic-resinous, paraffin deposits. The conclusion was made that new petroleum solvents differ from others not only in high efficiency but also in low cost and affordability, as they can be obtained with simple equipment directly from the degassed oil in field conditions.

### KEYWORDS

Oil, reservoir, technology, asphaltenes, resins, paraffin, sediments.

### 1. INTRODUCTION

On many fields of Kazakhstan, depending on the horizons, oil reservoirs contain up to 30÷40% of asphaltic-resinous and paraffin compounds, and the content of paraffin in them ranges from 19,2÷29,4%, resin – 9,7÷16,3%, asphaltenes – 0,83÷3,58% [1,2]. These oils are characterized by a high pour point (30÷35 °C), increased viscosity and the ability to form stable water-oil emulsions. In this regard, as the oil is withdrawn from the reservoir and the reservoir pressure decreases, phase changes occur in the fluids. Due to the laminar nature of the movement of oil in the pores of the bottomhole formation, perforation holes and the well bottom, asphaltic-resinous, paraffin deposits (hereinafter – ARPD) are gradually formed. The permeability of the bottomhole formation zone is deteriorating, and in some cases the well flowrates are reduced up to 5 tons / day and lower. At the same time also occurs pulling of bottom formation water to the well bottom, leading to premature watering of the produced oil through the lower perforated interval of the well [3,4].

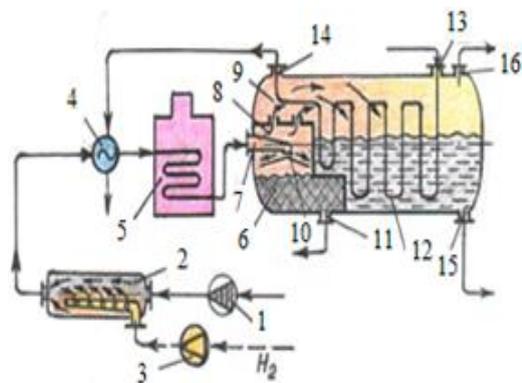
At present, hot oil or by-products of petrochemical production (styrene, synthetic rubber, etc.) containing aromatic hydrocarbons – benzene, toluene, xylene, ethylbenzene, isopropylbenzene, butylbenzene, polyalkylbenzene and others are used to remove ARPD from the bottomhole zone [5,6]. So, for example, an oil recovery method is known, which involves injection of a hydrocarbon solvent into the wellbore and bottomhole zone of an oil reservoir with ARPD, which is based on liquid products of petroleum feedstock pyrolysis obtained by rectification in the range of 35 to 150°C at atmospheric pressure in the presence of polymerization inhibitors [7]. However, petrochemical by-products due to high cost are not always available in field conditions and their efficiency is low. They are dominated by heavy high-molecular components of aromatic hydrocarbons and resinous substances that do not completely dissolve ARPD in the pores and cracks in the oil-bearing layer [8]. It is almost impossible to provide all wells in the fields with petrochemical by-products due to the limited number of relevant profile petrochemical plants and the high cost of their by-products produced [9-12].

When treating the bottomhole formation zone with hot oil, it is also impossible to achieve high solubility of ARPD, since in the composition of extracted oil, in addition to aromatic hydrocarbons, there are a large number of alkane and naphthenic high-molecular heavy hydrocarbons in which asphaltenes and resins are difficult to dissolve [13]. The fraction of aromatic hydrocarbons, which are a good solvent of ARPD, in the initial oil usually, does not exceed 1 ÷ 5%. Therefore, it is necessary to search for other and more effective ways of restoring the initial permeability of the bottomhole zone of the formation and the available sources of solvents of ARPD in the well.

### 2. MATERIALS AND METHODS

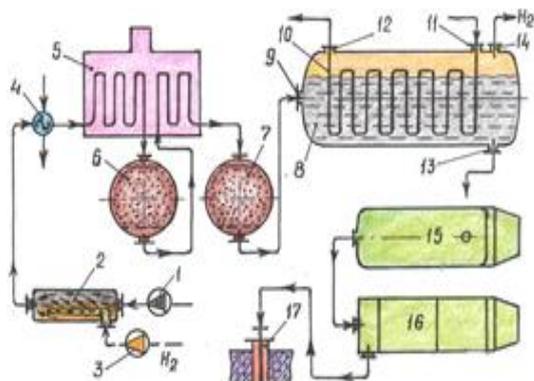
We have obtained a patent for a method of increasing oil recovery of formation with ARPD in wells, which involves injecting into the bottomhole formation zone of new effective oil solvents of two kinds obtained from field conditions from degassed oil [14]. Primary petroleum solvent with a basic content of aromatic hydrocarbons is obtained from degassed oil with the content of C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules with a distillation temperature equal to the boiling point of the xylene fraction of aromatic hydrocarbons. It can be used for small organic deposits in the bottomhole formation zone and in the well. Secondary petroleum solvent, so-called aromatized, is obtained from the above basic oil solvent by catalytic reforming method at optimum temperatures and pressures. Due to the large content (up to 50%) of aromatic hydrocarbons, it is advisable to use it for large colmatation of the bottomhole formation zone with ARPD [15].

The process flow diagram for obtaining an oil solvent with a basic content of aromatic hydrocarbons is shown in Figure 1. Initial degassed oil in special installations is exposed to simple distillation to obtain its components with the content of C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules.



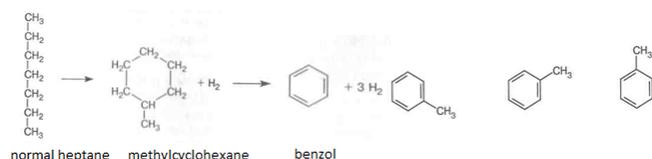
**Figure 1:** The process flow diagram for obtaining the base oil solvent: 1 – pump; 2 – mixer; 3 – compressor; 4 – heat exchanger; 5 – furnace; 6 – separator; 7 – intake; 8 – intake chamber; 9 – cooling chamber; 10 – outlet pipe; 11 – outlet pipe; 12 – cooling pipes; 13 – inlet nozzle; 14 – outlet nozzle; 15 – outlet nozzle; 16 – outlet nozzle

The aromatized petroleum solvent is prepared from a base oil solvent containing C<sub>6</sub>-C<sub>9</sub> carbon atoms in the molecules by catalytic reforming in the reactors (Figure 2) under the influence of high temperature and pressure [16].



**Figure 2:** The process flow diagram for the production of aromatized petroleum solvent ARPD: 1 – pump, 2 – mixer, 3 – compressor, 4 – heat exchanger, 5 – furnace, 6 and 7 – reactors, 8 – cooling chamber, 9 – intake pipe, 10 – cooling pipes, 11 – inlet nozzle, 12 – outlet nozzle, 13 – outlet nozzle, 14 – outlet nozzle, 15 – tank truck, 16 – pump

In this case, paraffin is converted to isoparaffin and naphthene, and naphthene to aromatic hydrocarbons, mainly benzene, toluene and xylene, and a liquid phase of oil components with C<sub>6</sub>-C<sub>9</sub> carbon atoms in the molecules is obtained (Figure 3) [17].



**Figure 3:** Chemical reaction of obtaining liquid phase of oil components with C<sub>6</sub>-C<sub>9</sub> carbon atoms in the molecules

Experimental studies have been carried out to determine the ability of the recommended new oil reagents to dissolve ARPD [18]. At the same time, petroleum solvents containing C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules were obtained in laboratory conditions on special installations of degassed oil with a density of 784 kg/m<sup>3</sup> and a viscosity of 3.8 MPa·s. As a sample of ARPD, solid bitumen and resin used in road construction were taken. Solid bitumen contains about 30% asphaltenes and 25% resins.

### 3. RESULTS AND DISCUSSION

The laboratory installation (Figure 4A) for obtaining the base oil solvent consists of a column, a glass bulb with a volume of 0.5 ml and a heat exchanger. The glass bulb is attached to the stand by clamps and has a metal plug with an asbestos gasket. The glass bulb through the orifice of

the metal plug and with the help of a copper tube communicates with the inner compartment of the heat exchanger. Through the outer jacket of the heat exchanger, cold water flows from the water supply network through plastic pipes [19]. A copper cartridge for the thermometer is sealed into the hole of the metal plug. Under the bulb there is an electric heater. The lower part of the bulb with the outside has a heat-insulating asbestos shirt.

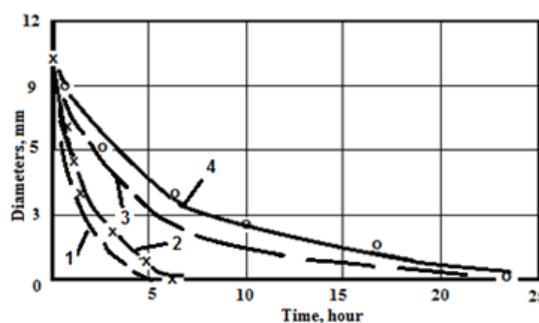


**Figure 4:** Laboratory installations for obtaining oil solvents: A – base; B – aromatized

250 ml of degassed oil is put in a glass bulb. The oil is heated to the boiling point of aromatic hydrocarbons (benzene, toluene and xylene) with a carbon content of C<sub>6</sub>-C<sub>9</sub> in molecules of 170°C. The evaporated oil fraction is cooled in a heat exchanger and collected in a receiving bulb. The resulting petroleum solvent has a basic amount of aromatic hydrocarbons, but their share in the total volume of the solvent is several times increased due to the absence of heavy hydrocarbons. It is known that asphaltenes dissolve only in aromatic hydrocarbons. Therefore, a new oil solvent is much more effective than existing solvents, including hot oil and petrochemical by-products.

To produce an aromatized petroleum solvent, a special installation was made in laboratory conditions (Figure 4B). It consists of a horizontal cylindrical reactor, a heat exchanger and a receiving cylinder. The reactor is filled with small particles of a platinum catalyst. From the outside, the reactor is contacted by electric heaters and has a casing of heat-insulating material – asbestos. The reactor is equipped with inlet and outlet nozzles. It is filled with 75% of its volume by the initial oil solvent with a basic content of aromatic hydrocarbons and is exposed to a high temperature of 460°C and a high pressure of 2 MPa. At the same time, the chemical transformation of paraffin into aromatic hydrocarbons takes place. The oil solvent with an increased content of aromatic hydrocarbons, obtained by catalyzed reforming, is cooled in a heat exchanger and collected in a receiving cylinder.

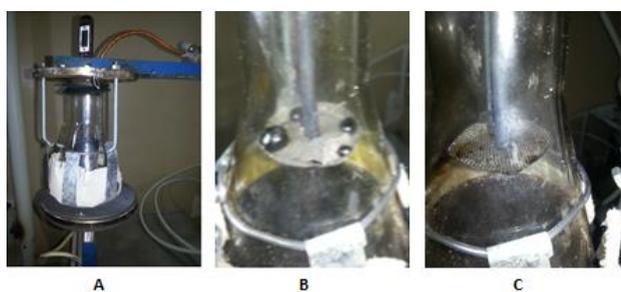
The dissolving power of these two oil solvents was evaluated under atmospheric conditions. Samples were taken of solid bitumen and resin in the form of balls with a diameter of 10 mm, which were loaded into petroleum solvents. At certain intervals, the diameters of the samples were measured, and the dissolving power of the oil solvents was estimated from the change in the diameter of the samples. Figure 5 shows a diameter (mm) changing diagram of solid bitumen resin samples in oil solvents as a function of time (hours). Lines 1 and 2 show the solubility of the resin and solid bitumen, respectively, in an aromatized petroleum solvent. Lines 3 and 4 describe the solubility of the resin and solid bitumen, respectively, in the base oil solvent.



**Figure 5:** The cross plot of decrease in diameter of samples of solid bitumen and resin under the influence of oil solvents under atmospheric conditions

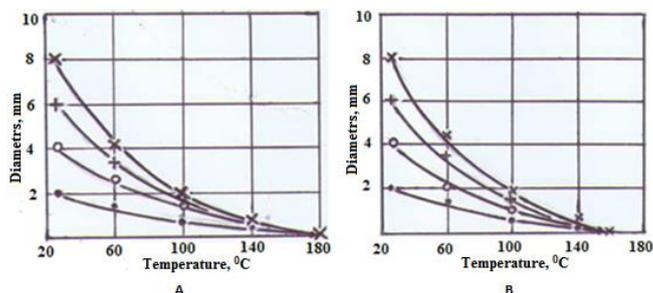
It can be seen from the diagram that the dissolving power of the aromatized oil reagent for resin and solid bitumen is about 5 and 6 hours, respectively, and is higher than that of the base oil reagent. Resin and solid bitumen in the base oil reagent dissolve accordingly for 22 and 24 hours. These results suggest that, depending on the degree of colmatation of the bottomhole zone of the oil reservoir, both types of oil solvents can be used. With small organic deposits in the wells, it is economically expedient to use a base oil solvent, and with large deposits – an aromatized petroleum solvent with a high content of aromatic hydrocarbons.

We also carried out experiments on establishing the change in the aggregate state of organic deposits under the influence of a heated base oil solvent with the content of C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules up to the maximum boiling temperature. In this case, 250 ml of oil is poured into a glass bulb (Figure 6A) with a capacity of 500 ml. On the upper part of oil there is a mesh cup, on which there are samples of solid bitumen and resin. Samples of solid bitumen and resin had a spherical shape with diameters of 2, 4, 6 and 8 mm. An electric heater is installed under the bulb. The neck of the bulb is closed with a plug, which has an orifice in the center. A copper tube is attached to the orifice of the plug, the second end of which is connected to the refrigerating chamber and the collector. The cooling chamber was cooled by running water.



**Figure 6:** General view of the laboratory installation: A – fixing the glass bulb to the body; B – placing the mesh cup with samples of solid bitumen and resin inside the glass bulb; C – mesh cup after dissolving the samples under the action of the heated base oil solvent

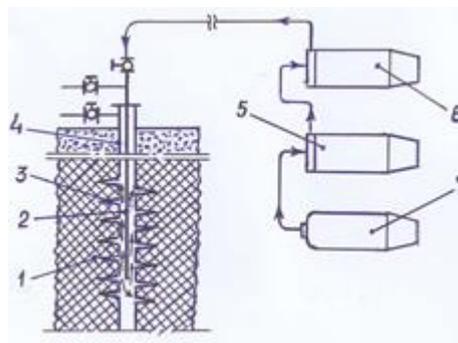
During the experiments, it was found that as the temperature increased up to 70°C for 25 minutes under the influence of the evaporating flow of the base oil solvent, bitumen and resin samples from the solid state passed into the liquid mobile state (Figure 6B). Starting from the temperature of 50 – 60°C, spherical samples assume a flat shape. When the temperature reaches 120-140°C after the beginning of the experiment within 40 minutes a mobile liquid film with a thickness of 1.5 – 0.5 mm gradually formed on the mesh surface, which drains through the holes of the mesh cup down into the bulk of the oil (Figure 6C): for samples of bitumen – at 180°C, and for resin – at 165°C. The diagram (Figure 7) shows the results of the experiment on determination of solubility (changes in the height of the samples) of bitumen (Figure 7A) and resin (Figure 7B) under the action of a heated base oil solvent to a temperature of 185°C.



**Figure 7:** Dependence of the change in the diameter of solid bitumen (A) and resin (B) samples on the temperature under the influence of the base oil solvent

The results of these experiments showed that, under the influence of temperature, the dissolving power of the base oil solvent with the content of C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules sharply increases. In a short time, i.e. within 50 minutes, the organic scale particles can be washed off with a base oil solvent from a solid surface. This indicates that the temperature has a significant effect on the dissolving power of the recommended ARPD reagents.

The technology of ARPD dissolution in wells with the recommended oil reagents is as follows. The well is killed with a displacement liquid and the circulation is broken. In the bottomhole zone of the formation 1 (Figure 8), through the tubing 2 and the perforation channels 3 of the well 4, a petroleum solvent is pumped through a mobile pump 5 without heating or with heating to 160°C by means of a mobile furnace 6 for large colmatation of the bottomhole formation zone. The volume of fluid displaced from the well is measured by the annular space.



**Figure 8:** Diagram of oil solvent ARPD injection into the well

The oil solvent is delivered on the tank truck 7. The amount of the first portion of the oil solvent injected into the well is calculated so that it fills the pipes and the annulus from the tubing shoe to the formation top. After that, the annular space is closed, and the entire volume of the oil solvent is injected through the tubing into the well. The solvent is then displaced into the formation. The volume of solvent remaining in the pipes and in the lower part of the well is displaced into the reservoir by a displacement fluid.

#### 4. CONCLUSION

Once the oil solvent is injected, the well is closed for "soaking" and allowed to react to organic deposits and redistribution of saturation in the bottomhole formation zone. In the bottomhole formation zone and the well bottom under the influence of an injected petroleum solvent with the content of C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules of ARPD in a dissolved form become more mobile. After aging, the ARPD particles together with the oil solvent are removed from the well. Then the well is allowed to start at producing mode, at which the operation is conducted at the level of the project cost-effective production rate.

Thus, the base oil reagent with the content of C<sub>6</sub>-C<sub>9</sub> carbon atoms in molecules (without heating or with heating within 120÷180°C) can be used to dissolve small ARPD in the bottomhole zone of the oil reservoir and inside the well, and an aromatized petroleum solvent with a high content of aromatic hydrocarbons – with a significant deterioration of the permeability of the bottomhole formation zone and a significant decrease in well production. These new petroleum solvents differ from others not only in high efficiency but also in low cost and affordability, as they can be obtained with simple equipment directly from the degassed oil in field conditions.

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