Efficiency of preliminary discharge of stratum water in Tuymazinskoe oil field

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Abstract. The high water content of oil is a common occurrence for many Russian fields at the late stage of development. Due to the elimination of associated water in oil, the overload of field pipelines often takes place. Products are often collected by a one-pipe system, which means that the formation water is discharged using special plants PWDS. Research workers have made it clear that the complexity of production "BashNIPIneft" and OGPD "Tuymazaneft" on Tuimazy field was due to the fact that the collection of production, in most cases, uses a centralized system, which loses its advantages when there is a large content of water in the emulsions. Research has indicated that the reagents, used in the field, proved to be ineffective, as the oil of Devonian formations is heavily saturated with paraffins. But, ultimately, the most effective agents for the destruction of emulsions have been nonetheless identified. This paper describes the implementation of the system of track discharge of formation water, which is currently in use for many oil companies not only in Russia but also worldwide.

1. Introduction

The purpose of the article is the use of the preliminary water discharge system and the selection of the most effective demulsifiers for breaking the emulsions of Devonian oils.

Existing plants for the preparation of oil are not always able to cope with the increase of the high volume of incoming fluid. Therefore, predischarge of water is used to reduce corrosion and to increase the efficiency of these oil treatment plants. This method is rational with a water content of more than 30 % [2, 3].

In many of the major oil fields in Russia, which are at the final stage of development, the water content in oil is very high. Due to the pumping of products with high water content to the integrated oil treatment system and the system of preliminary water discharge, as well as to the elimination of water, which is extracted together with oil, there are overload pipelines. Tuymazinskoe oil field is considered as the most striking example of this process as oil-industry workers experienced great difficulties when operating it.

2. Results and Discussion

The OGPD "Tuymazaneft" Devonian oil is produced at all oil plants. Production, collection and preparation of the product, in most cases, are conducted separately from the coal-bearing oil.

For example, it is possible to consider the process of collecting oil in Tuimazy oil field.
Products from Devonian formations are collected by a one-pipe system. This means that the discharge of produced water is not on the oil fields themselves, and on specially designated preliminary water discharge systems (PWDS).

The preliminary water discharge systems, which include sumps, separate the gas and formation water. Further, the oil is fed to the sumps and then pumped by centrifugal pumps onto the IOTS-4 (integrated oil treatment system). Produced water enters the water treatment unit, where it is cleansed of oil products, followed by injection into the MRP (maintaining reservoir pressure) system.

From this it follows that the extracted from the formation water is transported from the production wells to the system of preliminary water discharge. In the preliminary water discharge system, it is cleaned of oil emulsion and is pumped back into the oil reservoir.

The dosage of the demulsifier is exercised in the collection systems. The dosage is carried out immediately before the PWDS or CESS (combined end separation system). Oil falls onto IOTS-4, where the water and salts are removed from oil. It should be noted that the water content in the oil at that time had already reached more than 90%.

The analysis carried out by "BashNIPIneft" and OGPD "Tuymazaneft" made it clear that the complexity of production was due to the fact that in most cases, the centralized system of collecting oil, which in turn loses its advantages under such factors as: the presence of a high content of water in emulsions and significant extensions of pipelines.

The increase in volumes of produced water that is extracted together with oil emulsion leads to the destruction of pipelines and to the reduction of the strength factor owing to corrosion of tubing. Also the energy expenditure on pumping the separated water back to IOTS and the MRP system increased [1].

Studies of factors changing technical and economic calculations and reliability points of training and acquisition of oil have shown that they are more dependent on technology and technology division of the well production, which in turn does not allow for the individual properties of gas-liquid systems, their diversity and the difficulty of forecasting with the watering, mixing water and oil deposits in different interlayers.

In the process of oil production from the Devonian strata, it was necessary to analyze the effectiveness of demulsifiers used. Analysis has indicated that the reagents used are ineffective in the destruction of oil emulsions Devonian horizon. The main factor in the stability of these emulsions is a paraffin.

Degassing the oil and reducing the temperature rise resulted in the growth of wax crystals and in the increase of its concentration on the surface of interfaces. It follows that such an emulsion cannot be destroyed, and the entire operation requires large expenditures on reagents [4,5].

Analyses of samples of oil emulsions Devonian horizon are carried out in TOGPW-1, OOGPW-1, OOGPW-2, TOGPW-3 and TOGPW-4.

Various indicators of the stability of emulsions were found in all the shops. This means that the degree of efficiency of analyzed demulsifiers was also different. According to the research results, the most effective demulsifiers were revealed.

For TOGPW-1, the most effective demulsifiers turned out to be:
- Reapon 4B;
- Proksanov 305-50;
- Separol 25;
- Diproksamin 157-65M.

For OOGPW-1:
- Proxanol 305-50;
- SNPCH 4705;
- Separol VF-42;
- SDS-20;
- V Dissolvan 2892;
- SNPCH-4204.
For OOGPW-2:
- SNPCH 4601;
- V Dissolvan 2892;
- Separol 25;
- SDS-20;
- 157-65M Diproksamin;
- Daufaks;
- DB-02.

After analyzing the results of studies of the oil desalination process of the Devonian and coal-bearing horizon, the following conclusions were made:
- an increase of percentage of the Devonian oils, which enter UKPN-4 from the fields, leads to deterioration of indices of the desalination process of the oil mixture;
- for successful implementation of the process of desalting the mixtures of the Devonian and coal-bearing strata, SNPCH-4705 was recognized as the most effective emulsifier, and Diproksamin 157-65M - for oil Ardatov group.

From the above-mentioned it follows that deterioration of the desalting process depends on the composition and properties of miscible oils.

Produced water of coal-bearing seams has a fairly high content of salts ($\rho_s = 1091 \text{ kg/m}^3$ in the general manifold; and in the Ardatovsky manifold, $p = 1155 \text{ kg/m}^3$).

It was also concluded that the ionic composition of produced water has no effect on the process of desalination due to the low index of water production. (0.2-0.5 vol. %).

Calculations carried out in laboratories, did not allow revealing any harmful effects of iron sulfide in the process of desalination, as its content in the samples collected shall not exceed the norm. The literature indicates that the FeS content in the oils ranging from 50 to 150 mg/l does not affect the process of desalination.

Let us note that the changing of the process conditions of desalting different oils mixtures is associated with an increase of these oils proportion of Devonian horizon.

Many applications in OGPD "Tuymazaneft have been received by piped water separators, which represent obliquely positioned tubes, reducing maintenance costs and allowing one to virtually make water discharge process automated [4].

The first tube dehydrator (TD) in OGPD "Tuymazaneft" was introduced in 1997. It provided about 90 % of discharge of produced formation water in the oil fields.

As a result of TD introduction, the amount of water mains in the reservoir pressure maintenance system has been reduced significantly, which improves the properties of produced water.

Then, TD-29 and TD-36 were enacted, allowing a discharge of up to 96 % of water in the presence of oil products in it of less than 30 mg/l.

The proposed division of Carboniferous and Devonian oils OGPW-5 at plant TD-20 allowed:
- implementing discharge of the produced water directly in the field;
- eliminating the re-pumping from the PWDS-5 at the GPS (group pumping station);
- eliminating metal-intensive machinery IOTS-5C and PWDS-5D from the operation.

Thus, in the fields of Bashkirta, a system of the traveling discharge of produced water in the tube dehydrators (TD), which have been already widely used in many oil companies, is successfully implemented.

With sufficiently large water cut of well production, in order to separate most of the produced water, directly in the field, the preliminary water discharge system (PWDS) is used in the oil collection system. Let us consider the basic scheme of PWDS. From the collector, the production of the well enters a horizontal sump, where it is divided into oil and water under the action of gravity. For better separation of oil and water, a reagent demulsifier is supplied before the entry to the sump using a reagent dosage unit.

The amount of the injected reagent, as a rule, is from 20 to 100 g / tons of liquids, and it depends on the resistance of the water-oil emulsion to be destroyed.
Partially dehydrated oil from the upper part of the sumps enters a three-phase separator, where under a pressure of up to 6 atm, oil is separated from the gas and a more complete separation of the formation water occurs. After that, oil gets into the pump of the CPS (central pumping station), and after passing the oil metering unit, it is fed to the pressure header for further transportation to the oil treatment unit.

The gas from the three-phase separator, having passed through a gas processing plant (GPP), intended for trapping condensate, and a gas metering unit under separation pressure is fed to a gas-processing plant.

The separated water from the lower part of the sump and the three-phase separator enters a sump, intended for collecting oil, taken out of the mechanism together with water.

Stagnant water enters the pump at the central pumping station, and after passing through the water-metering unit, it is used to support the formation pressure.

The trapped oil from the sump of water enters the drainage tank, where the condensate accumulated in the gas separator is also discharged.

As the drainage tank is becoming filled, the liquid from it is pumped out into the pipeline of the product inlet, leading to the unit.

Since the water sump operates under very low excess pressure, which is not sufficient to transport gas to the gas processing plant, the gas from the sump passes through the condensate collector and enters the combustion candle.

**Figure 1.** The basic technological scheme of the preliminary water discharge system (PWDS): flows: I – formation oil; II – demulsifier; III – associated petroleum gas; IV – oil after the first stage of separation; V – formation water; VI – trapped oil from the sump water; VII – mechanical impurities, sludge; VIII – cleaned from mechanical impurities and oil formation water; IX – oil to the CPF (central processing facility); X – gas to the flare unit; XI – water to the group pumping-station; equipment: 1 – separator of the first stage of separation; 2 – compensator-depulsator; 3 – entrainment separator; 4 – tubular furnace; 5 – separator; 6 – sump for dehydration of oil; 7 – buffer reservoir; 8 – sump formation water; 9 – degasser; 10, 11 – pumps; 12 – unit for accounting for associated petroleum gas; 13 – oil metering unit; 14 – unit of registration of formation water.

**3. Conclusions**

1) On the basis of principles of market economy and cost optimization, renewal and modernization of oil gathering systems without capital investments in new technical solutions of preliminary discharge become the most acceptable at the final stages of exploitation (downhole separation technology, etc.).

2) For successful completion of the desalting process of mixtures, belonging to Devonian and coal-bearing strata, SNPCH 4705 and Diproksamin 157-65M are the most effective demulsifiers under Tuimazy field conditions. Also taking into account the tender procurement of reagents, let us note the need for a written fixing of more stringent criteria for cost-effective sufficiency of demulsifiers.
3) Application TD vehicles, intended for relief of associated formation water in the system of oil collection and treatment with its subsequent injection by centrifugal pumps into its layers, allowed improving the efficiency of oil production in the Tuimazy field and made the water discharge process automated, reducing accident rates of the equipment and the connecting conduits. In addition, such application allowed one to reduce energy consumption as well.

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