Influence of well watercut on pumping parameters

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Abstract. The article deals with the impact of well watercutting on the reliability of field pipelines and pumping parameters. As a result of the analysis of statistical data on the number of accidents over the last 9 years, it has been established that the main part of accidents is associated with high watercut oil. Besides, approaching the value of the volume fraction of water in the emulsion to a critical one can lead to a pressure drop beyond the standard values. The article deals with the impact of well watercut on the reliability of field pipelines and pumping parameters. As a result of the analysis of statistics on the number of accidents over the past 9 years, it has been established that the main share of accidents is associated with high watercut of well products. Its high content is the reason for intense corrosion and erosion wear of pipe material, which leads to formation of in-pipe corrosion zones and, as a result, pipeline leaks.

1. Introduction
The oil and gas industry takes a leading place in the Russian economy, and the rate of oil production increases every year. Thus, from 2010 to 2019 oil production volumes increased from 505.2 [1] to 560.2 [2] million tons per year, which represents an increase of 10.89%.

The volume of extracted associated water has increased 4 times since 1995 and in 2019 amounted to 3.8 billion m3. The increase in water cut of produced products results an increase in specific operating costs and energy consumption per unit of refined oil volume. According to the Federal State Statistics Service, over the last 7 years the cost of oil production in Russia has doubled - from 7491.9 RUB/t to 14942.94 RUB/t [3].

Intensive hydrocarbon production processes create risks of disturbing the ecological balance and are accompanied by emergency situations. The main environmental problems arising from oil production are associated with the appearance of emergency situations in the operation of field pipelines, followed by the release of a significant amount of pollutants into the environment, air and water pollution and formation of oil-polluted soils.

Over the period 2011-2018, there was a steady downward trend in the number of oil pipeline leaks in the fuel-power complex. Nevertheless, in 2018, as in previous years, leaks of field pipelines accounted for more than half (60%) of the total number of pipeline leaks. According to the State Report "On the state and protection of the environment of the Russian Federation in 2018"[1], in 2017-2018 there were 6482 cases of pollution. The total amount of oil and petroleum products entered the environment was 21493.7 m3, and the total area of pollution was 6398 ha or 64 km2.

According to Federal Service for Environmental, Technological and Nuclear Oversight of Russia [4], from the beginning of 2017 to the end of 2018, 25 major accidents occurred at oil and gas production facilities, with a total economic loss of 1.467 billion RUB.
Figure 1. Dynamics of oil production levels and leaks in field pipelines.

According to the results of a study about the causes of accidents at field pipelines [5], the majority of accidents (91%) involving spills of oil and petroleum products are associated with internal corrosion of pipe metal.

The main reason for internal corrosion is high watercut of well products. The chemical composition of oilfield water [6-7] makes it a good electrolyte for the process of pipe metal oxidation reactions with the formation of in-pipe corrosion areas. Alongside with corrosion, there is erosion destruction due to mechanical admixtures moving in the flow and eroding the inner surface of pipes. The metal is separated from various deposits and oxide coating, the contact area of the corrosive agent with the pipe material is increased, and as a result, there is an additional increase in oxidation rate.

Table 1. Chemical composition of oilfield water.

| Matter (ion)                        | Concentration, mg/l |
|-------------------------------------|---------------------|
| Cl                                  | 6000-22000          |
| HCO₃⁻                               | 100-2000            |
| Ca²⁺, Mg²⁺ and other metals         | 100-1100            |
| H₂S                                 | 0-4                 |
| O₂                                  | 0-2.5               |

According to rough estimates, the safe operation period of field pipelines without internal coating varies from 3 to 5 years, and with the presence of in-line protection - up to 15 years. After 5 years of operation there is a rapid increase in the number of breakthroughs. Further stabilization of the situation is achieved through overhaul, after which the accident rate is still quite high.
2. Methods and results
Let us consider the effect of watercut on pumping parameters. To diagnose the correlation between the 
water cut of the well products and the pressure in the pipeline, hydraulic calculations of the florwline 
with the diameter of 89x5 mm were made for different values of the watercut of the well products.

Table 2. Physical and chemical properties of downhole products.

| Property, unit of measure                  | Value  |
|-------------------------------------------|--------|
| Oil density at 20°C, kg/m3                | 839.0  |
| Oil viscosity at 20°C, cPs                | 9.09   |
| Oil viscosity at 0°C, cPs                 | 16.293 |
| Gas factor, m3/t                          | 33.56  |
| Relative density of gas, unit fraction    | 1.2    |
| Density of oilfield water at 20°C, kg/m3  | 1.1727 |
| Watercut, %                               | 55-85  |
| Critical watercut, %                      | 71.61  |

According to the obtained data, it can be concluded that as the percentage of water in oil approaches 
the critical one, there is a pressure increase in the pipeline, and when the water cut value passes through 
the inversion point, there is a rapid pressure drop.
Figure 3. Correlation between pipeline pressure and water cut of the pumped product.

For most oils, the value of critical watercut characterizing the transition point of water-in-oil emulsion to the oil-in-water emulsion is in the range of 65-75% [8]. Pipelines operated by watercut near critical values but not passing the inversion point are under additional stress from higher pressure. This significantly increases the risk of pipe leaks with subsequent product spills and soil contamination. Further increases of watercut reduce pipe pressure, but increase corrosion and erosion activity due to higher concentrations of admixtures and metal ions in oilfield water.

The results of hydraulic calculations of a pipeline with high-viscosity oil (HVO) showed that the efficiency of transportation of HVO without the addition of demulsifying compound and at a value of watercut above the critical one is comparable to pumping with the addition of reagent.

3. Conclusions

The high water content of downhole products associated with the long exploitation period of the field affects not only the increase in operating costs and energy consumption due to transportation of downhole products to oil treatment plants (OTP) and preliminary water discharge unit (PWDU) and retransmission of separated water back to injection wells, but also increases the possibility of emergency situations with pollutants entering the environment due to high corrosive activity.

As a solution to this problem, it is worth mentioning the installation of water treatment and pre-discharge units directly on well pads or at short distances from them. This solution not only reduces water transportation costs, but also reduces pipe erosion by reducing the concentration of mechanical admixtures.

Integrated use of block pre-discharge units and corrosion inhibitors will reduce corrosion rate many times and increase field pipeline exploitation life.

References

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