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Modeling and Forecasting of Paraffin Settings on an Existing Extractive Fund of Oil Deposits

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P A P E R I N F O

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A B S T R A C T

In the oil industry, the issue of controlling paraffin deposits remains relevant today. The most common way in the Perm Krai to remove paraffin is to lower the scrapers into the well. This method is the main in the fight against paraffin deposits, but does not provide absolute protection. The least costly way to control paraffin is to use flushing with hot oil or water, but it does not always provide sufficient efficiency. Accordingly, for the selection of effective technology for each particular well, it is necessary to know the depth of wax deposition, the intensity and thickness of the formed layer. To solve this problem, modeling was performed in the OLGA software product of paraffin deposits in the wells of Perm Krai deposits. Based on the calculations performed in the OLGA software product, recommendations are given on choosing a method for removing paraffin deposits from the analyzed wells. The proposed measures for the removal of paraine deposits were implemented in the wells and showed significant efficiency. At three wells, a change in annulus pressure led to a decrease in foaming. The main problem was solved - paraffin in the annulus is not formed.

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1. INTRODUCTION

In the oil industry at the present time, the issue of combating asphalt, resin and paraffin deposits remains topical [1-3]. On a significant number of production wells in the Perm Territory, repairs are carried out due to intense paraffin deposition. At the moment, the most common method is used to remove paraffin on the territory of the Perm Krai mechanized (descent of scrapers into a well). The frequency of tripping is usually selected on the basis of production experience. This method is fundamental in the fight against paraffin deposits, but does not provide absolute protection. The mechanized method of paraffin cleaning should be combined with other techniques (for example washing), as stated in the literature [4, 5]. The least expensive way to control paraffin is to use flushing with hot oil or water. But using these methods does not always ensure effectiveness. Since the injection takes place in the annulus and the fluid temperature is enough to warm the pipes to a depth of 400 m. The rest of the pipes are not heated enough to initiate melting of paraffin on the pipe wall. When washing with hydrocarbon solvents, it is necessary to push the reagent into the tubing string above the onset of paraffin deposition. It is necessary to withstand the reagent to undergo the reaction, otherwise the efficiency of the hydrocarbon solvent is significantly reduced.

Accordingly, for the selection of effective technology for each particular well (it should be noted that even at one field (object) the intensity and depth of wax deposition can vary significantly), it is necessary to know the depth of wax deposition, the intensity and thickness of the formed layer [6-9].

To solve this urgent problem, it is necessary to use modern tools that can estimate and predict the depth, intensity and thickness of deposited paraffin. Already on the basis of these data, implement the most technologically and economically efficient measures (combination of measures) for the removal of paraffin [10, 11].

In this paper, using the example of five wells from one of the oil fields in the Perm Krai, the intensity of

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paraffin deposition was estimated using the OLGA software package [12, 13]. To solve this problem, data on downhole equipment and well operating conditions were collected and systematized. The Pressure, Volume, Temperature (PVT) properties were simulated based on the composition of well fluids in PVTsim. Estimated hydraulic models were created and hydrodynamic modeling was carried out in the OLGA software package of paraffin deposits during fluid rise in the well. Recommendations on the control of paraffin deposits and measures to prevent its intensive deposition are formed.

2. MATERIAL AND METHODS

2. 1. PVT Modeling of Fluid Properties based on Composition

Fractional composition of oil samples was carried out according to ASTM 7213 by gas chromatography using the SimDis method. Laboratory studies were conducted in the following order:

1. Preparation of samples for analysis The oil sample was completely dehydrated. Oil dehydration was carried out in two stages: sedimentation by heating and removal of residual water with calcium chloride.
2. Distillation of the sample Distillation of oil samples was carried out to remove high-boiling components (above 600^0C) in order to further study the chromatographic method (calculated on petroleum products with a boiling point of not more than 600^0C).
3. Determination of fractional composition A sample of each oil sample was used, divided by distillation into two fractions: distillate distilled under atmospheric pressure and the residue boiling above 300^0C.
4. Determination of the composition Using the calibration table for the values of the boiling point was calculated component composition of the samples. PVT properties tables are formed in the software product PVTsim. Table 1 present the component compositions of the oil samples studied, as well as associated petroleum gas.

2. 2. Laboratory Studies of Emulsions

Rheological studies of water-oil emulsions from wells were carried out at the current production water-cut. Dynamic viscosity measurements were carried out on a Rheotest RN 4.1 rotational viscometer at a temperature of 20^0C. Table 2 shows the results of rheological studies of water-oil emulsions from the wells being analyzed.

TABLE 1. The results of the distillation of oil samples of the analyzed wells

Well	The mass of the distillate, g	Boiling point, °C	Residue weight, g
1	53	583,2	45
2	50	578,4	48
3	49	595,0	49
4	43	595,6	56
5	49	611,4	49

2. 3. Creation of Design Models of Wells

To create design models for each well, the following information was used: inclinometry; well design; perforation interval; parameters of the tubing string and pumping equipment; formation properties: pressure, temperature and productivity. The composition and technical parameters of the underground equipment were set in accordance with the passports of the wells. The parameters and hydraulic characteristics of the pumping equipment were taken from operating certificates for the installation of electric centrifugal pumps. Properties layers defined by the results of the interpretation of well test data. Hydraulic calculations were carried out using the obtained data on the composition of the fluid, created on the basis of the composition of the samples of oil from wells and associated petroleum gas in a single degassing. Modeling was carried out in the OLGA software product. The OLGA dynamic multiphase flow simulator enables engineers to predict the hydrodynamic behavior of a flow in a well and determine the optimal mode to eliminate or minimize potential problems. OLGA allows you to analyze possible operating scenarios, diagnose flow stability problems, analyze the operation of downhole equipment, predict the results and consequences of various well operation modes both in the short and long term for the most efficient operation of each well. Dynamic analysis of wells using OLGA allows engineers to predict complications and develop operating procedures for a virtual well, minimizing problems on a real asset.

Figures 1 and 2 presents the results of calculations in the form of graphs of the distribution of fluid flow, pressure and temperature along the length of the tubing and in the production string to the pump along wells no. 1 and no. 2. The calculations determined the bottomhole pressure, pressure at the pump intake and dynamic level (fluid level in a working well) in the well (Table 3).

Calibration (model fit the actual conditions) of the models was carried out according to the bottomhole

TABLE 2. Values of dynamic viscosity of well production

Well	Watering,%	The value of dynamics viscosity, mPa s
1	13,0	11,9
2	46,0	29,8
3	31,0	14,9
4	2,8	10,2
5	3,7	6,5

TABLE 3. Summary of hydraulic well calculation results

Well	Calculated bottomhole pressure, MPa	Actual bottomhole pressure, MPa	Dynamic level design, m	Dynamic level actual, m
1	8,53	7,66	1252	1146
2	8,79	8,22	1065	1182
3	10,75	9,48	1175	1018
4	11,02	8,81	1046	998
5	13,68	12,63	477	434

pressure, since telemetry systems are installed on these wells. The excess of the actual dynamic level from the calculated one in the wells is most likely due to the inaccuracy in converting the pressure at the inlet of the centrifugal pump to the fluid level in the annulus. In order to improve the accuracy and reliability of determining bottomhole pressure and dynamic level, it is recommended to use modern methods of calculating the pressure distribution in the well, taking into account changes in the parameters of the gas-liquid mixture in the annulus and wellbore profile (creation and use of multidimensional mathematical models) [14].

2. 4. Simulation of Paraffin Deposits in Wells

Modeling of paraffin deposits (performed in the OLGA software product) in the framework of hydrodynamic calculations was carried out using the models presented in Figures 1 and 2. Paraffin deposition modeling was carried out for a period of five days; however, the probable presence of deposits in the pipe at the time of the beginning of the calculation is not taken into account. In the hydraulic calculation, the place of deposition, the maximum thickness of the paraffin layer and the mass of precipitated and suspended paraffin on the wall were determined in the pump-compressor pipes and production casing. The results of the simulation of paraffin deposits in wells (the results for wells no. 3 and no. 4) are presented in Figures 3, 4 and Table 4. Each of the figures shows the distribution of the paraffin layer along the length of the tubing.

3. RESULTS AND DISCUSSION

When analyzing the data presented in the table, a high intensity of the formation of wax deposits in the pump-compressor pipe of the wells was established. The greatest amount of sediment is formed in wells no. 1 and no. 2. The depth of onset of paraffin deposits varies in the range from 378 to 1112 m. In well no. 2, the formation of parafin on the production string surface was also recorded.

TABLE 4. Summary of the results of the simulation of paraffin deposits in wells for 5 days

Well	Maximum thickness of paraffin layer, micron	Depth of maximum layer thickness, m	Mass of precipitated paraffin, kg	Weight of paraffin weighed in oil, kg
1	1142,5	10,0	13,17	1,03
2	1269,7	wellhead well	7,16	0,02
3	645,3	6,0	3,88	0,30
4	666,2	755,5	15,36	10,01
5	763,1	wellhead well	9,12	1,15

In wells no. 2, no. 3 and no. 5, paraffin formation in the annulus is established. To date, the main methods of struggle are hot flushing, washing with hydrocarbon solvent and the introduction of injection cable lines. These methods lead to significant costs and oil shortages. For these wells, an increase in the annular pressure is recommended for pushing the dynamic level below the depth of onset of paraffin. For each of these wells, modeling was performed to select the optimal annular pressure to prevent the formation of paraffin. The results of the calculations are presented in Table 5.

As a result of changes in the annular pressure, a decrease in foaming and stabilization of the dynamic level at a constant value was established, while paraffin in the annulus is not formed. Thus, on the basis of the results obtained, recommendations are formulated on the effective selection of technologies and technical means to prevent the formation of paraffin in production wells.

The obtained results indicate the prospects of using the OLGA software product for modeling and predicting paraffin deposits. The approach described in the article will allow us to select more effective technology for the prevention and suppression of paraffin deposits.

TABLE 5. The results of the calculations to determine the optimal annular pressure

Well	Current annular pressure, MPa	Recommended annular pressure, MPa	Dynamic level design, m
2	0,52	2,0	1269,0
3	2,02	3,0	950,0
5	1,83	5,5	700,0

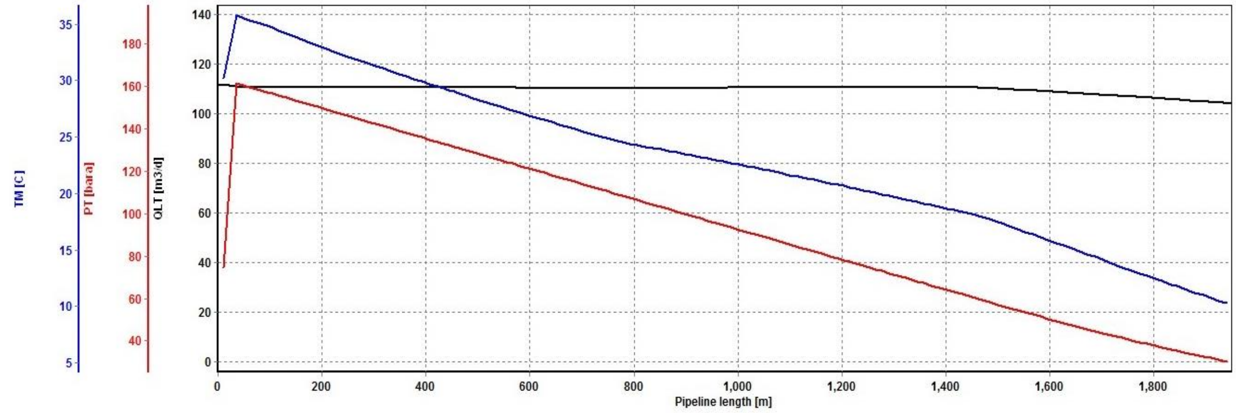

Figure 1. The distribution of fluid flow, pressure and temperature along the length of the tubing and in the production string to the pump (wellhead at the top of the figure). Well no. 3

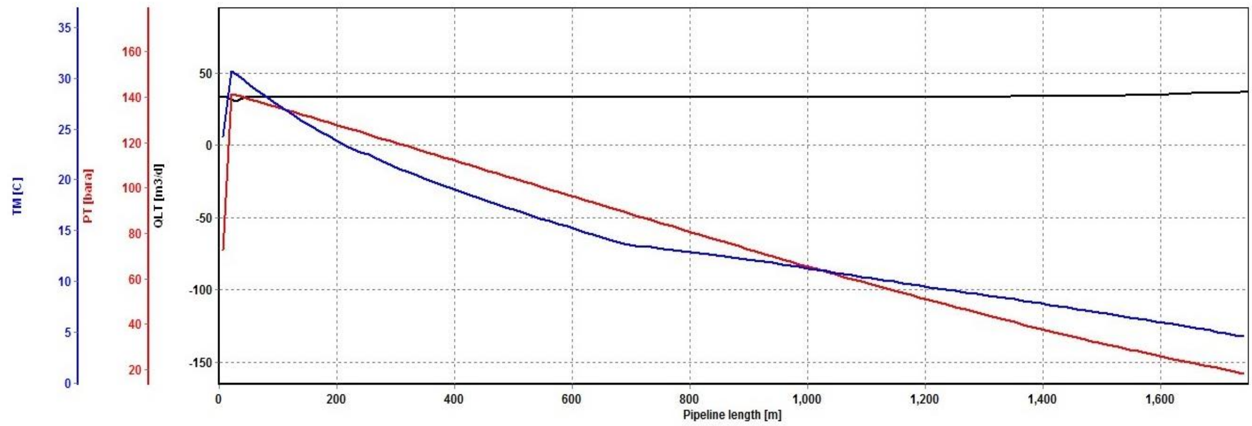

Figure 2. The distribution of fluid flow, pressure and temperature along the length of the tubing and in the production string to the pump (wellhead at the top of the figure). Well no. 4

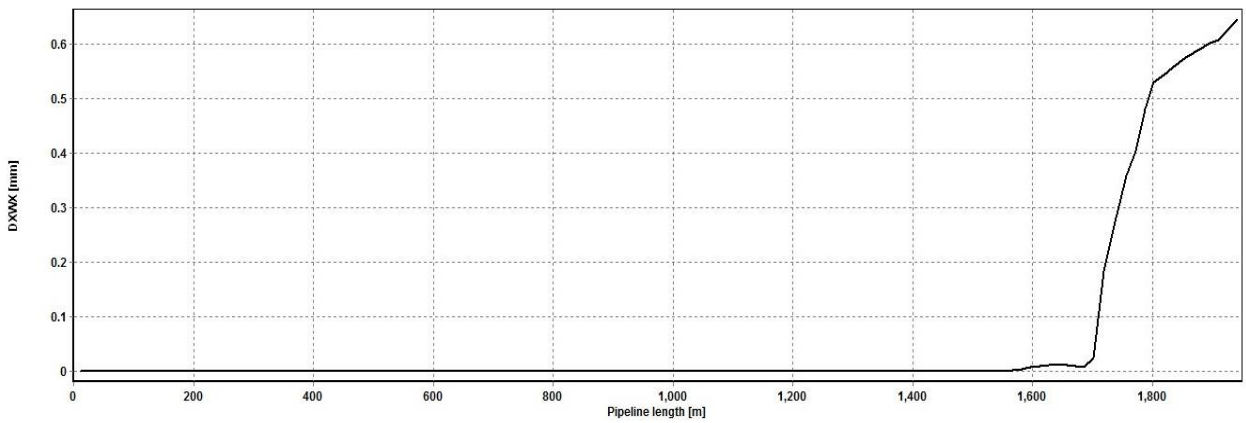

Figure 3. Modeling paraffin deposits (wellhead on top of the figure). Well no. 3

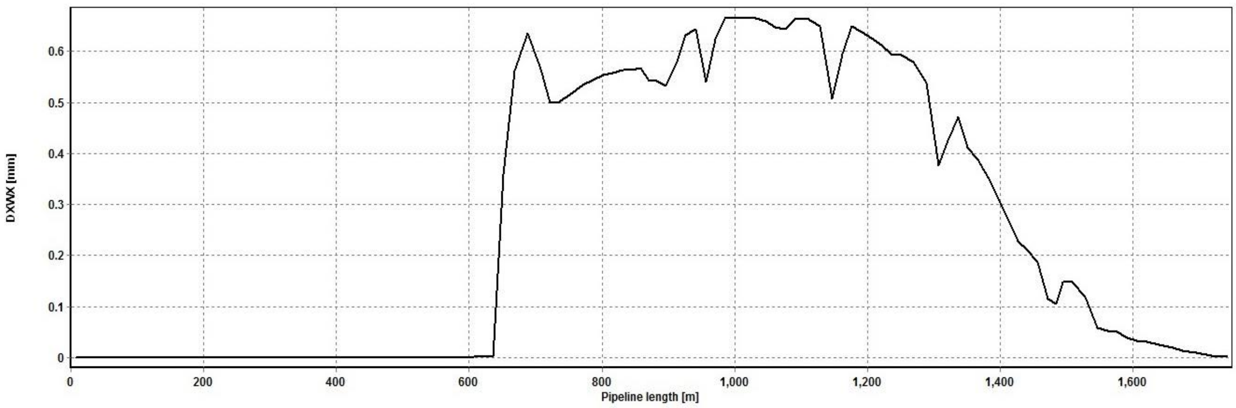

Figure 4. Modeling paraffin deposits (wellhead on top of the figure). Well no. 4

4. CONCLUSIONS

Thus, in this paper, an urgent task is considered by the selection of effective and economically feasible methods of controlling paraffin deposits on deep-well pumping equipment. To solve this problem, well models were created in the OLGA program product and paraffin deposits were simulated using five wells of one of the oil fields as an example. Based on the calculations, recommendations were given on the choice of the method of removing and preventing paraffin on the wells being analyzed. The proposed measures were implemented at the wells and, to date, have led to a reduction in the cost of carrying out the measures and have significantly reduced the oil shortages. At three wells, the change in the annular pressure led to a decrease in foaming and stabilization of the dynamic level, while the main problem was solved - paraffin in the annulus was not formed.

It is obvious that the proposed approach to the selection of measures for the prevention and removal of paraffin seems to be expedient to replicate to other producing wells of oil fields in the Perm Krai and Russia.

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چکیده

در صنعت نفت مسئله پارافین مشگل نسبی روز است. روش متداول شرکت کاری پرم حذف پارافین برای پایین آوردن اسکراپر چاه نفت است. روش مقابله با رسوب پارافین نمی تواند از رسوب پارافین بطور مطلق جلوگیری کند. ارزانترین روش با فلاش نمودن روغن و اب داغ برای جلوگیری از رسوب پارافین استفاده می شود. که این روش راندمان مطلوبی ندارد. برای انتخاب روش مناسب باید بکمک نرم افزارOLGA میزان پارافین و واکس چاه نفت و ضخامت لایه رسوبی سنجش شوند تا روش مناسب توسط نرم افزار توصیه گردد. با این کار بازدهی فرایند افزایش یافته و کاهش فشار میزان کف نیز کاهش می یابد. بعلاوه عدم تشکیل لایه پارافین مشگل اصلی را برطرف می کند.

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