Regulating temperature of oil saturation with paraffins to avoid asphaltene, resin and paraffin substances deposition during oil production

IOP Conf. Series: Earth and Environmental Science **282** (2019) 012023 doi:10.1088/1755-1315/282/1/012023

Regulating temperature of oil saturation with paraffins to avoid asphaltene, resin and paraffin substances deposition during oil production

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Abstract. In order to regulate temperature of oil saturation with paraffins to avoid asphaltene, resin and paraffin substances (ARP-S) deposition using thermal method as well as chemical reagents and additives implementation was considered. A particular attention is paid to the chemical composition of the produced hydrocarbons, as well as to the effect of individual high-molecular components of hydrocarbons during the extraction and further transportation at low temperatures and with a temperature gradient difference. The paper presents the influence of hydrocarbon composition on the development mechanism, the composition and the properties of ARP-S. The methods for the removal of deposits associated with the use of various additives and reagents, as well as the methods for the prevention of these sediments development are considered. A brief description of the main classes of chemicals used for the solution of ARP-S prevention and removal problem is given. It was shown that in order to select the most effective ways of organic substance sediment prevention and removal from the physical-chemical point of view, it is necessary to obtain an idea about the composition and the properties of the initial oil and the developed deposits.

1. Introduction

In the process of oil producing well exploitation with some temperature and pressure decrease accompanied by oil degassing, a sharp decrease of paraffin, asphaltene and resinous substance solubility in it takes place which leads to their precipitation on the surface of the mining equipment [1]. During oil pumping and storing the internal walls of tanks, pipes can also experience the development of ARP-S. Therefore, it is necessary to clean the technological equipment, pipes and tanks from time to time [2].

Nowadays, the problem of asphalt-resinous and paraffin deposits is very significant, because these deposits are contained in the oil of almost all oil-producing regions of Russian Federation. The chemical composition depends on the properties of an extracted oil, the thermal and hydrodynamic conditions of a reservoir, the geological conditions and the method of a field development and its operation [3].

During oil production, they encounter one of the problems causing the complication in a well robot, oilfield equipment and further transportation through pipelines. These deposits are accumulated in the flowing parts of an oilfield equipment and on the inner surface of pipes, which leads to the decrease of oil production and transportation system productivity.

ARP-S increase the wear of equipment, energy costs and pressure in a system. Nowadays, this problem is a very urgent task for the production and transportation of hydrocarbons. The following factors influence the development of ARP-S:

• Pressure reduction,
• Intensive gas release,
• Temperature drop,
• The composition of hydrocarbons,
• Temperature gradient change.

The main factors for reducing the temperature of the fluid: earth geotherma in the area of the well; thermal resistance of the well structure; the dynamic level of oil in the annular space.

2. Methodology

The main method of ARP-S removal is the prevention of deposit development on an oilfield equipment, but if the deposits developed, then the secondary method is the removal of these sediments [4].

ARP-S deposits are formed in a bottom hole zone of a well, on the walls of a wellbore and oilfield equipment. The following methods of prevention and disposal of these sediments are proposed:

• The injection of reagents, acids, coextractants, suppressing the development of paraffin bunches during the extraction and the transportation of hydrocarbons into a system,

• The covering of the inside of oil field equipment with a layer reducing the adhesion of ARP-S to the pipe walls,

• The injection of biodegradable composition into an extracting medium, which does not allow the development of ARP-S,

• The installation of electric heaters at a well bottom designed to maintain the temperature above the melting point of paraffin in a well,

• The increase of asphalt-resinous compound percentage,

• The maintaining of constant pressure in the system of oil production equipment at the well bottom,

• The use of exothermic reactions, and thus the increase of produced hydrocarbon temperatures at the bottom of a well and the prevention of asphalt-resinous and paraffin deposit development,

• Steam heating. The use of steam generated by steam-mobile units like steam field installations PPUA-1200/100 with a temperature of up to 310 °C and pressure up to 10 MPa is only effective up to a depth of 300-400 m for borehole countering purposes. Washing with hot oil is energy-intensive; the inter-treatment interval is usually 90 days.

It should be noted that during the selection of one or more methods for ARP-S prevention or removal, the component composition and the properties of hydrocarbons, the percentage ratio of asphaltenes, resins and paraffin should be taken into account (Table 1.2).

Table 1. Physical and chemical properties and fractional composition of degassed oil

Name		The number of studied		Change range	Average value
		wells	sample		
1		2	3	4	5
Dynamic viscosity, mPa s					
at 20 °C		50	73	11.0 – 67.6	31.1
at 50 °C		54	79	6.1 – 26.7	11.3
Freezing point, ^{0}C		48	72	(-35.0) – 6.0	-13.9
Melting point of paraffin, ^{0}C		52	77	49.0 – 64.0	54.9
Initial boiling point, ^{0}C		54	79	60.0 – 145.0	101.1
Wt., %	sulphur	54	79	0.70 – 2.10	1.29
	silica gel resins	54	79	3.70 – 19.20	2.94
	asphaltenes	54	79	0.30 – 17.60	8.33
	paraffins	54	79	1.20 – 3.60	2.42
	water	39	56	0.00 – 11.00	0.92
Volumetric output of fractions, %	up to 100 ^{0}C	32	37	0.0 – 5.0	0.6
	up to 150 ^{0}C	54	79	1.0 – 14.0	7.6
	up to 200 ^{0}C	54	79	7.0 – 24.0	16.4
	up to 250 ^{0}C	54	79	18.0 – 34.0	25.9
	up to 300 ^{0}C	54	79	29.0 – 51.0	38.1
	up to 350 ^{0}C	2	2	54.0 – 80.0	67.0
Oil classification		II $T_2\Pi_2$			

Table 2. Component composition of oil gas, degassed and reservoir oil

Name	With a single degassing of reservoir oil under standard conditions				At the differential degassing of reservoir oil under operating conditions				Base oil	
	Extracted gas		oil		Extracted gas		oil			
	% wt.	% moles	% wt.	% moles	% wt.	% moles	% wt.	% moles	% wt.	% moles
Hydrogen sulfide	отс.	отс.	-	-	отс.	отс.	-	-	отс.	отс.
Carbon dioxide	2,23	1,41	-	-	2,77	1,56	-	-	0,16	0,54
Nitrogen + rare	0,86	0,85	-	-	1,01	0,89	-	-	0,06	0,31
Including helium	0	0	-	-	0	0	-	-	0	0
methane	35,65	61,94	0,02	0,25	44,02	68,05	0	0,05	2,45	23,33
ethane	11,07	10,26	0,04	0,30	13,24	10,91	0,06	0,46	0,79	4,03
propane	21,35	13,49	0,31	1,59	20,78	11,68	0,62	3,10	1,74	6,04
isobutane	4,11	1,97	0,17	0,66	3,14	1,34	0,28	1,06	0,44	1,15

N butane	11,29	5,41	0,67	2,63	7,81	3,33	1,02	3,85	1,39	3,67
isopentane	3,06	1,18	0,48	1,53	1,72	0,59	0,60	1,82	0,66	1,40
N-pentane	3,81	1,47	0,80	2,54	2,10	0,72	0,95	2,88	1,01	2,14
hexanes	4,67	1,51	3,06	8,09	2,40	0,69	3,22	8,21	3,17	5,63
heptanes	1,37	0,38	2,42	5,51	0,73	0,18	2,45	5,37	2,35	3,59
octanes	0,53	0,13	2,65	5,29	0,28	0,06	2,64	5,07	2,51	3,36
Residue (C9+highest)	0	0	89,38	71,61	0	0	88,16	68,13	83,27	44,81
Molecular mass	27,86		227,8		24,79		219,7		153,0	
Molecular weight of the residue	-		284,4		-		284,3		279,8	
Density - gas, kg/m3	1,1582		-		1,0304		-		-	
- gas relative (by air), share of un.	0,9611		-		0,8551		-		-	
- oil, kg/m3	-		874,0		-		869,2		788,0	

Proceeding from the mentioned above, it should be noted that the rough surface of pipe walls, contributing to the release of gas from the oil and its cooling. Thus, the solubility of ARP-S in oil deteriorates and the rate of deposit formation increases. However, the increase of a gas-liquid mixture flow rate can somewhat slow the growth of paraffin deposits. It was [5,6] found that the solubility of paraffin decreases in heavy oils. Therefore, the intensity of paraffin deposition in these oils is increased and implies the use of it. Thus the concentration of paraffin compounds in oil. The higher this value, the more intense the deposition of paraffin on the walls of these pipes [7].

3. Results and Discussions

ARP-S development factors. The following results were obtained: the thickness of ARP-S deposits depends on the depth.

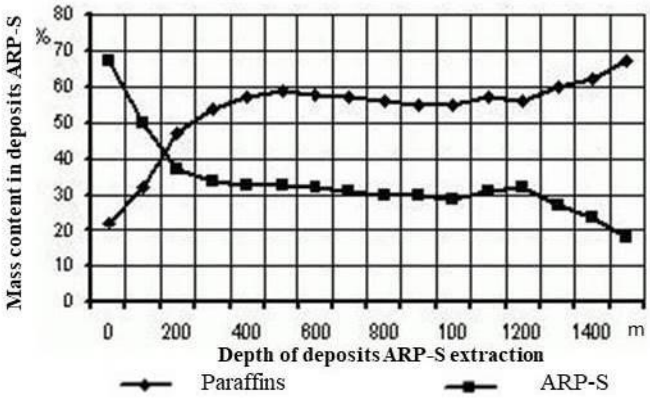

Figure 1. Dependence of deposit thickness on depth.

Figure 2. Deposits of asphaltene, resin and paraffin substances.

Analyzing Fig. 1 and Fig. 2 it should be noted that the development of ARP-S on the borehole wall is associated with a temperature drop, thereby making it difficult to extract hydrocarbons from the formation and no dynamics growth occur in oil extraction industry.

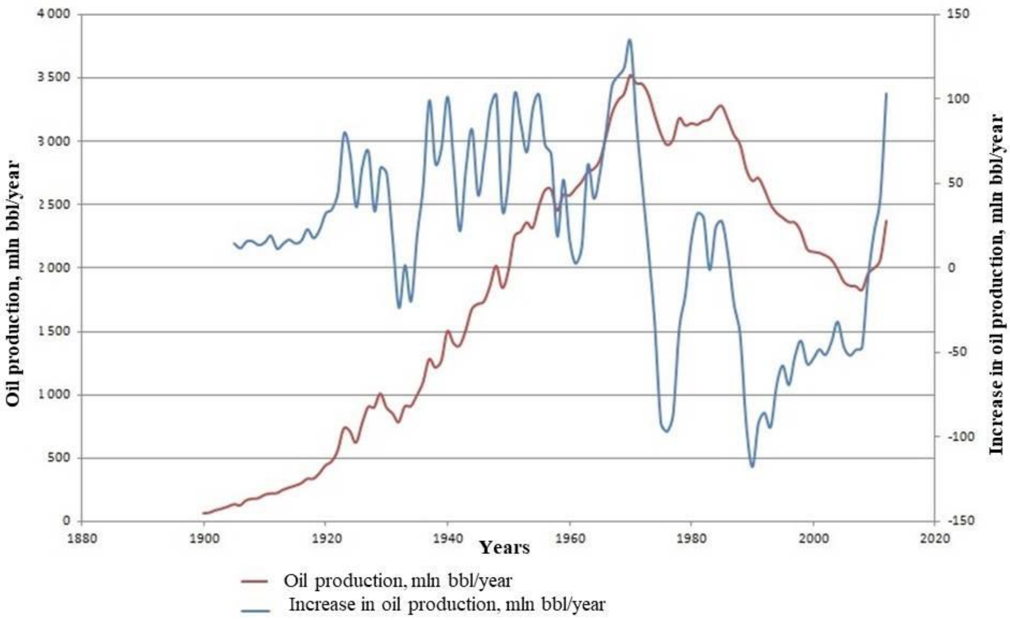

Figure 3. Graph of oil production growth dependence on produced oil.

Analyzing Fig. 3, it should be noted that the increase of oil production increased with the discovery of new fields and their putting into operation, but the volume of produced oil has not changed, which is very surprising nowadays [8]. ARP-S makes it very difficult to extract the production of oil and its further transportation.

The most effective method of heat treatment is to heat the well bore with an electric heater (flexible skin-heater).

The main objective of such systems is to maintain the temperature of the moving fluid above the wax deposition temperature (Fig. 4).

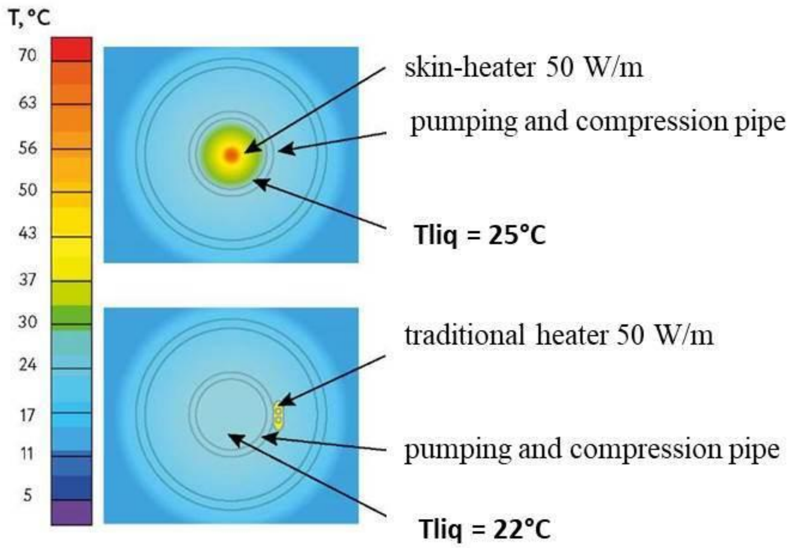

Figure 4. Comparison of fluid heating efficiency using flexible skin-heater and a resistive cable.

The optimal solution from the point of view of energy consumption is when the heating system works only in the zone where the fluid temperature in normal conditions drops below the wax deposition temperature and the heating element has a variable heat generation along the depth of the well. Moreover, the power of such a heater should vary smoothly in a wide range: the linear power of its lower part will be close to zero, whereas in the near-surface part the power can reach 70 W/m.

The heater maintains operability: with external pressure up to 150 atmospheres and the temperature of the oil and gas medium up to 70 ° C.

4. Conclusions

With any production method, an internal section of a tubing is narrowed gradually due to the development of asphalt-resinous and paraffin deposits, which leads to the decrease of a well productivity and oil production volume, and to the failure of underground equipment.

The problem of ARP-S development becomes more serious due to the transition of many ields to the late stage of development. Solving this problem one should be guided by common approaches, namely, to find out the causes of these deposits. The process of ARP-S development is determined by many factors, among which there are the operating conditions of the process equipment during extraction, transportation and the storage of hydrocarbons, the properties of the hydrocarbons themselves. High-molecular components of oil, namely, their composition, structure and percentage ratio have a particular importance in a number of factors that determine the propensity of hydrocarbons to the development of asphalt-resinous and paraffinic deposits. Knowing the properties and the composition of hydrocarbons, their thermal and hydrodynamic conditions in a productive reservoir and selecting the methods of fighting with ARP-S properly, it is possible to avoid the wear of oilfield equipment and pipelines. At one time, this is an economically advantageous condition for oil and gas industry, which in turn contributes to the reduction of overhaul number and a reduced downtime of wells, allows to extend the life of equipment, provides rhythmic work of industry and reduces the cost of oil production.

5. Summary

Adsorption processes are based on the action of acids, reagents and inhibitors of paraffin deposits. When they use chemical methods based on dosing in obtained products of chemical compounds that reduce, and sometimes completely remove or prevent the formation of asphalt-resinous and paraffin deposits.

The most effective method of heat treatment is to heat the well bore with an electric heater (flexible skin heater).

While maintaining a constant pressure in a well, asphalt-resinous and paraffin deposits will not be deposited in oilfield equipment.

Acknowledgements

This work was funded by the subsidy allocated to Kazan Federal University for the state assignment in the sphere of scientific activities (10.7636.2017/7.8).

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