Analysis of technological conditions influence on efficiency of oilfield treatment

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Abstract. The results of influence of process parameters on oil quality and recommended effective technological modes of oilfield treatment processes are presented in this paper. It is shown that the parameters that significantly affect the efficiency of oil processes are temperature and water-oil emulsion flow rate with a given number of working process units and the structure of flowsheet flows.

1. Introduction

Currently, oilfield treatment requires large-capacity industrial installations, which are characterized by a great variety of equipment used in a complex process flow structure [1-5]. The increase of plant efficiency can be achieved by optimization of technological modes both for existing and designed installations [6-8]. At present, it is becoming possible to achieve by using mathematical modeling methods, which determine the timeliness of this work and allow analyzing the technology of large-capacity industrial oil treatment.

To solve the assigned problems effectively, MS (Modeling Systems) of all kinds can be used. A simulation system of oilfield treatment has been developed. This system based on a modular principle of model formation of process flowsheet units allows defining dehydration and desalting processes [8-10].

The purpose of this paper is to analyze the influence of process parameters on oilfield treatment and to estimate technological modes for enhancing efficiency of dehydration and desalting using mathematical modeling.

2. Objects and research techniques

The object of this study is an oil treatment unit of the oilfield located in Eastern Siberia (figure 1). It is designed to process a large volume of oil, so the flowsheet of the unit has a complicated structure of flows and includes three parallel lines. Since the used equipment is designed for a certain capacity, the process flowsheet includes the required number of concurrent units.

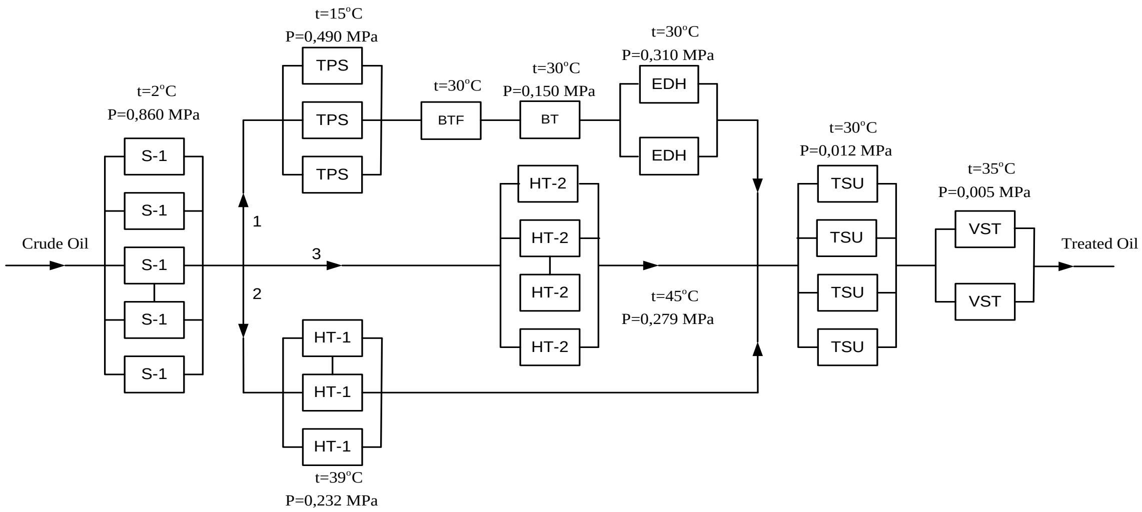

Figure 1. Block diagram of oilfield treatment unit:
S-1 – first stage separator; TPS – three phase separator; BTF - block tube furnace; BT - buffer tank; EDH – electric dehydrator; HT-1 – “Heater Treater” unit of type I; HT-2 – “Heater Treater” unit of type II; TSU – terminal separation unit; VST – vertical steel tank.

The oilfield treatment unit includes three production lines. The first production line consists of three parallel working TPS, in which oil is degassed and dehydrated. Then, the oil flow is heated in the furnace, passes through the buffer tank and enters the electrical dehydrator, in which dehydration and desalting occur by electric field.

The second production line consists of modern modular HT-1 units in which crude oil is heated, degassed and dehydrated.

The third production line includes HT-2 units, equipped with electric dehydrogenating grids, which increase the efficiency of water separation.

Table 1. Physical and chemical oil properties.

Physical and chemical oil properties and technological parameters	Values
Density, kg / m^3	864
Viscosity at 20°C, mm^2 / sec	29.5
Molecular weight , g / mole	292
Water cut, % wt.	20

3. Discussion of results

The influence of process parameters on the oilfield preparation was studied by means of MS. Figure 2 shows the study results of oil-water emulsion separation in TPS.

It was determined (figure 2) that with the increase of temperature the output water cut of TPS decreases and with the increase of emulsion flow rate and water cut at the inlet of TPS increases.

In other units of the process flowsheet, the studies showed similar regularities of the dehydration and desalting processes.

Table 2 shows the options for process parameter variations of oilfield treatment units.

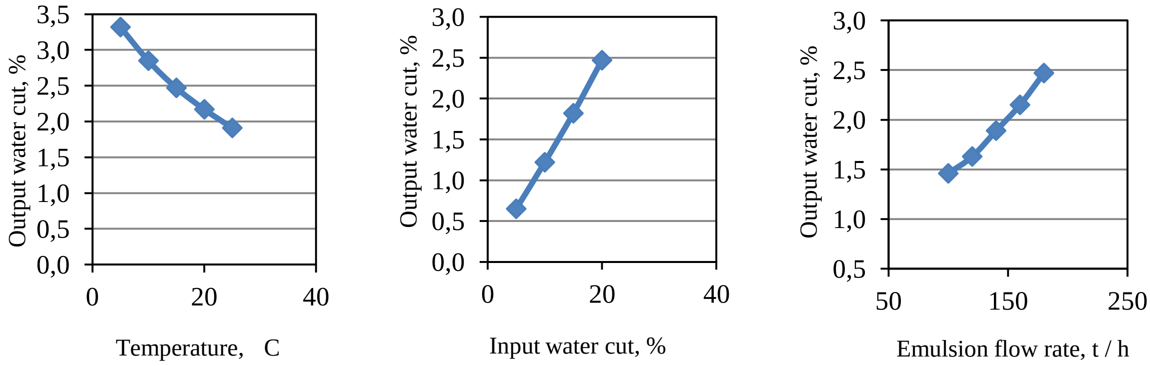

Figure 2. The results of research in TPS.

Table 2. Options of process parameters in calculating oilfield treatment unit.

	Flow rate, kg/h						
	1000238.1						1012142.9
	Input water cut, % wt.						
	20.93					26.00	29.00
Options	1	2	3	4	5	6	7
Unit	Temperature, °C						
TPS	15°C	**25**°C	15°C	15°C	25°C	25°C	25°C
EDH	30°C	30°C	30°C	30°C	30°C	30°C	30°C
HT (I)	Input temperature at oilfield treatment unit: 15°C						**25°C**
	39°C	39°C	**45°C**	39°C	**45°C**	**45°C**	**45°C**
HT (II)	45°C	45°C	45°C	**40°C**	**45°C**	**45°C**	45°C
VST	30°C	30°C	30°C	30°C	30°C	30°C	30°C

For different variants of process parameters (table 2) the studies were conducted using a simulation system, the results of which are shown in table 3 and figure 3.

Table 3. The research results.

Flows	Base Option			Option 2		
	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l
Oilfield Treatment Unit	1000.24	20.93		1000.24	20.93	
TPS	549.91	2.24	1076.38	549.91	1.39	670.17
EDH	453.95	1.15	191.33	444.07	0.62	102.20
HT-1	157.12	3.62	1766.36	157.12	3.62	1766.36
HT-2	209.49	1.11	540.91	209.49	1.11	540.91
Flows	Option 3			Option 4		
	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l
Oilfield Treatment Unit	1000.24	20.93		1000.24	20.93	
TPS	549.91	2.24	1076.38	549.91	2.24	1076.38
EDH	453.95	1.15	191.33	453.95	1.15	191.33
HT-1	157.12	3.13	1527.42	157.12	3.62	1766.36
HT-2	209.49	1.11	540.91	209.49	1.23	597.10

Flows	Option 5			Option 6			Option 7		
	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l	Flow rate, t/h	Water cut, % wt.	Salt content, mg/l
Oilfield Treatment Unit	1000.24	20.93		1000.24	26.00		1012.14	29.00	
TPS	549.91	1.39	670.17	549.91	1.75	840.39	556.46	2.16	1040.93
EDH	444.07	0.62	102.20	420.08	0.53	88.31	412.95	0.59	96.97
HT-1	157.12	3.13	1527.42	157.12	4.03	1976.19	158.99	3.91	1914.52
HT-2	209.49	1.11	540.91	209.49	1.39	675.94	211.98	1.69	821.16

The results showed that the parameters significantly affecting the efficiency of oil treatment processes are temperature and flow rate of oil-water emulsion at a given number of working units and the flow pattern of the process flowsheet.

Figure 3 shows the values of residual water cut and salt concentration at the outlet of oilfield treatment unit under different operating conditions. The study results showed that the most effective option is the temperature condition 5 (table 4), where the residual water cut of oil is about 0.10 % wt. and salt content is 39.75 mg/l.

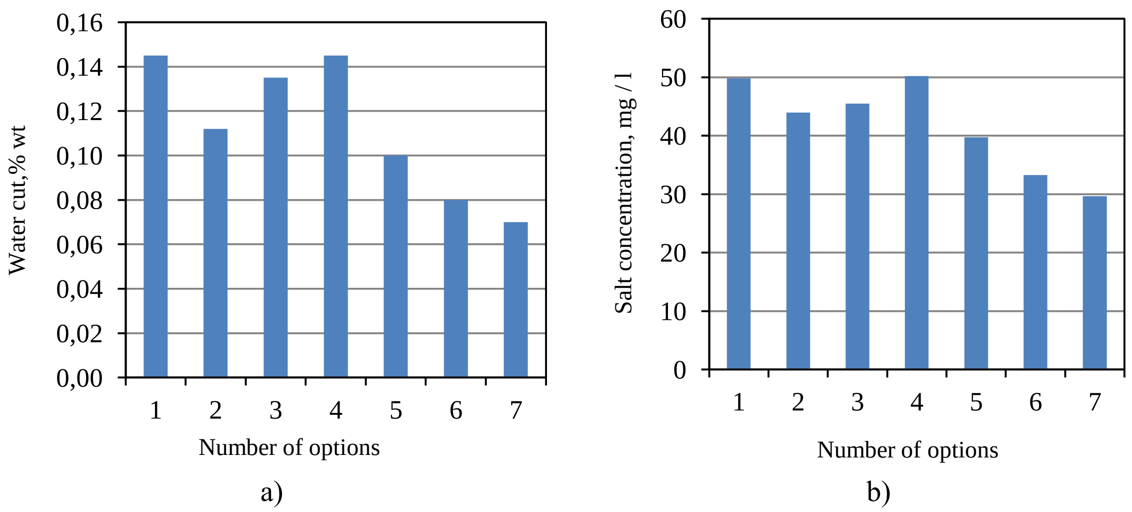

Figure 3. Quality characteristics of treated oil of calculated process options: a) water cut; b) concentration of chlorine salts.

Analysis of technological modes of the operating production unit (table 3) showed that temperature increase up to 25 °C in a three phase separator and up to 45 °C in a heather-treater reduces the residual water cut of oil compared to the base option of 0.10 % wt. water cut.

Having examined the operation of the unit by increasing flow rate and water cut of the formation fluid (options 6 and 7), technological conditions were selected to define the oil quality indicators required by all-Union State Standard: water content and chlorine salts at the outlet from the oilfield treatment unit are 0.07 % wt. and 29.65 mg/l, respectively.

4. Conclusion

The study results based on the simulation system showed that deeper water separation is observed when TPS and EDH are connected in sequence (line 1), even at high load (60% of the total oilfield treatment unit expenditure).

It was shown that temperature and flow rate of emulsion are parameters that have the most significant effect on the residual water cut and salt content in oil.

Thus, the required quality can be achieved by oil treatment both by residual water cut and by salt concentration by varying the process parameters in the units of technological lines. With the application of modeling system the material balance in various process conditions can be determined to give operational forecasts and recommendations on operation modes of oilfield units in the process of oilfield development.

References

[1] Tronov V P 2000 Oilfield treatment *Promyslovaya podgotovka nefti* (Kazan: FEN)

[2] Lutoshkin G S and Dunyushkin M I 2007 *Problems in collecting and preparation of oil, gas and water industries (Sbornik zadach po sboru i podgotovke nefti, gaza i vody na promyslakh)* Textbook for high schools (Moscow: Alyans)

[3] Lutoshkin G S 2005 *Collecting and preparation of oil, gas and water (Sbor i podgotovka nefti, gaza i vody)* Textbook for high schools (Moscow: Alyans)

[4] Howard M, Gioffre P and Swackhammer T. 2013 Spill Prevention, Control and Countermeasure (SPCC) guidance for regional inspectors pp 16–18

[5] Guluyev G, Rzayev A and Pasayev F 2008 Development of methods of determination of disperse composition of oil emulsion *The Second International Conference "Problems of cybernetics and information"* pp 80–82

[6] Frantsina E V, Ivashkina E N, Ivanchina E D and Romanovskii R V 2014 Developing of the mathematical model for controlling the operation of alkane dehydrogenation catalyst in production of linear alkyl benzene *Chemical Engineering Journal* **238** 129–39

[7] Krivtsova N I, Gaga S G, Desiatnichenco A A, Popok E V and Zaitceva E V 2014 Synthetic liquid fuels obtained by thermolysis of animal waste *Procedia Chemistry* **10** 441–47

[8] Kim S F, Usheva N V, Moyzes O E, Kuzmenko E A and Samborskaya M A 2013 Modular design of mathematical models of oilfield treatment devices and technological schemes (Modul'nyy printsip postroyeniya matematicheskikh modeley apparatov i tekhnologicheskikh skhem promyslovoy podgotovki nefti) *Neftepererabotka i neftekhimiya* **10** 41–44

[9] Kim S F, Usheva N V, Moyzes O E, Kuzmenko E A, Samborskaya M A and Novoseltseva E A 2014 Modelling of dewatering and desalting processes for large-capacity oil treatment technology *Procedia Chemistry* **10** 448–53

[10] Kim S F, Usheva N V, Samborskaya M A, Moyzes O E and Kuzmenko E A 2013 Modelling of oil-water emulsion destruction process for large-capacity oil treatment technologies *Fundamental'nye issledovaniya* **8** 626–29