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THE PREDICTION OF WATER CUTTING AND DENSITY OF OILWATERCONDENSAT MIXES

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ABSTRACT
This article is devoted to studying of problems, existence of a significant amount of gas-condensate deposits of Azerbaijan causes high prospects of use of condensate also as a thinner at pipeline transport high-viscosity flooded by the crude oil. Finds relevance of an assessment of influence of concentration and viscosity of a thinner – condensate on physical and chemical characteristics of petrowater condensate mixes at various temperatures and the modes of currents. It is well-known the facts that availability of the dispersed water in petrocondensate mix reduces efficiency of operation of pipelines. So, the increase in volume of water and raised viscosity leads to rise in price of transportation by petrowater condensate mix. Besides the high content of the connected water in mix causes intensive education by asfaltqamparafin postponed, increases oil hardening temperature. On it regular control for changes of noted parameters (degree of water content and density of mix) is of great importance. Considering the aforesaid, for an assessment of influence of the content of condensate on reophysics indicators transported bypass crude oil at various temperatures laboratory researches were conducted. On the basis of the obtained data on test various petrowater condensate mixes were offered empirical a formula for determination of their water content and density. The analysis showed that the offered empirical models in comparison with the rule of additivity yield more acceptable results from the point of view of practice and will well be coordinated with data experimental defined the distinguished parameters.

KEYWORDS:Physical and chemical, incompatibility, compounding, viscosity, asfaltens, water content, dispergatings, pipelines.

INTRODUCTION
As is known, high-viscosity oil with a unique chemical property is a valuable raw material for the petrochemical industry and as a rule, their transportation in winter climate conditions involve a number of important features. High-viscosity oil resources by having very special rheological properties are unused source of energy at the present time, but very promising for the future development, A significant number of the many highly productive fields of Azerbaijan that producing high-viscosity oil and causing problems during transportation are offshore with complicated natural - climatic conditions (the temperature of pipeline at the sea bed drops to 5 ^{0}C). Temperature drop of the oil transported by sub-sea pipelines should be accompanied by steps to improve its rheological properties and to ensure favorable hydrodynamic parameters [1,2].

MATERIALS AND METHODS
The presence of significant amounts of gas condensate deposits in the Caspian Sea creates opportunity for using the condensate as diluents for transportation of high-viscosity oils. So that, gas condensates differ from petroleum feedstock by significantly lighter fractional compositions, high content of gasoline fractions, the practical absence of resin-asphaltene compounds and low sulfur content and metals. Furthermore, due to the high content of naphthenic hydrocarbons, they have good low-temperature characteristics. Improving the processes of their separation increases the yield of the desired products from their potential content of the feedstock and enhances the effectiveness of their further use.

Taking into consideration given all above, it's important to assess the impact of concentration and viscosity of the diluent, in this specific case the impact of the condensate to coefficient of hydraulic resistance and productivity of the pipeline under different hydraulic modes of flow and temperatures of oil condensate mix.

RESULTS AND DISCUSSION

When transported mixture of oil and condensate contains a substantial amount of dispersed water, it results in reduction of the operation efficiency of sub-sea pipelines.

The presence of dispersed water in oil leads to rising transportation cost as result of increasing its volume and viscosity of the oil and water mixture, compared to a net oil [3,4]. In addition, the transportation of oil with the high content of the dispersed water at low sea-bed temperatures by sub-sea pipeline is also associated with a number of difficulties. Big content of bound water in the oil, causing the rapid formation of asphaltene deposits, increases the freezing temperature and viscosity of oil. Experiments prove that the viscosity of oil is directly dependent on its water content (Table 1).

Table 1 Changing the oil viscosity (Muradxanli, well №17 at 38, 70, 80% water-cut (t=20 ^{0}C))

Shear rate, γ, s^{-1}	38%		70%		80%	
	Shear stress, τ, Pa	Viscosity, μ, Pa s	Shear stress τ, Pa	Viscosity, μ, Pa s	Shear stress, τ, Pa	Viscosity, μ, Pa s
0.3333	2.1075	6,3231	2.9505	8,8524	15.174	45,527
0.6	3.372	5,62	5.058	8,43	17.703	29,505
1	3.7935	3,7935	7.587	7,587	23.183	23,183
1.8	5.8167	3,2315	11.802	6,5567	31.191	17,328
3	7.587	2,529	16.86	5,62	40.464	13,488
5.4	11.128	2,0607	24.447	4,5272	54.795	10,147
9	15.174	1,686	33.299	3,6998	69.969	7,7743
16.2	21.918	1,353	48.473	2,9921	84.04	5,1877
27	30.348	1,124	66.597	2,4666	110.78	4,103
48.6	42.993	0,8846	84.04	1,7292	145.16	2,9868
81	58.167	0,71	114.6	1,4148	168.08	2,0751
145.8	76.4	0,524	152.8	1,048	244.48	1,6768

Flow curves of oil emulsions with different water content are presented in Figure 1. As seen in figure 1. shape curve $\tau = f((\gamma))^{\cdot}$ changes with increasing water content, with the volume of associated (dispersed) of water. Emulsions at low water contents have rheology properties close to Newtonian, in case of transition to solid phase with high viscosities at low shear stresses and abrupt conversion which equivalent to the yield strength.

In the dispersion environment where oil has a non-Newtonian properties, viscosity properties of oil and water mixture sharply strengthened with the increasing of volume of dispersed water. For Consideration of these oil emulsion properties special study requires in the rheology of multicomponent systems.

Dilution of oil with condensate naturally reduces the viscosity of resulting mixture, as result of this the hydraulic loss of pressure of the friction decreasing as well. As a rule, it was assumed that when the dilution hydraulic drive mode does not change, then the main parameters of a mixture, in particular the density obeys the additivity rule. Considering given the above, laboratory tests were conducted to assess the impact of the content with condensate- diluent to the rheological and physic-chemical characteristics of transportation of oil with high water cut at different temperatures.

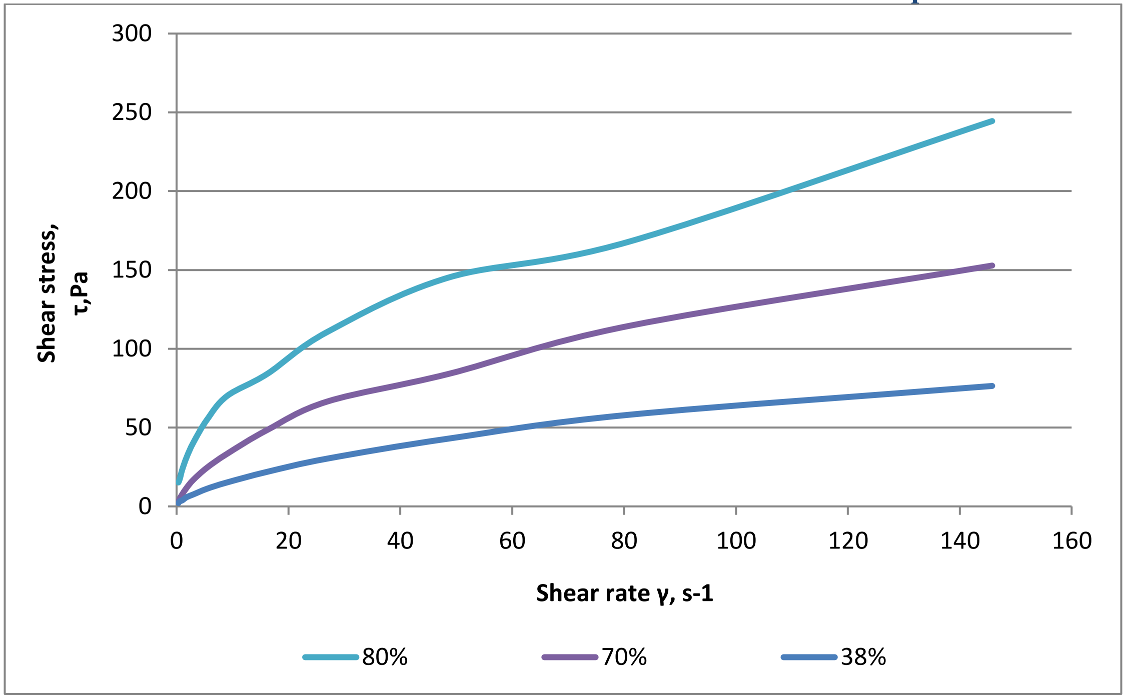

Fig.1 Flow curves of oil emulsions with different water-cut

For experiments were used samples of condensate and crude oil with primary water content 38% and 50%. The density of the mixture was determined by making dilution of condensate with crude oil with specific water content. The densities of watered oil, condensate, and their mixtures were determined by using a pycnometer. It should be noted that the experiments were carried out at 5^0C and 20 ^{0}C. Starting density of oil with 38% water cut at 5 ^{0}C equals 927 kg/m^3, and at 20 ^{0}C equals 915 kg/m^3 and oil with 38% water cut , 935 kg / m^3 and 928 kg / m^3 respectively. Starting density of condensate at 5 ^{0} C - 820 kg / m^3, and at 20 ^{0}C - 811 kg / m^3.

In the course of numerous studies found that, using condensate as a diluent obtained three-component mixture which can be called oilwatercondensat. A comparative analysis showed that the dependence for determining the density in which the water content is not included in an explicit form, does not have sufficient accuracy for engineering calculations. During pumping high-viscosity oils in a mixture with condensate the density of transporting product depends on the ambient temperature. Therefore, there is a three-parameter task of predicting water cut of oilcondensate mixture, depending on the mass fraction of condensate, and density as well.

During diluting heavy oil with condensate, density of the resulting mixture is naturally reduced. This experiment proves that the density of the mixture is an additive value, and this statement is not true for oilwater condensate mixture. Determination of water content in field conditions is difficult, as opposed to the density.

Three-dimensional depending $\beta_w = f(\rho_m, \beta_c)$ was investigated by taking into account three parameters-density, water-content and mass fraction of the condensate in a mixture and empirical formula depending watering of the mixture on mass and density of the condensate fraction was derived by using a mathematical analysis:

$$\beta_w = a + b \cdot \beta_c + c \cdot \rho_m \quad (1)$$

here β_w - mass fraction of water in the mixture; ρ_m - density of oilwatercondensat mixture; a, b and c - the coefficients of the models corresponding to a given temperature (Table 2).

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Table 2 The coefficients of the models corresponding to a given temperature and water-cut of oilwatercondensat mixture

Mathematical model	Temperature, ${}^0S$	The coefficients of equations		
		a	b	c
$\beta_в = a + b \cdot \beta_к + c \cdot \rho_{см}$	5	-5,5325	0,4028	0, 0064
	20	-5,3644	0, 3950	0,0006

In particular, a three-dimensional addictiongraph of water content of oilcondensate mixture and density of the mixture and condensate content at t = 20 ^{0}C is given in fig. 2.

After determining the water-cut of oilwatercondensat mixture by additivity rule, the errors between them computed according to the proposed formula as well. The results of determination of the dispersed water contents in the oilwatercondensat mixture and compatible errors shown in Table 3.

As can be seen from Table 3, proposed empric model for determining the degree of water content oilwatercondensat mixture allows to predict changes in water content depending on the content of the diluent - condensate and density of mixture a with acceptable accuracy for engineering practice.

The article also proposed a model for determining the density of oilwatercondensat mixtures with known water-cutting of production.

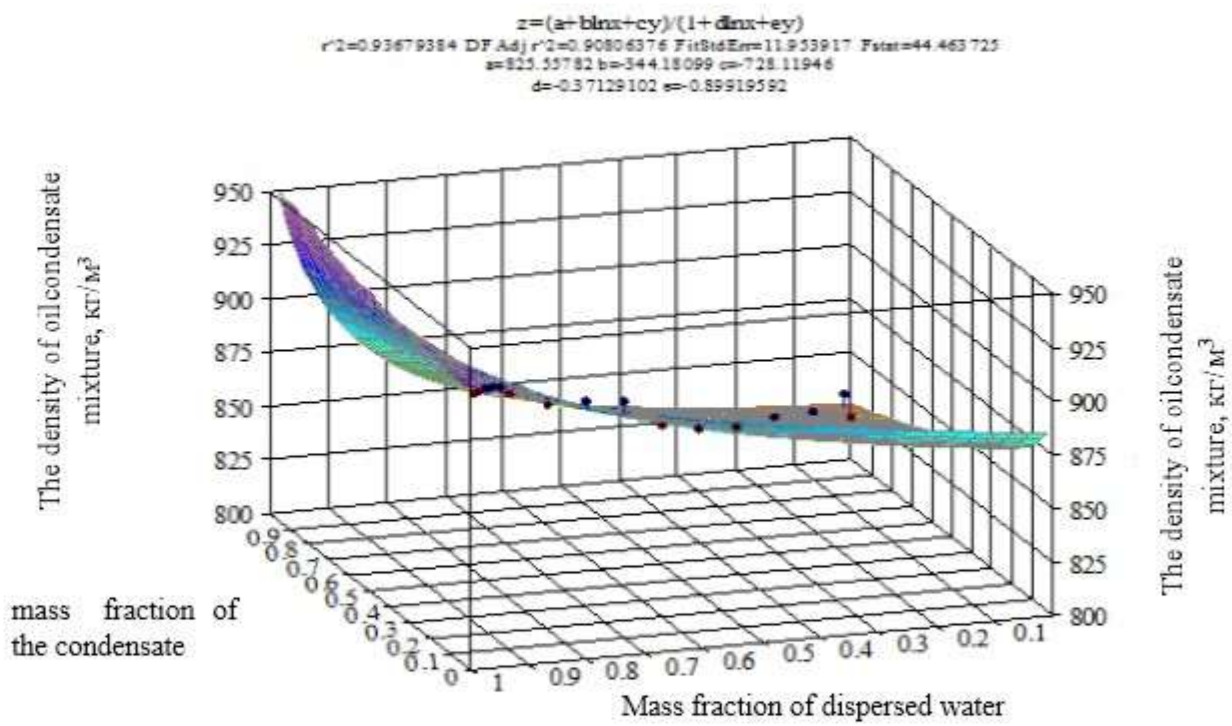

Fig. 2 Graph of the depending content of the dispersed water of oilwatercondensat mixture on content and density of condensate at 20 ^{0}C

The results of the determination of the dispersed water in the oilwatercondensate mixture

Temperature, ^{0}S	$\beta_к$	Density of mix, ρ_m кq/м^3	Water content in the mixture at 38% water cut		Error,%	Density of mix, ρ_m кq/м^3	Water content in the mixture at 50% water cut		Error,%	Density of mix, ρ_m кq/м^3	Water content in the mixture at 75% water cut		Error,%
			By the rule of additivity	According to the proposed formula			By the rule of additivity	According to the proposed formula			By the rule of additivity	According to the proposed formula	
5	0.010	928	0.380	0.3915	2.94	936	0.495	0.4425	10.61	-	-	-	-
	0.020	928	0.370	0.3955	6.45	939	0.490	0.4657	4.97	983	0.735	0.7463	1.54
	0.040	927	0.360	0.3972	9.37	938	0.480	0.4673	2.64	980	0.720	0.7353	2.08
	0.060	926	0.360	0.3988	9.73	934	0.470	0.4499	4.28	975	0.705	0.7114	0.90
	0.080	924	0.350	0.3941	11.19	931	0.460	0.4388	4.61	972	0.690	0.7003	1.47
	0.100	919	0.340	0.3703	8.18	927	0.450	0.4213	6.37	967	0.675	0.6765	0.22
	0.200	904	0.300	0.3149	4.73	914	0.400	0.3787	5.33	940	0.600	0.5446	9.24
	0.300	896	0.270	0.3041	11.21	902	0.350	0.3424	2.16	-	-	-	-
	0.400	886	0.230	0.2806	18.03	891	0.300	0.3125	4.00	907	0.450	0.4146	7.86
	0.500	865	0.190	0.1870	1.60	866	0.250	0.1933	22.66	-	-	-	-
	0.600	853	0.150	0.1507	0.46	851	0.200	0.1379	31.03	871	0.300	0.2655	11.49
	0.700	844	0.110	0.1336	17.66	839	0.150	0.1017	32.21	-	-	-	-
	0.800	839	0.080	0.1420	43.66	834	0.100	0.1101	10.07	847	0.150	0.1930	22.28
20	0.010	917	0.380	0.3770	0.80	928	0.495	0.4959	0.18	-	-	-	-
	0.020	920	0.370	0.3998	7.45	929	0.490	0.5186	5.51	974	0.735	0.7376	0.35
	0.040	917	0.360	0.3889	7.43	930	0.480	0.5203	7.75	973	0.720	0.7393	2.61
	0.060	915	0.360	0.3843	6.32	928	0.470	0.5032	6.60	969	0.705	0.7221	2.37
	0.080	912	0.350	0.3734	6.27	923	0.460	0.4923	6.56	964	0.690	0.6988	1.26
	0.100	910	0.340	0.3688	7.81	922	0.450	0.4752	5.30	962	0.675	0.6941	2.75
	0.200	896	0.300	0.3207	6.45	906	0.400	0.4333	7.69	934	0.600	0.5585	6.92
	0.300	884	0.270	0.3851	5.30	893	0.350	0.3977	11.99	-	-	-	-
	0.400	875	0.230	0.2683	14.28	882	0.300	0.3684	18.57	895	0.450	0.3934	12.57
	0.500	853	0.190	0.1702	11.63	860	0.250	0.2515	0.60	-	-	-	-
	0.600	847	0.150	0.1721	12.84	844	0.200	0.1971	1.43	859	0.300	0.2472	17.60
	0.700	836	0.110	0.1428	22.97	832	0.150	0.1616	7.18	-	-	-	-
	0.800	827	0.080	0.1260	36.51	828	0.100	0.1698	4.11	833	0.150	0.1635	8.26

The following empirical equation was derived for determining the density of mixture, depending on the mass fraction of oil and condensate at various temperatures and water content:

$$\boldsymbol{\rho_{см}} = \frac{\boldsymbol{A + B \cdot ln\beta_к + C \cdot \beta_н}}{\boldsymbol{1 + D \cdot ln\beta_к + E \cdot \beta_н}} \qquad (2)$$

here ρ_m - density of oilwatercondensat mixture; β_c and β_o - mass fraction of condensate and oil in the mixture; A, B, C, D and E - the coefficients (Table 4). The results of definition of the density of the oilwatercondensat mixture experimentally, by additivity rule, with using empirical formula (2), and also their compatible errors for 38 and 50% water-cut are shown in table 5 and 6. As shown in Table 5 and 6, offered mathematical formula in comparison with the rules of additivity give more acceptable results and good agreement with the experimental determination of density. The average error in determining the density of the mixture does not exceed 0.2%.

Table 4 The coefficients of the equation (2), corresponding to a given temperature and the water content of the mixtures

The initial water cut of oil, %	Temperature ^{0}S	The coefficients of the equation				
		A	B	C	D	E
38	5	825,55	-344,18	-728,12	-0,37	-0,90
50	5	946,17	-1335,77	-3834,04	-1,43	-4,67

Table 5 The results of definition of the density of the oilwatercondensat mixture at 38% water-cut

Temperature, ^{0}C	β_k	Density, кq/м^3			Error,%		
		By experiment - I	By the rule of additivity -II	According to the model (1)- III	I-II	I-III	II-III
5	0.01	928	925.93	928.60	0.22	0.06	0.29
	0.02	928	924.86	928.18	0.34	0.02	0.36
	0.04	927	922.72	926.82	0.46	0.02	0.44
	0.06	926	920.58	925.04	0.59	0.10	0.48
	0.08	924	918.44	922.99	0.60	0.11	0.50
	0.10	919	916.30	920.72	0.29	0.19	0.48
	0.20	904	905.60	907.52	0.18	0.39	0.21
	0.30	896	894.90	893.19	0.12	0.31	0.19
	0.40	886	884.20	879.31	0.20	0.76	0.55
	0.50	865	873.50	866.67	0.98	0.19	0.78
	0.60	853	862.80	855.59	1.15	0.30	0.84
	0.70	844	852.10	846.07	0.96	0.25	0.71
	0.80	839	841.40	838.01	0.29	0.12	0.40
	0.90	832	830.70	831.24	0.16	0.09	0.07
	0.98	832	822.14	826.61	1.19	0.65	0.54
20	0.01	917	913.96	918.94	0.33	0.21	0.54
	0.02	920	912.92	918.46	0.77	0.17	0.61
	0.04	917	910.84	916.83	0.67	0.02	0.66
	0.06	915	908.76	914.79	0.68	0.02	0.66
	0.08	912	906.68	912.50	0.58	0.05	0.64
	0.10	910	904.60	910.06	0.59	0.01	0.60
	0.20	896	894.20	896.74	0.20	0.08	0.28
	0.30	884	883.80	883.04	0.02	0.11	0.09
	0.40	875	873.40	869.89	0.18	0.58	0.40
	0.50	853	863.00	857.67	1.17	0.55	0.62

	0.60	847	852.60	846.48	0.66	0.06	0.72
	0.70	836	842.20	836.34	0.74	0.04	0.70
	0.80	827	831.80	827.19	0.58	0.02	0.55
	0.90	821	821.40	818.96	0.05	0.25	0.30
	0.98	812	813.08	812.98	0.13	0.12	0.01

Table 6 The results of definition of the density of the oilwatercondensat mixture at 50% water-cut

Temperature, ^{0}C	β_k	Density, кq/м^3			Error,%		
		By experiment -I	By the rule of additivity -II	According to the model (1) - III	I-II	I-III	II-III
5	0.01	936	933.85	935.75	0.23	0.03	0.20
	0.02	939	932.70	935.04	0.67	0.42	0.25
	0.04	938	930.40	933.13	0.81	0.52	0.29
	0.06	934	928.10	930.83	0.63	0.34	0.29
	0.08	931	925.80	928.25	0.56	0.30	0.26
	0.10	927	923.50	925.48	0.38	0.16	0.21
	0.20	914	912.00	909.93	0.22	0.45	0.23
	0.30	902	900.50	893.82	0.17	0.91	0.74
	0.40	891	889.00	878.88	0.22	1.36	1.14
	0.50	866	877.50	865.86	1.33	0.02	1.33
	0.60	851	866.00	854.90	1.76	0.46	1.28
	0.70	839	854.50	845.85	1.85	0.82	1.01
	0.80	834	843.00	838.38	1.08	0.53	0.55
	0.90	830	831.50	832.00	0.18	0.24	0.06
	0.98	823	822.30	826.66	0.09	0.44	0.53
20	0.01	936	926.83	928.68	0.98	0.78	0.20
	0.02	939	925.66	928.12	1.42	1.16	0.27
	0.04	938	923.32	926.57	1.57	1.22	0.35
	0.06	934	920.98	924.64	1.39	1.00	0.40
	0.08	931	918.64	922.44	1.33	0.92	0.41
	0.10	927	916.30	920.02	1.15	0.75	0.41
	0.20	914	904.60	905.69	1.03	0.91	0.12
	0.30	902	892.90	889.71	1.01	1.36	0.36
	0.40	891	881.20	873.99	1.10	1.91	0.82
	0.50	866	869.50	859.72	0.40	0.73	1.12
	0.60	851	857.80	847.43	0.80	0.42	1.21
	0.70	839	846.10	837.21	0.85	0.21	1.05
	0.80	834	834.40	828.89	0.05	0.61	0.66
	0.90	830	822.70	822.07	0.88	0.96	0.08
	0.98	823	813.34	816.80	1.17	0.75	0.43

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