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ОПРЕДЕЛЕНИЕ КОЭФФИЦИЕНТА ИЗВЛЕЧЕНИЯ НЕФТИ С ЦЕЛЬЮ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ РЕГУЛИРОВАНИЯ РАЗРАБОТКИ НЕФТЕГАЗОВЫХ МЕСТОРОЖДЕНИЙ

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DETERMINATION OF THE OIL RECOVERY FACTOR TO INCREASE THE EFFICIENCY OF REGULATION OF THE DEVELOPMENT OF OIL AND GAS FIELDS

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Аннотация. В статье рассмотрена методика, основанная на информации о дебитах скважин и расчета коэффициента Спирмена. В ее основе лежит апробированный в промысловых условиях подход, заключающийся в оценке взаимосвязей между уровнем отбора жидкости и добычей нефти, воды, обводненностью продукции. При этом высокая связь между жидкостью и нефтью, а также низкая между жидкостью и водой, жидкостью и обводненностью позволяет прогнозировать успешное проведение форсирования. Произведен ретроспективный анализ результатов форсирования отбора жидкости на месторождении. Выявлено улучшение взаимодействия между скважинами по нефти можно считать благоприятным фактором с точки зрения повышения нефтеизвлечения, а диагностирование усиления связи по воде – отрицательным, ускоряющим процесс обводнения. В то же время динамика изменения взаимосвязи может служить для оперативного регулирования процесса добычи.

Ключевые слова: обводненность; жидкость; динамика; форсирование; регулирование процесса, коэффициент Спирмена.

Annotation. The article considers a technique based on information about well flow rates and calculation of the Spearman coefficient. It is based on an approach tested in field conditions, which consists in assessing the relationship between the level of fluid withdrawal and the production of oil, water, and water cut. At the same time, a high relationship between liquid and oil, as well as a low one between liquid and water, liquid and water cut, makes it possible to predict successful forcing. A retrospective analysis of the results of forcing fluid withdrawal at the field was made. An improvement in the interaction between wells for oil has been revealed, which can be considered a favorable factor in terms of increasing oil recovery, and diagnosing an increase in communication for water can be considered a negative one, accelerating the process of watering. At the same time, the dynamics of the change in the relationship can serve for the operational regulation of the production process.

Keywords: water cut; liquid; dynamics; forcing; process control, the Spearman coefficient.

The most important indicator of the development of oil deposits is the flow rate of oil wells, which allows you to assess how efficiently the production system is used, as well as determine the oil recovery factor.Carrying out and researching work to establish a certain mode of operation of the well is associated with the presence of a large amount of information about the operation of the well itself and nearby ones. it is not always possible to keep track of such an amount of data.

This technique is the law on information about well flow rates [1]. It is based on an approach tested in field conditions, which consists in assessing the relationship between the level of fluid withdrawal and the production of oil, water, water cut. At the same time, a high relationship between liquid and oil, as well as a decrease between liquid and water, liquid and water cut, makes it possible to predict successful forcing. At the same time, dynamic changes in the relationship can serve for the operational regulation of the process.

Spearman's rank correlation coefficient is used to diagnose the relationship. The choice of this coefficient was due to the simplicity of calculation, resistance to errors in the initial information. Referring to the methods of non-parametric statistics, it is not associated with a specific distribution law.

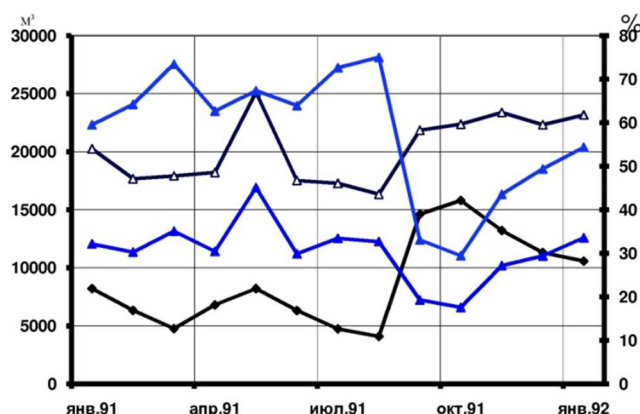**Dynamics of oil, water, liquid selection. Water cut**

Figure 1 – Dynamics of liquid, water, water cut and oil production from well s32
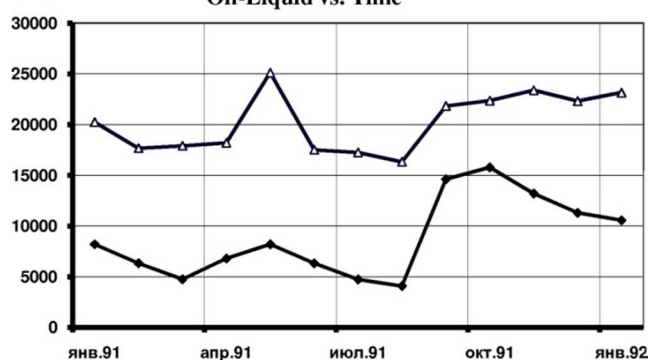
Oil-Liquid vs. Time

Figure 2 – Dynamics of fluid withdrawal and oil production from well s32

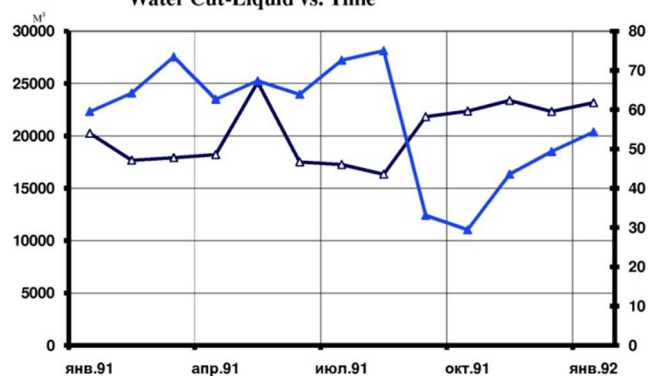**Water Cut-Liquid vs. Time**

Figure 3 – Dynamics of fluid withdrawal and water cut from well s32
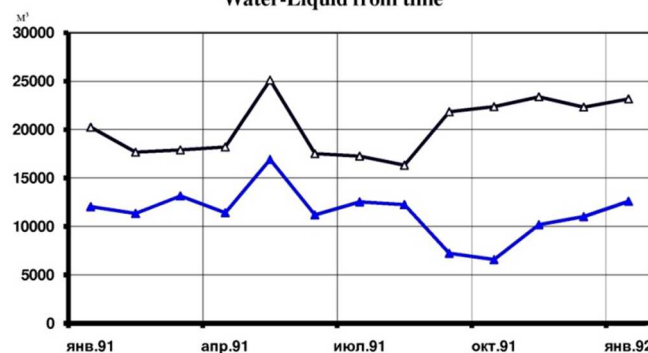
Water-Liquid from time

Figure 4 – Dynamics of liquid, water, water cut and oil production from well s32

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Consider the procedure for calculating and applying the coefficients using the example of well s32 of the X field (fig. 1). To determine the diagnostic coefficients, monthly data on the flow rates of liquid, oil and water for 1991 were taken, the water cut values were calculated and listed in table 1. the specified indicators are ranked in descending order. The values of the ranks are also given in table 1. The Spearman coefficient sarede termined by the following formula [2]:

$$r_s = 1 - \frac{6\sum\limits_{i=1}^{n}\Delta R_1^2}{n^3 - n - (T_A + T_B)},$$

where ΔR_1 – is the difference between the ranks in the i-th line; n – is the number of calculated points;

$$T_A = \frac{1}{2}\sum\limits_{i=1}^{l_A}\left(t_i^3 - t_i\right);$$

$$T_B = \frac{1}{2}\sum\limits_{i=1}^{l_B}\left(t_i^3 - t_i\right),$$

where l_A, l_B – is the number of groups of related ranks in sequences;
t_i – number of related ranks in the i-th group.

Table 1 – A production well that used monthly liquid, oil and water data, calculated water cut values and well ranks s.32

Months	Liquid flow rate m³/mon	Rank	oil flow rate, m³/mon	Rank	water flow, m³/mon	Rank	watercut, %	Rank	$\Delta R_{iн}^2$	$\Delta R_{iв}^2$	ΔR_i^2
I	20246	7	8200	7	12046	8	59,4981	5	0	1	4
II	17670	4	6326	5	11344	6	64,1992	8	1	4	64
III	17909	5	4758	3	13151	11	73,4323	11	4	36	36
IV	18206	6	6802	6	11404	7	62,6386	6	0	1	0
V	25123	12	8207	8	16916	12	67,3327	9	16	0	9
VI	17517	3	6324	4	11193	5	63,8979	7	1	4	16
VII	17267	2	4731	2	12536	10	72,6009	10	0	64	64
VIII	16331	1	4083	1	12248	9	74,9984	12	0	64	121
IX	21839	8	14617	11	7222	2	33,0692	2	9	36	36
X	22368	10	15789	12	6579	1	29,4125	1	4	81	81
XI	23387	11	13201	10	10186	3	43,5541	3	1	64	64
XII	22326	9	11309	9	11017	4	49,3460	4	0	25	25

In our case, the Spearman coefficient for liquid is equal to 0,98, for liquid – water – 0,78 and for liquid – water cut – 0,30. To make decisions about calculation, it is necessary not only to use the values of the coefficients themselves, but also to assess in advance how desirable these or those values of each of the results in the identification, as well as their entire complex. For this purpose, a retrospective analysis of the results of forcing the withdrawal of fluid at the «X» field was carried out. As a result of compiling a rating scale (desirability) for evaluating the coefficients (fig. 4), which makes it possible to equally evaluate both each indicator in the assessment and the entire complex [3].The values on the desirability scale are marks on a curve $d = \exp(-\exp(-Y))$, that can be directly used as a nomogram.

After converting the obtained values of the Spearman coefficients according to the nomogram into partial d_1 desirability, the value of the generalized desirability function, which is the geometric mean of the partial values, is determined by the formula:

$$D = \sqrt[3]{\prod_{I=1}^{3} d_i}.$$

The choice of the geometric mean for these purposes shows that the influence of each of the considered indicators can be decisive (if the desirability of one of them is close to zero, then the geometric mean is close to zero).

The value of the generalized desirability function for square s32 for 1991 (tab. 2) allows for an increase in fluid withdrawal, which was done in 1992. If there is a forced fluid withdrawal necessary for analysis, it is necessary to make changes to the diagnostic indicators, taking into account the nature of the needs during forcing. Thus, the pleasure between oil wells can be considered a favorable feeling from the point of view of the problem of oil recovery, and the diagnosis of discomfort from communication with water can be considered a negative one, stimulating the process of watering.

Table 2 – The results of the value of the desirability function of wells s.32

Well operation period	Values r_s			Private desirability			Generalized desirability function
	liquid-oil	liquid-water	Liquid-watercut	$d_{ж-н}$	$d_{ж-в}$	$d_{ж-обв}$	
January 1991 – December 1991	0,98	078	0,30	1,0	0,68	0,95	2,63
January 1991 – June 1992	0,97	0,85	0,73	1,0	0,51	0,61	2,12
January 1991 – December 1992	0,96	0,88	0,79	1,0	0,40	0,40	1,8
January 1992 – December 1992	0,86	0,95	0,88	1,0	0,20	0,21	1,41

The hydrodynamic coupling can also be estimated using the Spearman coefficients. As the calculations are measured, it is diagnosed at values $r_s \succ 0,5$.

Conclusions

This approach is recommended for use when making a decision on the process of control and regulation of the development of oil and gas fields.

Литература:

1. Калинин В.В., Выбор скважин для форсированного отбора и регулирование процесса по устьевой информации // Азербайджанское нефтяное хозяйство. – 1986.. – № 3. – Р. 33–36.
2. Кэндел М.Дж. Ранговые корреляции. – М. : Статистика, 1985. – 216 с.
3. Адлер Ю.П., Маркова Е.В., Грановский Ю.В. Планирование эксперимента при поиске оптимальных условий. – М. : Наука, 1976. – 280 с.

References:

1. Kalinin V.V. Well selection for forced drainage andregulation of process according to wellhead information // Azerbayjan oil industry. – 1986. – № 3. – Р. 33–36.
2. Kandel M.J. Rank correlation. – M. : Statistics, 1985. – 216 p.
3. Adler Y.P., Markova Y.V., Granovsky Y.V. Planning experiment in the search for optimal conditions. – M. : Nauka, 1976. – 280 p.