Middle-East Journal of Scientific Research 17 (7): 919-925, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.17.07.12282

Application of the Software Product "Prospecting" for Analyzing and Optimizing the Efficiency of Waterproofing Work

[1]Ramil' Nazifovich Bahtizin and [2]Irik Galikhanovich Fattakhov

[1]Academy of Sciences of Republic Bashkortostan, Ufa, Russia
[2]FSBEI of HPE "Ufa State Petroleum Technological University"
Branch in Oktyabrsky City, Oktyabrsky, Russia

Abstract: The article outlines the opportunities of using product of applied programming for the analysis of work condition on water control in production wells on the example of "Prospecting" program for adjusting the effectiveness of interventions. The analyzed samples are 238 carbonate reservoir wells of 21 oil fields, where the same types of waterproofing work were carried out. Each of the wells had 40 analyzed variables and 2 output data. After researching all graphs, a summary table with recommendations on the future work plan and the main relevant factors was obtained. The ultimate goal of the work is proof of the possibility of increasing oil recovery efficiency, indicating the quantity of oil recovery efficiency and the pace of its selection.

Key words: Program · Informative data · Extraction · Predictions · Results · Oil recovery efficiency

INTRODUCTION

The issue of reliable predicting of anticipated efficiency of planned work for increasing oil recovery reservoirs has occupied the minds of prominent researchers in the field of oil field development for decades. This can be both a simple correlation techniques, aimed only at certain relationships between the two parameters and more complex tools [1, 2, 3], such as informative data, principal component analysis, artificial neural networks.

In [4] the author sets out the possibility of practical application (physical entity and algorithm of work) created by his software "Prospecting" [5], based on the application of the theory of information data [2, 3]. Many works are aimed at the integration of differential problems with intensification of oil producing with the help of applied programming [6-8]. A number of articles is devoted to programme planning for the deployment of production and injection wells [9-11]. There is a group of works aimed at flooding simulation including non stationary ones [12-14]. And even regulation of enterprise is based on using the software [15].

Taking into account that the effects of various factors on the rate of the process can be determined by calculating the informativeness of these factors, the following methods of data processing are suggested. Suppose, you have two groups of objects: A and B and some common sign for them. When in differentiable conditions of objects A and B this trait is different for each group of these objects-this means that it is informative, or vice versa: on this basis one can distinguish objects and groups of objects in a group. If the sign is not descriptive, this distinction is impossible. A statistical criterion such as the Fisher criterion assesses the reasonableness of the differences, but not their extent, whereas informativeness gives exactly the degree of these differences. In its turn, Kulbak's measure provides informative assessment of investigated signs [2, 3]. This method has been automated with the help of special software "Prospecting" to consistently carry out all the necessary operations when calculating Kullback's measure results and output in the form of tables and graphs.

For detailed consideration 238 reservoirs of carbonate wells of 21 oil fields of the western part of Bashkortostan were chosen, where the same types of waterproofing were carried out. The survey was carried out on 40 analyzed data and a total increase of oil production was accepted as an output and while drawing

Corresponding Author: Ramil' Nazifovich Bahtizin, Academy of Sciences of Republic Bashkortostan, Ufa, Russia.

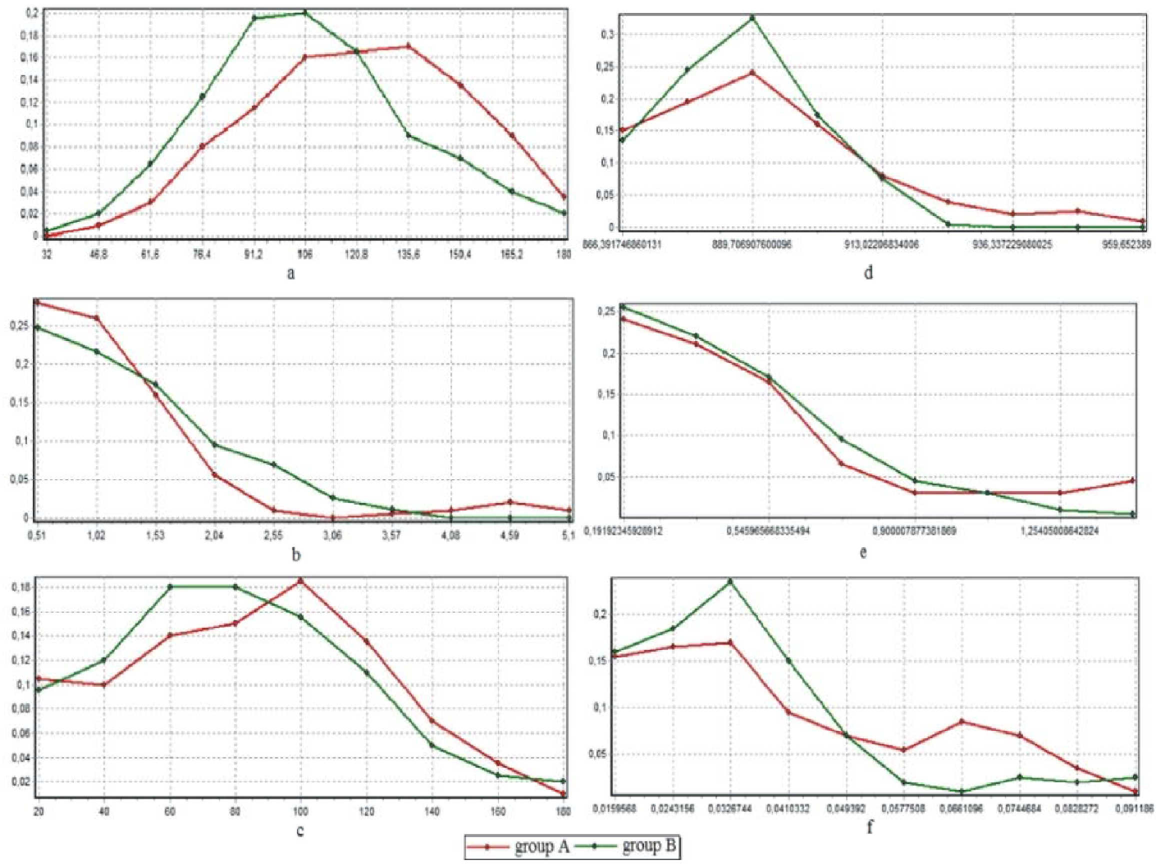

Fig. 1: Distribution of smoothed frequency parameters: A (weak) and B (effective impact)

a chart the duration effect was further considered after work. Taking into account the said above, 9996 variables, collected in table cards of wells, development projects and other normative documents were used.

The most informative graphs obtained from 40 were given descriptive characteristics, 21 distributions were achieved. Figure 1a is an example of one of the variables, the formation of pressure at the time of processing in particular. Abscissa shows the intervals which the considered sign is divided by, the ordinate shows the smoothed frequency of groups A and B, these intervals being measured in fractions. On the whole, only 6 of all diagrams in the article are given here, due to the limited amount of work. All recommendation descriptions relating to the impact of planned activities were consolidated into one summary Table 1. It shows meaningful intervals, i.e. the values under which the most favorable outcome of planned work on water control is possible, in other words they ensure profitable growth in oil production. Here are less effective intervals, corresponding to the range of values under which the effectiveness of works will be insufficient.

Further, the main description of all the selected dependencies is given directly. All the analyzed groups are presented in Table 2.

The first group is the operational characteristics. Their variable-flow of oil up to q_o processing starts it (Figure 1b). q_o and $□_n$ value intervals may seem contradictory at first sight, but in fact they are not. q_o is the average flow rate over the past three months, before the processing operation, in most cases, at the time of the impact in the field well was in depleted condition. And $□_n$ is the average production rate for the whole period of the well existence, the duration of which varies from six months to 47 years at the time of processing. Such long period will no doubt result in the depletion of the field well range and lower strength of lined columns.

The next parameter is the flow of liquid to qæ processing. In its turn, q_l and $□_l$ in general are similar, except the offset boundary values within a range. Explanations of the efficiency of work at small values are similar to the debit of oil prior to processing. The maximum oil flow to the oil exploitation q_{max}, t/month is included in the same group of characteristics. The dependence of

Table 1: Comparison of settings groups with their variables

Group of indicators	Parameter
Operational characteristics	Petroleum production to processing, t/h
	Liquid flow rate prior to processing, t/h
	Water treatment products,%
	Average oil production rate for all design time, t/h
	The average flow of fluids for all design time, m3/h
	The average water flow rates for all design time, m3/h
	The initial flow rate, m3/h
	Maximum oil flow on oil, tons/month
	The ratio of the maximum flow rate to the average for oil fractions
	Cumulative production of oil at the time of processing, t/month
	Cumulative production at the time, fluid processing M3/month
	Cumulative production of water at the time of processing, M3/month
	The lifetime of the well, 24 hours
	Operating time, day
	Watering products after processing,%
	The ratio of the actual operation of the wells by the time of its existence, share
Conditions of reservoir	Artificial bottom hole, m
	Reservoir pressure at the time of processing, ATM.
Technological parameters	Pressure pumping, ATM.
	Uploaded gipana, m³
	The duration of repairs, days
Capacitance and filtration properties of reservoir	Initial neftenasysennost',%
	Porosity,%
	Permeability, MD
The physico-chemical properties acid exposure	Oil density, kg/m3
	SKO tails
	The multiplicity of T-BILLS
	The multiplicity of acid treatment
Tolsinnye reservoir properties	Perforation interval, m
	Total thickness, m
	Number of interlayers of oil in the well
	Average thickness of oil presently in the well
	The ratio of average yield to intervals of perforation, t/d * m
Special factors of heterogeneity perforation	Share a common reservoir thickness, proportion
	Effective area of perforation holes on 1 m, m/m
	Square perforation holes on 1 m, m/m
	Square apertures, M2
	The number of perforations
	Punch type, size
	Punch type, age

maximum oil production growth rate showed that lower values of q_{max} correspond to greater efficiency. Apparently, this dependence is due to the fact that the productive parts of the reservoir were not abrupt displacement of oil and the most pervious channels were not watered immediately, i.e. development occurred more evenly, "one voice". The similarity of parameters q_{in} and q_{max} lies not only in the unity of the conformity, but also in the proportionality of boundary values (30,3 m^3/day and 880 t/month).

This group of operating characteristics includes both analyzed irrigations. The first one is the irrigation of water cut production before the B_{before} WPW. At values of irrigation less than 73.5% it's more likely to receive larger values of oil production increase. If the value of water cut is from 60 to 75%, then it's more often the collector, which was irrigated in some of its parts. After blocking interlayers other parts start working around. And irrigation of 80, 90% or more, is already inherent in the reservoirs, in which there were major channels (the result of hydrochloric acid treatments, pressure differences in the reservoir, pollution of bottom hole formation zone, etc.), with high conductivity. The second one is the irrigation of production following a WPW B_{after}. You should pay attention to the irrigation after processing. On the chart you can see the analogy of B_{after} similar to B_{before}. Only the boundary value reduces. That certainly confirms the importance of threshold reductions during

Table 2: Summary table of most informative data for analysis

Coefficient	The Dimension Of The	Target intervals	Ineffective intervals
q_o	t/d	(1,4-3,7)	<1,4; >3,7
q_l	m^3/d	<5,7	>5,7
□$_o$	t/d	<1,4; > 4,7	(1,4-4,7)
□$_l$	m^3/d	< 10,8; > 35	(10,8-35)
q_{in}	m^3/d	<30,3	>30,3
q_{max}	t/month	<880	>880
B_{before}	%	<74	>74
B_{after}	%	<64,55	>64,55
p_l	bar	<120	>120
p_{inj}	bar	<90	>90
V_{inj}	m^3	(3,53; 6,33)	<3,53; >6,33
m	%	<2,7; >10,54	(2,7; 10,54)
k_p	mD	<18,5; >40	(18,5;40)
ρ_o	kg/m^3	<910	>910
L_b	m	<1498	>1665
□	t/d * m	<1,077	>1,077
S_r	dm^2	<5	>5
sH	dm^2/m	(0,177; 0,306)	< 0,177; > 0,306
n_a	u	[2;3]	0,1,4 и более
T_e	h	<8343	>9514
Q_l	m^3	<68000	>68000

the irrigation of water cut products, both for increasing oil recovery efficiency as a whole and to enhance the effectiveness of planned work in the well (in our case, WPW) in particular. You can see the similarity of parameters of B_{before} and B_{after} conformities of their interaction with the growth of oil extraction.

The time of well exploitation T_e is also related to operational characteristics. The analysis shows that in case of long-term exploitation of the well (over 25 years) the opportunity to obtain profitable effect is extremely low. This is a natural consequence of lasting destruction of column from corrosion and various repair and research work conducted in the well. That will undoubtedly cause the emergence of cross-flows. It also includes cumulative production of fluid at the time of processing Q_l. Cumulative production of liquid over 68 000M3 is the reason for reducing the possibility of an effective impact on the well. The explanation of this conformity is reduced to a significant depletion of the area around the researched well.

The conditions of layer formation, which in one case represent a reservoir pressure at the time of processing the p_l are described in another group. The diagram shows that under smaller values of pressure there is a big guarantee that there will be more consolidation in the washed/watered part of the layer. And in the other case it is the depth of the layer formation (the depth of artificial slaughter) L_b. There is also quite an interesting case with differentiation of depth values in relation to the work efficiency. The most favorable for waterproofing work are the depths of less than a kilometer and a half.

Other characteristics are technological parameters, in the first case it is the polymer injection pressure p_{inj}. The schedule of correlation values (Fig. 1c) of more and less effective WPW reveals that if the polymer enters the layer under smaller values of pressure, it considerably increases the probability of favorable outcome measures on water limit. And this conformity says about the best crossing (piestic) characteristics of the reservoir. You should also pay attention to the identity of parameters associated with the pressure p_l and p_{inj}. And in the second one it is the amount of injected polymer V_{inj}. As you can see in the graph Figure 1c, you must select appropriate amount of injected polymer. It is essential to accurately calculate the amount of the waterproofing screen around the well. For this purpose we suggest using our software. The program makes well-founded determination of polymer quantity based on values of porosity, pressure, viscosity, well sizes, drilling wells, extraction and other parameters (amounting to eleven variables).

Another characteristic is expressed by filtration properties of reservoir porosity coefficient, m. Small values of porosity formation in large areas being analyzed are characterized by large areas not involved in the design and contain significant reserves of oil. And large amounts of the analyzed parameter say about areas with stores with well-established filtering channels. Another variable is coefficient of permeability of the k_p. Lower values of permeability of the reservoir area of effective water control work are most often characterized by the presence of multiple intervals (presently), washed by filtration flows. This explains the efficiency of liquid barriers after blocking the main washed zones and the development of the least permeable, but the most oil saturated. A similar explanation can be found for the value of permeability parameter of over 40 mD (also blocking the most conductive and putting into operation less permeable ones). There is also a correlation of filtration-capacitive properties: permeability and porosity.

Physical and chemical properties are another group of characteristics, expressed by oil density ρ_o. As you can see in the graph, presented in Figure 1d, while increasing oil density the probability of a favorable outcome for water insulation is reduced. This is explained by the fact that even with the resultant WPW (all water cut interlayers are blocked) in the newly developed oil saturated layers, filtration of heavy oils (more viscous) is significantly hampered.

Another characteristic is expressed by the thickness property of the layer, in this case it is a relative debit □ (Fig. 1e) – the ratio of the average oil flow to the interval of perforation. The new coefficient suggested by the author describes the average quantity of oil from the well for the whole operation period at the time of the WPW related to the perforation interval (real interval of oil-saturated collector). This ratio shows that under its smaller values (1,077 <, an average 1 m^3 of oil per day from 1 m perforation for the whole operating period), the positive effect of the planned WPW is more likely.

The perforations characteristics are expressed in one case by all perforation holes areas made at the height of oil wellbore S_r. As can be seen from the graph (Figure 1f), too large area of the holes (thus a large number of holes) worsens the favorable chance of WPW. This is due to the increased potential for cross-flows and other violations of the integrity of both the casing and its cement ring because of the overload while layer breaking. The degree of excellence in the other one sH is a ratio of an area of perforation holes to a perforated interval of the well S_r/hper. That is confirmed by this dependence as well. The new coefficient (suggested by the author) is used to show the degree of perfection of the wellbore (equivalent to its destruction capacity) and its impact on the effectiveness of WPW.

Characteristics of acid effects are analyzed on the example of multiplicity of acid treatment n_a. WPW is most effective when the multiplicity of acid treatment on the well is two or three. Fewer number can be ineffective, which says about weak links in the filtering canals of the collector and more number (4 or more) are unproductive because of too large network of canals in the oil-saturated reservoir.

In order to confirm the importance of predictable planning of waterproofing work, we will use the results of the preliminary analysis of objects (238 wells of carbonate layers South Tatar oil fields) where waterproofing work of one type – polymer acid exposure was carried out.

Figure 2 provides a diagram of the frequency distribution of discharge of well debits[8] in three groups:

- q_{before},% is an average monthly flow rates before waterproofing work for the previous six months.
- q_{after},% is the average production rate of waterproofing work, calculated as the sum of the ratios of total oil production growth due to WPW to the duration effect and qbefore.
- q_{plan},%, -this group of parameters is presented only by marginal growth in oil production, obtained with the use of the software product "Prospecting".

As you can Figure 2 the average monthly debits q_{before} mainly lie in the realm of small values, no more than 25 tons of oil per month. The number of q_{after} shows a significant shift in the frequency region of the large values of 25-35 t/month, reaching 50 and 90. And our planned q_{plan} parameter of the frequency shifts to the maximum possible value of 30-90 t/month, with clear growth dynamics in the maximum value.

Diagrams of Figures 3 also demonstrate a substantial frequency shift in the maximum values both in the duration effect after the restriction of water (Figure 3a) and the growth in oil production, taking into account the recommendations of the software product "Prospecting" and without them.

These recommendations will improve the oil recovery efficiency in OGPD “Tujmazaneft”. Table 3 shows the current real and possible (based on planning with the help of software "Prospecting") oil recovery rates in 238 researched objects in 2013.

As can be seen from Table 3, the use of the software "Prospecting" will help improve the current values of oil recovery up to 1,3 - 7,5% in comparison with the initial values. The pace of extraction can also increase by 9,13 - 0,65% as compared to the existing one.

Table 3: The possible dynamics of oil recovery by applying the software «Prospecting»

Oil field	Horizon	Oil extraction coefficient	Selection rate% The initial	Current	Possible	Boost	% Gain	Current	Possible	Boost
Abdulovskoe		Turnejskij tier	0,303	0,092	0,093	0,002	2,030	3,18	4,00	0,82
Mines-Kubovskoe		Turnejskij tier	0,352	0,167	0,176	0,009	5,447	1,79	6,33	4,54
Mines-Kubovskoe		Zavolzhsky horizon	0,270	0,031	0,033	0,002	7,503	0,62	1,56	0,94
Mines-Kubovskoe		Famenskij tier	0,383	0,315	0,322	0,007	2,293	2,50	11,63	9,13
Mikhailovskoye		Zavolzhsky horizon	0,304	0,097	0,099	0,001	1,406	0,71	1,36	0,65
Mikhailovskoye		Famenskij tier	0,420	0,318	0,324	0,006	1,914	3,20	8,50	5,30
Serafimovskoe		Turnejskij tier	0,342	0,139	0,142	0,003	1,896	1,99	3,22	1,23
Stakhanov		Turnejskij tier	0,303	0,206	0,208	0,003	1,268	3,93	6,35	2,42
Stakhanov		Famenskij tier	0,261	0,190	0,194	0,004	1,941	1,81	6,56	4,75

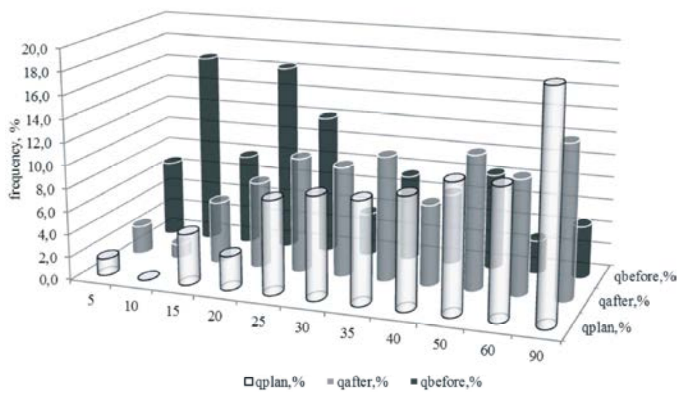

Fig. 2: Distribution of frequency diagram (z axis) of average monthly flow rates (x-axis) wells for discharge (the y-axis) before (for six months), after WPW and planning work with the help of products of applied programming

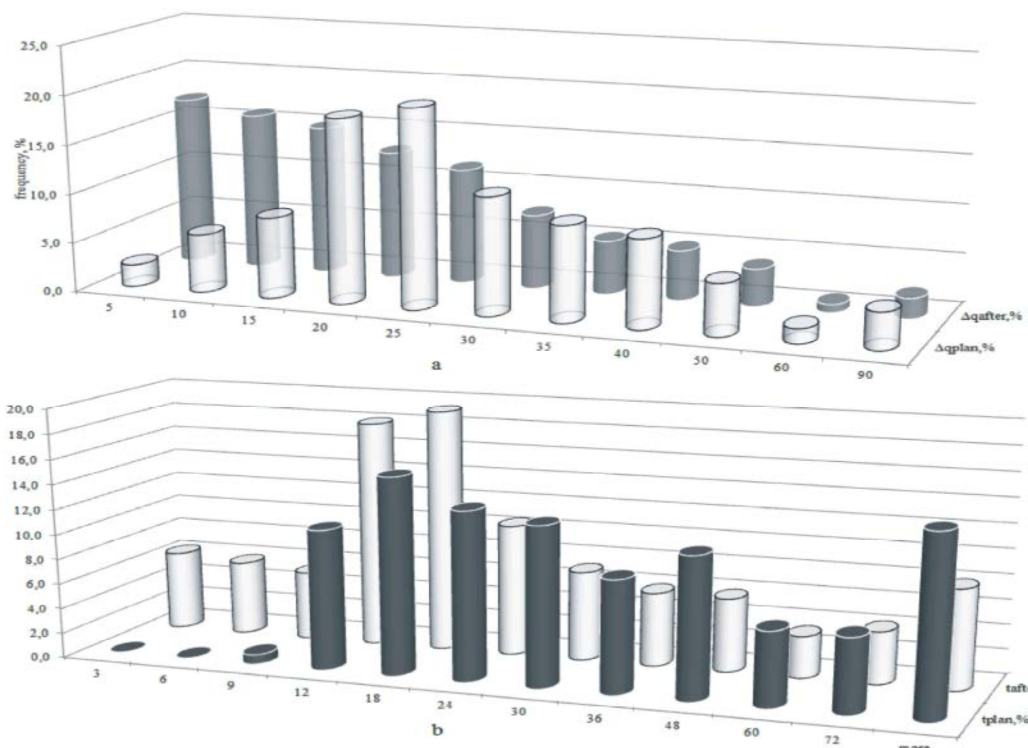

Fig: 3: a - Diagram of frequency distribution of the duration effect; b - Diagram of frequency distribution of the growth in oil production, taking into account the recommendations of the software product and without them

CONCLUSIONS

- The basic opportunity of using the software product "Prospecting" to predict the success of various methods of oil extraction growth (water isolation work, hydraulic fracturing, acidizing etc.) for the further frequency efficiency of planned work in oil production is proved.
- Recommendations on selection of candidates for carbonate reservoir wells of 21 oil fields of the western part of Bashkortostan, with the introduction of the most informative data are given in the summary table.
- The result of the above analysis is the proof of the possibility of raising oil recovery values and speed of their selection with the use of the software product "Prospecting" in order to forecast the effectiveness of interventions. It shows the importance of applied programming.

REFERENCES

1. Mirzadzhanzade, A.H., M.Zh. Hasanov and R.N. Bahtizin, 1999. Etudes on the modeling of complex systems in oil and gas production. Ufa: Gilem, pp: 464.
2. Mirzadzhanzade, A.H. and G.S. Stepanova, 1977. The mathematical theory of the experiment in the extraction of oil and gas. M., «Nedra», pp: 229.
3. Kul'bak, S., 1967. The theory of informativeness and statistics. M., «Nauka», pp: 408.
4. Fattakhov, I.G., L.S. Kuleshova and A.A. Musin, 2009. The method of processing the results of experimental studies on the example of a polymer acid influence on the BFZ wells using special software // Automation, Telemechanization and Communication in Oil Industry, 3: 26-28.
5. Fattahov, I.G., *et al*., 2012. Certificate of state registration of computer software No 2012611957. Prospecting (Izyskanie).
6. Fattakhov, I.G., 2012. Integration of differential problems in oil production intensification using applied programming // Proceedings of the higher education institutions. Oil and Gas, 5: 115-119.
7. Fattakhov, I.G., 2012. The program for determining the reservoir structure and choosing the method of waterproof operations // European Applied Sciences (Stuttgart, Germany), 1(2): 329-331.
8. Fattakhov, I.G. and F.F. Fazlyev, 2013. Waterproofing work at sidetrack and horizontal wells// International scientific periodical «Modern Fundamental and Applied Researches», 2(9): 20-23.
9. Tavallali, M.S., I.A. Karimi, K.M. Teo, D. Baxendale and S.H. Ayatollahi, 2013. Optimal producer well placement and production planning in an oil reservoir // Computers & Chemical Engineering, 55(8): 109-125.
10. Leow, W.X., M.S. Tavallali, I.A. Karimi and K.M. Teo, 2012. Simultaneous Optimal Placement of Injector and Producer Wells Using Mathematical Programming // Computer Aided Chemical Engineering, 11th International Symposium on Process Systems Engineering, 31: 1482-1486.
11. Toh, R.Y., M.S. Tavallali, W.X. Leow and I.A. Karimi, 2012. A Comparison Study of Adjoint-Based Gradient Search Technique and Mathematical Programming for Optimal Well-Placement // Computer Aided Chemical, Engineering 11th International Symposium on Process Systems Engineering, 31: 665-669.
12. Mohammad Sayyafzadeh, Peyman Pourafshary, Manouchehr Haghighi and Fariborz Rashidi, 2011. Application of transfer functions to model water injection in hydrocarbon reservoir // Journal of Petroleum Science and Engineering, 78(1): 139-148.
13. Er-long Yang and Jing-cui Wang, 2011. A New Method to Predict Polymer Flood Performance // Procedia Environmental Sciences, 2nd International Conference on Challenges in Environmental Science and Computer Engineering (CESCE 2011), 11: 1522-1528.
14. Artun, E., T. Ertekin, R. Watson and B. Miller, 2012. Designing cyclic pressure pulsing in naturally fractured reservoirs using an inverse looking recurrent neural network // Computers and Geosciences, 38(1): 68-79.
15. Guo Haixiang, Liao Xiuwu, Zhu Kejun, Ding Chang and Gao Yanhui, 2011. Optimizing reservoir features in oil exploration management based on fusion of soft computing // Applied Soft Computing, 11(1): 1144–1155.