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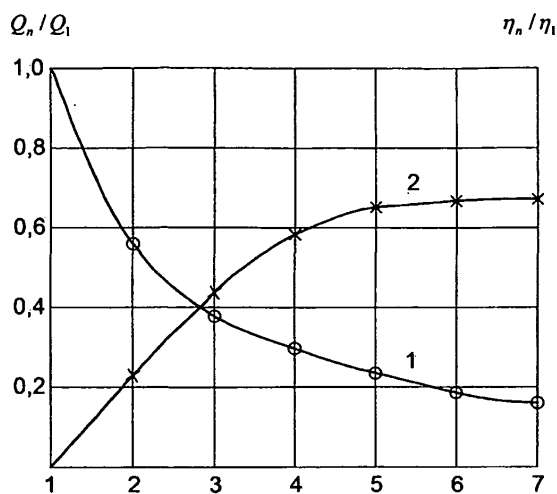
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(54) **METHOD FOR MONITORING THE OIL-FIELD DEVELOPMENT**

(57) The invention relates to the oil industry, in particular to methods for monitoring the development of oil fields. In order to increase the monitoring efficiency of the oil field development by the fuller recording of parameters that characterize a deposit to be developed, for hydraulically unrelated areas with equal values of desir-

ability functions, the method involves additionally measuring the stability of a water-oil emulsion in each well, calculating the mean value of the water-oil emulsion within each area and advising the use of methods for increasing oil recovery at the areas according to the incrementation of the water-oil emulsion value.



Number of cycles

Fig. 1

Description

[0001] The invention relates to the oil industry, in particular to methods for monitoring the development of oil fields.

BACKGROUND

[0002] The known methods of monitoring the development of oil fields involve laboratory studies of the properties of porous media and layer fluids, geophysical and geo-trade studies of wells, building and collective analysis of collector state maps, breaking down the oil bed into representative areas with the characteristic geologic and filtrational characteristics and selecting zones for using methods of action on the layer and increasing oil recovery.

[0003] A method is known for monitoring the development of oil beds (RU pat. No. 2119583, publ. 09/27/1998), that involves laboratory studies of the properties of porous media and layer fluids, geophysical and geo-trade studies of wells, building geologic areas, tracking seams along zones of characteristic permeability, building maps of initial and residual oil-saturated depths, refining developed oil-saturated depths taking into account accumulated production volumes and injection volumes.

[0004] A disadvantage of this method is that the method does not take into account processes of distributing pressure gradients in the layer and the formation of dead zones, and also their effect on the development of the layer, which decreases the reliability of the determination of the situation of low-mobility oil zones.

[0005] A method is known for determining the boundaries of low-mobility oil zones (Devlikamov, V.V., Khabibullin, Z.A., Kabirov, M.M. "Abnormal Oil." M.: Nedra, 1975. p. 168) that involves measuring the content of structure-forming oil components, measuring layer pressure in wells and calculating dynamic shift stress. Based on calculated values of dynamic oil shift stress for each well and a map of the distribution of layer permeability, a map of the distribution of dynamic shift stress is built. According to the measured values of layer pressure in each well, maps of the distribution of layer pressure gradients are built. The values of the oil shift dynamic pressure gradients are compared with the actual layer pressure gradients. The boundaries of the low-mobility oil zones are carried out by superimposing the maps of the distribution of oil shift dynamic pressure gradients on the map of the distribution of actual layer pressure gradients.

[0006] A disadvantage of this method is its applicability only for uniform layers. With a high degree of zone and layer heterogeneity, and also with increasing heterogeneity of the layer structure, the monitoring method does not take into account the effect of filtration rates on the processes of distributing pressure gradients in the layer and the formation of dead zones, and also their effect on the development of the layer, which decreases the reliability

of the determination of the situation of low-mobility oil zones.

[0007] A method of monitoring the development of oil fields (RU pat. No. 2172402, publ. 08/20/2001) that involves measuring layer pressure, viscosity of layer fluids, relative phase permeability of oil and water, building maps of pressure fields and maps of fields of filtering and penetration rates, superimposing the maps of pressure fields on the maps of fields of filtering and penetration rates and determining the situation of hydraulically unrelated areas. For each of the hydraulically unrelated areas, desirability function values for using the methods for increasing oil recovery (MIOR) are calculated according to a multidimensional equation of its dependence on the number of production and injection wells, permeability, layer and zonal heterogeneity, output rate, water cut and fluid yields of the wells of the area.

For using MIOR, hydraulically unrelated areas are selected according to the decrementation of the desirability function.

[0008] Among the disadvantages of this method are that the method does not take into account the effect of the methods of action on the layer, leading to irreversible changes in the structure of pore space and changes in the properties of layer fluids. Many years of action on layers with development of fields leads to irreversible change in the structure of pore space, reduction of permeability, change in the properties of layer fluids and change in the structure of reserves. Action on the bed by means of water disturbs the equilibrium state of the bed system, since the physicochemical properties of the injection water differ from those of the layer. The injection water is a new component of the bed; therefore upon its interaction with the rock matrix, the hydrocarbons and layer water, the heterogeneity of the layer structure is heightened, the difference in the permeability of rocks is increased and the properties of layer fluids are substantially changed. Thus, conditions for the formation of oil-water emulsions are created in the layer (Amiyan, V.A. "The Possibility of Forming Emulsions in the Critical Zone." M., 1959, No. 11, p. 39, TSNIITeneftgaz. Ser. Neftepromyslovoye Delo. Novosti neftyanoy i gazovoy tekhniki).

[0009] It is known from industrial practice that the productive layer undergoes the most significant changes upon application of thermal methods of action. Thermal processes are accompanied by the formation of viscous and stable oil emulsions (Pozdnyshv, G.N., Fattakhov, R.SH., Bril, D.M. "The Formation of Stable Oil Emulsions upon Application of Thermal Methods of Action on the Layer and Ways of Their Destruction." Tematicheskii Nauch.-Tekhn. Obsor: Ser. Neftepromyslovoye Delo. M.: VNIIOENG, 1983. Issue 16 (65), p. 44). At the Kenkiyak field (North Kazakhstan), the cyclical injection of steam into the production wells was accompanied by the formation of finely dispersed structures of steam condensate emulsions in the oil (Alimanov, D.A. "Some Questions on High-Viscosity Oil Output in the Kenkiyak Field."

Neftepromyslovoye Delo: Nauch.- Tekhn. Inform. Sb. M: VNIIOENG., 1981, No. 6, pgs. 19-20).

[0010] Upon application of different methods of action, oil emulsions of different stability are formed in the layer. Resistance to decomposition of the reinjected oil-water emulsion characterizes the change of state of the oil bed as a result of using the methods for increasing oil recovery. Therefore, within the boundaries of the bed, the mean value of the magnitude of the oil emulsion stability in hydraulically unrelated zones will be different. An increase in the oil-water emulsion stability considerably complicates lifting and transporting the emulsion, leads to the rapid deterioration of equipment; the application of deemulsifiers also entails a considerable increase in expenditures for oil output. In connection with this, the selection value of the area for using MIOR increases.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Fig. 1 is a graph of the change in additional oil output and a change in oil emulsion stability in an embodiment of the disclosed technology.

[0012] Fig. 2 is a graph of the change in additional oil output and a change in oil emulsion stability with repeated hydrochloric acid treatments in an embodiment of the disclosed technology.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE DISCLOSED TECHNOLOGY

[0013] The technical task of invention is an increase in the efficiency of monitoring the development of oil fields with lifting and injection of oil-water emulsions by the fuller recording of parameters that characterize the a deposit to be developed, namely, recording of the value of the resistance to decomposition of the reinjected oil-water emulsion.

[0014] The technical result is achieved in the method of monitoring the development of oil fields, which involves measuring layer pressure, viscosity of layer fluids, relative phase permeability of oil and water, building maps of pressure fields and maps of fields of filtering and penetration rates, superimposing the maps of pressure fields on the maps of fields of filtering and penetration rates, determining the situation of the hydraulically unrelated areas, calculating for each of the areas the desirability function value for using MIOR according to the multidimensional equation of its dependence on the number of production and injection wells, permeability, layer and zonal heterogeneity, output rate, water cut, water withdrawal rates of the wells of the area; for hydraulically unrelated areas with equal values of a desirability function, the method involves additionally measuring the stability of a water-oil emulsion in each well, calculating the mean value of the water-oil emulsion within each area and advising the use of MIOR at the areas according to the incrementation of the water-oil emulsion value.

[0015] For a specific well, it is recommended to use

MIOR until the maximum value of the magnitude of the stability of the oil-water emulsion is achieved and stabilized.

[0016] With the selection of hydraulically unrelated areas for using MIOR, situations arise where different areas have a practically equal (depending on the precision of calculations) desirability function value. In this case, the selection of the area for using MIOR can be done depending on the stability value of the oil-water emulsion, which characterizes oil bed states as a result of using the methods for increasing oil recovery in the areas compared.

[0017] It is known that an increase in the frequency of use of methods of action on a layer reduces the magnitude of additional oil output. Numerous studies have established that, with an increase in the frequency of hydrochloric acid treatments of production wells, the magnitude of additional oil output is reduced (Amiyan, V.A., Ugolev, B.C. "Physicochemical Methods for Increasing the Productivity of Wells." M.: Nedra, 1970, p. 279). It is also known that the efficiency of the cyclic steam-heat treatments of wells is reduced with an increase in the number of cycles (Artemenko, A.I., Kashchaytsev, V.A., Fatkullin, A.A. "Cyclic Steam Action as One of the Priorities of High-Viscosity Oil Production." Neftyanoye Khozyajstvo, 2005, No. 6, pgs. 113-115).

[0018] A reduction in the magnitude of additional oil output with an increase in the frequency of action on the layer is connected with an increase in the magnitude of the stability of oil emulsions. The stability of oil-water emulsions increases with an increase in the frequency of action on the layer and reaches a maximum value. Upon stabilization of the maximum value of the magnitude of stability of the oil-water emulsion, the magnitude of additional oil output is insignificant. Therefore, for a specific well within the boundaries of a selected area, use of MIOR will be effective in achieving and stabilizing the maximum value of the magnitude of stability of the oil-water emulsion.

[0019] The invention is clarified by the figures:

[0020] Fig. 1 is a graph of the change in additional oil output (1) and a graph of the change in oil emulsion stability (2) with repeated cyclic steam-heat treatments of well 427: Q_n / Q_1 is the ratio of the output level after the nth cycle, Q_n , to the output level after the 1st cycle, Q_1 ; n / n_1 is the ratio of stability level of the oil emulsion after the nth cycle, n , to the stability level of the oil emulsion after the 1st cycle, n_1 ;

[0021] Fig. 2 is a graph of the change in additional oil output (1) and a graph of the change in oil emulsion stability (2) with repeated hydrochloric acid treatments of well 279: AQ / Q is the ratio of the level of additional output to the output level after carrying out the cycle; An / n is the ratio of the level of the change in the oil emulsion stability to the level of oil emulsion after carrying out the cycle.

[0022] Realization of the proposed method of monitoring the development of an oil bed was carried out on the

example of the Gremikhinskiy field situated on the territory of the Udmurtsk Republic. The basic and formative objective of the development of the Gremikhinskiy field is layer A4 of the Bashkir level. The objective is developed through a seven point system area of arranging wells with distance of 173 m between the wells. The viscosity of oil in layer conditions was equal to 148.14 mPa. For developing this objective, different methods of action were used on the layer.

[0023] In accordance with the sequence of operations presented in RU patent No. 2172402 and which involves measuring layer pressure, viscosity of layer fluids, relative phase permeability of oil and water, building maps of pressure fields and maps of fields of filtering and penetration rates, superimposing the maps of pressure fields on the maps of fields of filtering and penetration rates, for layer A4 of the Bashkir level, hydraulically unrelated areas were determined within the boundaries of the oil beds. For purposes of this disclosure, "hydraulically unrelated areas" is defined as areas which have the greatest area with least expense (lowest speed of travel) of a liquid through a vertical border. When the speed of filtration is low enough, or the current of a liquid starts with the given area (on cards of speeds of a filtration) - so, the speed of liquid through the vertical border is zero or the speed approaches zero. Thus, each hydraulically unrelated area is separated from another unrelated area based on areas of least flow between one another. For each of the specific areas, the desirability function values for using MIOR were calculated according to the multi-dimensional equation of its dependence on the number of production and injection wells, permeability, layer and zonal heterogeneity, output rate, water cut and water withdrawal rates of the area. Areas were revealed for which the desirability function for using MIOR had practically equal values - 0.4331 and 0.4330. For purposes of this disclosure, "practically equal values" or "close values" are those which are equal to at least two decimal places. Thus, 0.4331 and 0.4330 are defined as "close" because each begins with 0.43. Upon analyzing the methods of action on the layer, it is established that, in the first area (desirability function 0.4331), the operating wells are located in the zone of the action of the wells in which pulse dosed injection of vapor was carried out. At present, injection of industrial waste water is being carried out. In the second area (desirability function 0.4330), the operating wells are located in the zone of action by hot water. The injection of hot water began to be carried out after the development of area in natural manner. Raising of layer fluids in the wells of both areas is accomplished with the use of ECP [electrical centrifugal pump] installations.

[0024] Samples of oil emulsions were taken in the wells of these areas. Measurement of the stability of emulsions were carried out by the following procedure. 100 ml of an oil-water emulsion was poured into a polypropylene glass, which was placed in a bath filled with distilled water. Two electrodes were lowered in the bath. The

strength of the current through the electrodes was 1.2 A. The potential between the electrodes was equal 12 V. The process of treating the emulsion was monitored by the change in the oxidation- reduction potential (ORP) in the polypropylene piles with the distilled water, which were lowered into the bath with the electrodes. The ORP of distilled water was +120 mV. The treatment process was interrupted upon the water in the bath achieving a maximum ORP value equal to -205 mV. The duration of the pause was determined by a decrease of the ORP of the water in the bath to a minimum value of -50 mV. This cycle was repeated until the formation of an interface between the oil and the water. The greater the emulsion treatment cycles, the greater the oil emulsion stability. Then the average value of the oil emulsion stability was calculated for both areas.

The average value of the stability of the oil-water emulsion in the first area exceeded the average value of the stability of the oil-water emulsion in the second area by 1.3 times. The use of MIOR was recommended in the second area.

[0025] Within the boundaries of the arrangement of the first area, 7 repeated cyclic steam-heat treatments were carried out on well 427. After carrying out the steam-heat cyclic treatment of the well, sampling of oil emulsions was done. The oil emulsion stability was measured in accordance with the above methodology. From the graph in Fig. 1, it follows that, after the 4th cycle, the oil emulsion stability reaches a maximum value and carrying out the following cycles is not effective, since the additional oil output has an insignificant value.

[0026] Within the boundaries of the arrangement of the second area, 4 hydrochloric acid treatments were carried out on well 279. From the graph in Fig. 2, it follows that, after the 3rd hydrochloric acid treatment, the oil emulsion stability reaches maximum value. Additional oil output with subsequent cycles has low values, which makes it possible to draw a conclusion about the impracticality of further use of MIOR.

[0027] The proposed method of monitoring oil field development makes it possible, with equal average desirability function values in hydraulically unrelated areas, to accomplish a selection of areas for using MIOR, taking into account the effect of the methods of action on the layer, which lead to irreversible changes in the structure of pore space and changes in the properties of layer fluids.

Claims

1. Method of control for oil deposit development implying positioning of hydrodynamically unrelated sites, calculation of desirability function values of applying the advanced oil recovery methods, measurement of oil emulsion resistance in each well within hydrodynamically unrelated sites, and application of advanced recovery methods in hydrodynamically un-

related area to increase water-oil emulsion resistance.

2. Method as pointed at claim 1, implying measurement of formation pressure, viscosity of formation fluids, relative phase oil and water permeability for positioning of hydrodynamically unrelated sites; construction of maps displaying pressure fields and maps displaying fields of filtration and permeability rates; superimposing of maps displaying pressure fields on maps displaying fields of filtration and permeability rates. 5 10
3. Method as pointed at claim 1, desirability function values of applying the advanced oil recovery methods are calculated for each hydrodynamically unrelated site by multidimensional equation of its dependence on a number of production and injection wells, permeability, layer-by-layer and zonal nonuniformity, depletion of reserves, water content, and liquid rate of wells in the site. 15 20
4. Method as pointed at claim 1, implying application of advanced recovery methods in the hydrodynamically unrelated sites with similar desirability function values of applying the advanced oil recovery methods to increase average value of water emulsion resistance within the site. 25
5. Method as pointed at claim 1, implying application of advanced recovery method in well up to attaining and stabilization of maximum value of water-oil emulsion resistance. 30

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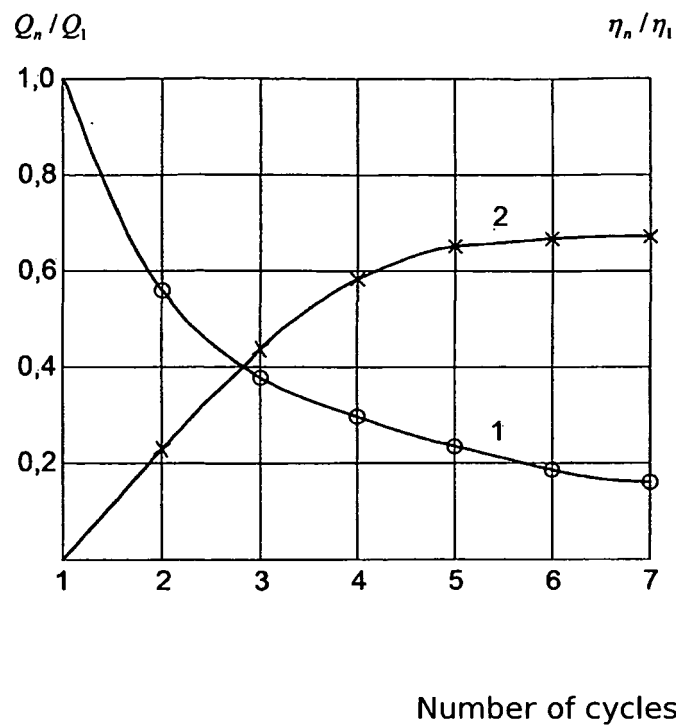


Fig. 1

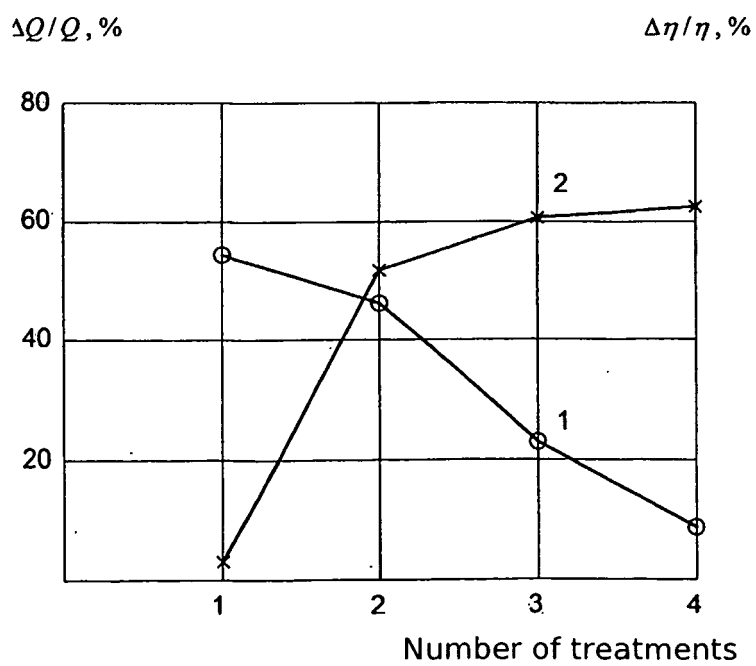


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2010/000153

A. CLASSIFICATION OF SUBJECT MATTER		E21B 43/00 (2006.01) E21B 47/00 (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) E21B 43/00, 43/16, 43/22, 47/00, 47/06, 47/12, 49/00, G01N 21/78, 21/91, C10G 33/08		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Esp@cenet, RUPTO, WIPO, USPTO		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2172402 C1 (NGDU "IRKENNEFT" OAO "TATNEFT") 20.08.2001	1-5
A	RU 2096600 C1 (AKTSIONERNOE OBSHESTVO OTKRYTOGO TIPA "NOYABRSKNEFTEGAZ") 20.11.1997	1-5
A	RU 2239177 C1 (DOCHERNEE ZAKRYTOE AKTSIONERNOE OBSHESTVO "NIZHNERVARTOVSKII NAUCHNO- ISSLEDOVATELSKII I PROEKTNY INSTITUT NEFTYANOI PROMYSHLENNOSTI") 27.10.2004	1-5
A	WO 2009/009382 A2 (GLORI OIL LIMITED) 15.01.2009	1-5
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 26 August 2010 (26.08.2010)		Date of mailing of the international search report 26 August 2010 (26.08.2010)
Name and mailing address of the ISA/ Facsimile No.		Authorized officer Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- RU 2119583 [0003]
- RU 2172402 [0007] [0023]

Non-patent literature cited in the description

- **Amiyan, V.A.** *The Possibility of Forming Emulsions in the Critical Zone.*, 1959, 39 [0008]
- **Pozdnyshev, G.N. ; Fattakhov, R.SH. ; Bril, D.M.** The Formation of Stable Oil Emulsions upon Application of Thermal Methods of Action on the Layer and Ways of Their Destruction. *Tematicheskii Nauch.-Tekhn. Obsor: Ser. Neftepromyslovoye Delo. M.: VNII OENG*, 1983, vol. 16 (65), 44 [0009]
- **Alimanov, D.A.** Some Questions on High-Viscosity Oil Output in the Kenkiyak Field. *Neftepromyslovoye Delo: Nauch.- Tekhn. Inform. Sb. M: VNII OENG.*, 1981, 19-20 [0009]
- **Amiyan, V.A. ; Ugolev, B.C.** Physicochemical Methods for Increasing the Productivity of Wells. *M.: Nedra*, 1970, 279 [0017]
- **Artemenko, A.I. ; Kashchavtsev, V.A. ; Fatkullin, A.A.** Cyclic Steam Action as One of the Priorities of High-Viscosity Oil Production. *Neftyanoye Khozyajstvo*, 2005, 113-115 [0017]