To the issue of searching an alternative heating method for bottom hole zone of the oil formation

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Abstract. When extracting oil the formation's thermodynamic conditions, formation fluids' properties, medium's porosity, technologies to be used, and a row of other factors may change in wide ranges. This causes an essential influence on the efficiency of the process of displacing oil from reservoir of the pay zone. Thus, the traditionally used advanced recovery methods, including the application of surface heating devices to heat the heat transfer mediums and its further injection into the formation, by no means always bring results to be expected. The effective solution for this problem is development of alternative technical and technological actions in the field of formation's bottom hole heating through control and activation of thermohydrodynamic processes in the well.

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Introduction

The efficiency of oil displacement process from the reservoir using heat transfer mediums depends upon thermodynamic conditions of the formation, formation fluids' properties, medium's porosity, technologies to be used and a row of other factors, and may change in wide ranges.

Experimental part

When the formation temperature rises [1] :

– viscosity of oil decreases, thermal expansion occurs, the laid-down paraffin gets dissolved etc., that eventually brings to the enhancement of formation oil recovery;

– surface properties of formation fluids and formation rocks change;

– surface active agents of the oil in the water to be injected dissolves;

– the surface tension drops down and the selective wetting of pore channels by water improves;

– the thickness of surface active oil molecule adsorption layer reduces, as the result, the permeability of formation for oil increases.

At the same time the influence of formation's temperature under its different permeability values is by far controversial (fig.1):

– under low temperatures with increase of the porous medium's permeability, the oil recovery tends to decrease, this dependence often takes place under temperatures below 40 ℃;

– under high temperatures, with increase of the permeability the oil recovery tends to increase, which, obviously, is connected with weakened relaxation behaviour of the oil in this interval of temperatures.

The figure 2 shows a dependence of oil viscosity upon the temperature, in its turn, the displacement ratio values essentially depend upon the oil viscosity, and subsequently, upon the temperature (fig.3). It is also noteworthy that with increase of formation's temperature the viscosity of oil decreases in significantly greater degree than the viscosity of produced water [1].

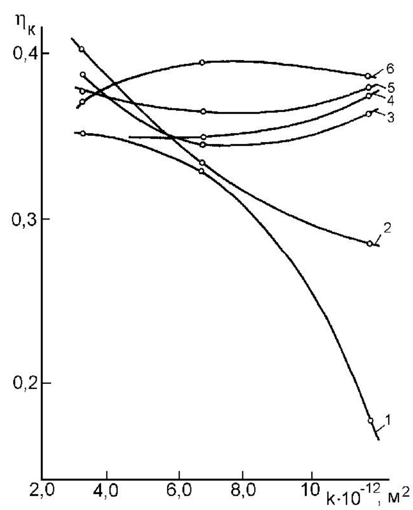

Fig. 1 — Dependence of oil recovery upon permeability of porous medium [2]
1 — 25℃; 2 — 40 ℃; 3 — 50 ℃; 4 — 60 ℃; 5 — 75 ℃; 6 — 90 ℃.

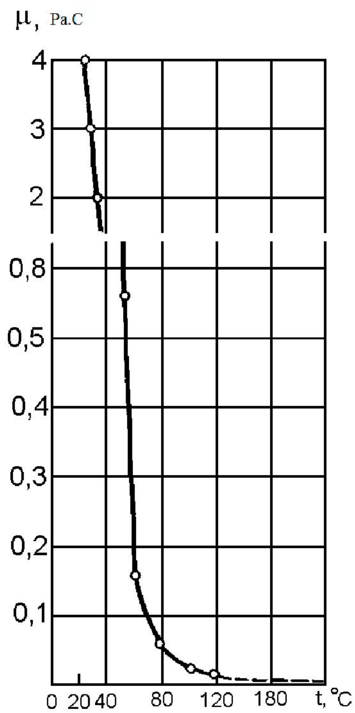

Fig. 2 — Dependence of oil viscosity upon the temperature [2]

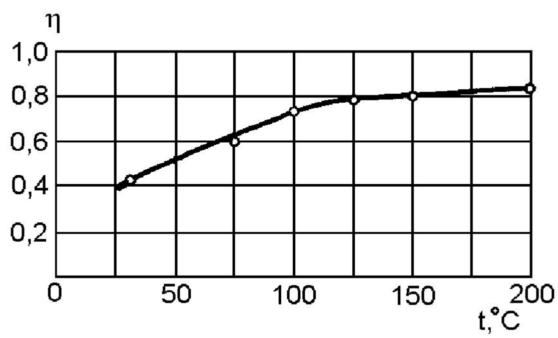

Fig. 3 — Oil displacement ratio change upon the formation temperature [2]

A few researchers believe that the most intensive growth of oil displacement is monitored under high temperatures of formation from 30-120 *ºC*. In this event its value is in direct dependence upon the temperature, and reaches 78% [1, 3, 4, 5, 6, 7, 8, 9, 10]. Further in the interval of 120-150 *ºC* the displacement ratio increases for 2%, but in the interval of 150-200 *ºC* – for 3%.

However, as the industrial experience shows, this statement is not always correct, and, apparently may be fair for certain formation conditions. So, during several years at Tuimazin Field (Bashkiria ASSR a former USSR Republic) the plan of new technique contemplated heating of formation's bottom hole zone. The heating was performed using an equipment available those years – using steam trucks. But the expected efficiency from the thermal processing to be conducted was not reached. So, on 43 wells, whose bottom hole zone was heated in the year 1974 using steam trucks, not a single well recorded increase of production.

As the obtained experience shows the injection of hot oil with temperature of 80-100 °C on the well's inlet allows cleaning the tubing, in the best case – flushes the bottom hole, but it does not make essential cause onto clean out of the bottom hole zone. Heat insulation of tubing, run them in till the filter and long injection of hot oil within 20-25 hours allow to increase the formation temperature for 5-7 °C over formation temperature, which also in insufficient and economically unfeasible.

Thus, the use of surface heaters for heating heat transfer mediums and the subsequent injection into the formation in terms of Tuimazin oil filed was less efficient and economically unjustifiable due to significant losses of heat energy of the heat transfer mediums.

Even earlier, in 1970, at the same place, a self propelled units for electric heating of wells were applied to heat the bottom hole zone. The method consisted of heating the bottom hole zone using three phased thermoelectric heaters with capacity of 10-21kW with U-shaped tubular electric heater. Heating time was determined based on duration of gathering the temperature sufficient for melting the paraffin and resinous substances. As the rule, it took 3-7 days' time. After the thermal processing the heater was pulled up, and they run in downhole pumping equipment and commissioned the well. The temperature drop during tripping operations did not allow obtaining the expected effect [2]. The analysis of results obtained at Tuimazin field, and the up to date literature sources [11, 12, 13, 14, 15] makes reasonable the investigation of issue concerning increase of capacities of steam generators significantly, and/or search for an alternative technical and technological solutions for heating bottom hole zone of the formation, for instance, through control and activation of thermohydrodynamical processes in the well.

Usually the course of thermo-hydrodynamical processes in the well during construction, completion, operation, and work over, and other operations irrelevant to thermal processing of the formation, have accidental, uncontrollable character. And therefore, as the rule, if these processes do not cause emergencies in the well, they do not draw specialists' attention. However, when selecting certain technical and technological solutions purposely to control thermal effects onto the pay zone, as represented, can be attained a significant increase of mobility of the oil in it, and enhancement of well's productivity, and improvement of efficiency of the development of liquid hydrocarbon fields in general. In other words, enhancement of formation oil recovery without application of any thermal processing that is based on usage of expensive processes of water heating, steam generation at the surface or directly in well bore, and transportation of the heat transfer medium to the formation. The available experience of semi-industrial tests at Tuimazineft Ltd (the Republic of Bashkortostan) confirms that development of this direction is reasonable. So, in addition with well-known methods of heating the oil formation's bottom hole zone at Tuimazineft Ltd, at the stage of semi-industrial test, operability of non-standard heating methods using a submersible oil pump was verified [2].

This method, if necessary, allows injection of fluid heated up in bottom hole zone using a standard equipment. A submersible centrifugal pump has a performance of about 46%. A part of capacity lead to it disperses into environment transferring into a heat with resistive and inductive losses of the electric motor, besides, a part of energy is consumed for dissipative losses when turbulization of the fluid by a large number of wheels of the centrifugal pump, which also is accompanied with heat generation. The remaining energy transforms into kinetic energy of the fluid jet on the pump's outlet. However it also can be transformed into thermal energy. For this purpose it is sufficient to let the flow pass through a set of openings that have set sizes and positions. When passing through the openings the head loss is accompanied by energy consumption, which can be transformed into the thermal energy only.

The looped flow of the fluid, repeatedly passing through rotating wheels of the pump and outlet openings, gets heated up to the set temperature. The temperature of the fluid heated is determined by capacity of the pump and velocity of feeding cold fluid from the surface. The velocity of feeding the fluid may serve as a temperature controller to protect the electric motor from overheating.

Thus the submersible pump can be reviewed as a system's element having a zero performance. All the electric energy fed to the pump is transformed into electromagnetic, mechanical and hydraulic energy, and then all types of energies are transformed into the heat and dispersed in environment, that is what is required for increasing the temperature of the formation's bottom hole zone.

The method was developed by Tuimazaneft Ltd and RENES CJSC, passed pre-check in the submersible equipment repair shop, and tested at the injection well 2148, where a submersible pump with capacity of 45 kW was used as a heater. Daily energy to be generated was about 4186.8 Mj [2].

Conclusions

Such non-standard application of the equipment for other purposes has its own advantages, for instance, standard submersible pumps are on serial production and have quality certificates, safety rules are developed and approved for them, supply and service by hire and repair shops with certified specialists engaged are arranged and adjusted for them.

Thus, application of the alternative method for heating the bottom hole zones due to dissipation of mechanical energy is economically justified, does not require application of specially developed technical and technological solutions, and development and approval of new regulations for work conduct.

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References

1. Baibakov, N.K. and A.R. Garushev, 1988. Thermal methods for development of oil fields. Nedra, pp: 343.
2. Mingulov, Sh.G. and A.V. Shipulin, 2005. Application of the dissipation method for heating the bottom hole zone of oil formation. Petroleum facility, 11: 62-63.
3. Jourdan J.K., B.M. Mac–Cardell, C.B. Hocott, 1957. Effect of Oil-Recovery Rate in Water Flooding. Oil Gas J, 55(19): 98–130.
4. Chillingarian, G.V., P.Vorabutr, 1981. Drilling and drilling fluids. Elsevier scientific publishing company. Amsterdam-Oxford-New-York
5. Millhone, R.S., 1983. Completion fluids for minimizing productivity damage. Journal of Petroleum Technology, 35(1): 39.
6. Droddy, M.J., 1990. Drilling fluids and formation damage. Houston Geological Society Bulletin, 33(4): 27-30.
7. Miura, K., K.Cels, Morooka, J.R. Mendes, I.R. Guilherme, 2006. Characterization of operational safety in offshore oil wells. Journal of Petroleum Science and Engineering, 51(1): 111-126
8. Esmaeilzadeh, I.F., 2013. Manipulation of key parameters in RESS process for attapulgite particles utilizing in drilling mud and investigation on its rheological characteristics. Journal of Petroleum Science and Engineering, 112: 359-369

9. Crespo1, F., R. Ahmed, 2013. A simplified surge and swab pressure model for yield power law fluids. Journal of Petroleum Science and Engineering, 101: 12–20
10. Li H., Y. Chen, D. Rojas, M. Kumar, 2014. Development and application of near-well multiphase upscaling for forecasting of heavy oil primary production. Journal of Petroleum Science and Engineering, 113: 81–96
11. Ratov, B.T., 2010. Development of new technical means and technologies to increase barreler., PhD thesis, KazNTU, Almaty.
12. Ratov, B.T., B.V. Fedorov, T.A. Zhanabaev, M. Otebaev, 2012. Hydraulic device for vibration razglinizatsii flyuidosoderzhaschih wells. The preliminary patent of the. RK no. 73568
13. Nifontov, Y.A. and K.S. Nadirov, 2013. Localization of contaminated soils during construction, operation and preservation of pits. Oil and gas, 3(75): 127-134.
14. Ratov, B.T., B.V. Fedorov, 2013. Hydroimpulsive Development of Fluid-Containing Recovery. Life Sci J, 10(11s): 302-305.
15. Ratov, B.T., B.V. Fedorov and T.A. Zhanabayev, 2013. The Causes of Fluctuation of Hydrodynamic: Pressure in Wells and Recommendations for its Reduction. Life Sci J, 10 (12s): 589-591.

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