Potential for the wellbore zone development using the dynamic impact

I N Babichev, I G Fattakhov, L S Kuleshova, L F Zaripov and M A Morozov

1PJSC TATNEFT named after V.D. Shashin, 75, Lenin St., Almetyevsk, Republic of Tatarstan, 423450, Russia
2Ufa State Petroleum Technological University, Branch of the University in the City of Oktyabrsky, 54a, Devonskaya St., Oktyabrsky, Republic of Bashkortostan, 452607, Russia

Abstract. To increase the effect of acid formation treatment (increase in production/injectivity, an overhaul period, reduction of costs of geological and technical works), the authors suggest using a dynamic impact on the wellbore zone (WZ) by using acid creating the rinsing effect with the help of swab equipment and an acid aggregate when waiting for the acid reaction. The article aims to analyze the potential for the application of dynamic impacts on the WZ. The differences of the technology from other impact methods were studied. The main parameters of the wells before and after the dynamic WZ treatment were determined using three indicators: a fluid flow rate, an oil flow rate and a water cut rate. The economic effect of the technology was compared with the effect of the clay-acid treatment (CAT) technology and complex vibrational depression chemical effects (CVDCE). The technology can be used at other NGDUs in order to improve the profitability of field development.

1. Introduction

Currently, due to the gradual depletion of hydrocarbon reserves, an important factor in stabilizing the amount of oil produced is the widespread use of tertiary oil recovery enhancement methods (OIEM). The most widely used OIEMs are wellbore zone treatment methods (WZT):

1. Well and wellbore zone cleaning;
2. Acid treatment;
3. Acid fracturing (AF).

Most WZ treatments are carried out using hydrochloric and hydrofluoric (hydrofluoric) acids. In order to increase the efficiency of interaction of the acid with the rock material, various surfactants are added. They preserve properties and leach reaction products.

In practice, hydrochloric acid compounds are used for carbonate deposits; clay acids (HCL + HF) are used for terrigenous deposits. [1–2] There are 10 WZ treatment methods: chemical, thermal, wave, shock-wave, implosion, ultrasonic, acoustic, hydraulic fracturing, water jet.

The main negative aspects of WZ methods are as follows:

- formation and deposition of reaction products in productive formations;
- low coverage of the total pore space of the acid composition;
- incomplete reaction of the injected reagents;
- incomplete removal of reaction products from the WZ which causes the secondary clogging of the productive formation;
- high cost of complex WZ treatment methods;
- large values of depression and repression of the productive object (GR, KKhDV, “Lens”, etc.) [3-4].

After the acid composition influences the formation, the well is swabbed, and reaction products are carried out from the WZ avoiding clogging with reaction products. The main disadvantage of this method is the fact when waiting for acid reaction (AR) for 2-6 hours, acid compositions do not fully react which reduces the efficiency of the WZ treatment [5].

The methods of deep-penetrating chemical impacts on the formation are promising for stimulating wells: the WZT using thickened acid-based compositions (two-component acids), deep and directed hydrochloric acid treatment (HAT).

2. Oil flow stimulation efficiency
The recommended sequence of HAT operations is as follows [11]:
- simple HAT;
- directed or cyclically directed treatment;
- deep HAT;
- acid fracturing (AF);
- creation of cavern drives, dynamic HAT, etc. [6].
The WZT methods have different efficiency of oil flow stimulation (Table 1).

| WZT method | Asymptotic value of additional oil production per 1 well, tons | Duration of the effect, months |
|------------|-------------------------------------------------------------|--------------------------------|
| 1. creation of macro- and microcracks and cavities | 2800 | 42 |
| - AF | 2500 | 12 |
| - seismic impact | 2300 | 36 |
| - systemic acid impact | 2300 | 60 |
| - erosion of caverns | 2300 | 36 |
| 2. increased inflow coverage of low permeable formation intervals | 660 | 30 |
| - massed hydrochloric acid treatment | 700 | 18 |
| - directed hydrochloric acid treatment | 680 | 12 |
| - hydrochloric acid treatment | 470 | 24 |
| - hydrocarbon acid treatment | 700 | 18 |
| 3. selective impact on water-saturated intervals of the formation | 580 | 24 |
| - the use of hypane with liquid glass | 750 | 24 |
| - biopolymer exposure | 390 | 24 |
| - hydrophobization of rocks | 270 | 24 |
| - use of crumb rubber | 490 | 24 |
| 4. cleaning of the wellbore zone, the well wall and the perforation holes: | 360 | 24 |
| - clay bottoming | 230 | 6 |
| - the use of hydrocarbon composition | 190 | 24 |
| - thermobaromatation | 170 | 18 |
| - wave impact | 160 | 12 |
| - decolmatation of the well surface. | 100 | 6 |
| - thermal implosion + perforation | 360 | 24 |
| - injection of surfactant solutions | 230 | 6 |
| | 190 | 24 |
| | 170 | 18 |
| | 160 | 12 |
| | 100 | 6 |
3. Dynamic impact on the wellbore zone

To increase the area and volume of interaction of acid with the pore space, a longer period is required. However, an increase in the response time can cause negative consequences — secondary clogging of the object with reaction products. The task is to increase the effect of acid treatment of the reservoir (cleaning of channels, pores), and removal of reaction products from the productive reservoir by applying dynamic impacts on the object [7].

After the acid is injected, when waiting for the acid reaction (technological exposure), dynamic actions are carried out by moving the acid through the reservoir and creating a “rinsing” effect using equipment for swabbing wells and an acid unit.

Due to the dynamic movement of the acid composition in the treated layer and the rinsing effect, acid is interacted with the rock. The combination of the response time and "rinsing allows the acid composition to interact with the reservoir components which increases wellbore permeability, cleans canals and pores which expand, and additional cavities are formed [8-9].

The acid composition is prepared and injected into the well through tubing pipes. After the acid composition is injected into the wellbore zone, the annular space is cut off by fitting the process packer over the formations, and the acid is pressed into the formation. After the acid is pumped, the swab equipment is installed at the wellhead and the swab cuffs are lowered to the maximum allowable depth according to the technical characteristics of the swab equipment.

In the proposed embodiment, an acid composition is first prepared and pumped through tubing pipes into the well, after adjusting the acid composition to the bottomhole zone, the annular space is cut off by fitting the process packer over the formations, and the acid is pressed into the formation. After the acid is pumped (pumped), the swab equipment is installed at the wellhead and the swab cuffs are lowered to the maximum allowable depth, according to the technical characteristics of the swab equipment.

The swabbing method removes the liquid (oil) from the tubing to the oil tanker, swabs the equipment into the lubricator (in order to ensure smooth passage of the fluid into the tubing during the injection). The tee valve located between the lubricator and the preventer is switched. The pumped-out volume of the fluid from the oil tanker is pumped back into the tubing in compliance with the technological WZT parameters for the given well (volume, pressure, etc.) [10]. The above process is performed during the reaction time of the acid composition depending on its concentration and chemical composition.

The technology was implemented by the "Jalilneft" company for wells No. 7563 TsDNG-5 and No. 262777 TsDNG-6. As a result of the experimental use of dynamic WZT at well No. 7563, the well rate increased from 2 to 9 m$^3$ per day, oil production increased from 0.5 to 2 tons per day. At well No. 26277, the well rate increased from 1 to 2.8 m$^3$ per day, oil production increased from 0.7 to 2.5 tons per day.

The method can increase WZ permeability, clean the well and increase the flow rate, acceleration, turnaround time of the well, production, reduce the cost of geological and technical works aimed at stabilizing production.

The technology is simple and cheap. It does not require expensive chemical reagents that increase the oil recovery and formation permeability. Figure 1 shows a schematic diagram of the WZT by dynamic impacts.

**Figure 1.** The schematic diagram of the WZT by dynamic impacts: 1 - swab-unit; 2 - lubricator; 3 - swab equipment; 4 - tank truck; 5 - pump unit; 6 - intake and discharge lines.
4. Results
The main parameters for evaluating the well operation before and after the dynamic WZT are three indicators (Table 2).

Table 2. The main parameters of the wells before and after the dynamic WZT

| Object | Values of well parameters | Names of indices |
|--------|---------------------------|-----------------|
|        | Fluid production rate, m³/day | Oil production rate, t/day | Water cut, % |
| Well 7563 TsDNG–5 Kynov horizon | 2.0 | 0.5 | 70 |
| Before implementation | 9.0 | 2.0 | 74 |
| After implementation | 1.0 | 0.7 | 20 |
| Well 26277 TsDNG –6 Bobrikov + Radaev horizon | 2.8 | 2.5 | 0 |
| Before implementation | 2.8 | 2.5 | 0 |
| After implementation | 2.8 | 2.5 | 0 |

Thus, the economic effect of the AWZT is more significant than those of the CAT and the CBDCE (Table 3).

Table 3. Economic effect of the technology implementation

| Types WZT | Cost of WZT accounting for PW, thousand rubles. | Average daily increase in oil, tons | NPV for the effect duration | Duration of effect, months | Payback period, months | Cost profitability Index |
|-----------|-----------------------------------------------|-----------------------------------|-----------------------------|---------------------------|------------------------|-------------------------|
| CAT       | 560                                           | 1.0                               | 959                         | 12                        | 7                      | 1.44                    |
| CBDCE     | 1250                                          | 1.3                               | 1036                        | 18                        | 11                     | 1.3                     |
| AWZT      | 624                                           | 1.5                               | 1512                        | 18                        | 6                      | 1.5                     |

5. Conclusion
Various WZT methods were examined, their disadvantages were identified and the efficiency of oil flow stimulation was evaluated. The “Jalilneft” company implemented the technology of dynamic WZT for two wells. This technology increased the well flow and oil production rates.

The efficiency of the technology was assessed using three indicators. The economic effect of the CAT, CBDCE and AWZT methods was calculated. The significant positive economic effect can be obtained by implementing the AWZT.

References
[1] Andreev A V, Mukhametshin V Sh and Kotenev Yu A 2016 Deposit productivity forecast in carbonate reservoirs with hard to recover Reserves SOCAR Proc. 3 40–5
[2] Kozikhin R A, Daminov A M, Fattakhov I G, Kuleshova L S and Gabbasov A Kh 2018 Identifying the efficiency factors on the basis of evaluation of acidizing of carbonate reservoirs IOP Conf. ser. Earth Env. vol 194(6) 062013
[3] Xu B 2018 Influencing factors governing paraffin wax deposition of heavy oil and research on wellbore paraffin remover Pet. Sci. Technol. 36 (20) 1635–41
[4] Baykov N M 2003 New technologies of acid treatment of the productive strata Oil Industry 3 114–16
[5] Izmailova G R, Kovaleva L A and Nasyrov N M 2016 Acoustic wave energy absorption and distributed heat sources upon an acoustic impact on media High Temp+ 54(1) 56–61
[6] Habibullin M Ya and Sidorkin D I 2016 Determination of tubing string vibration parameters under
pulsed injection of fluids into the well SOCAR Proc. 3 27–32

[7] Korn G A and Korn T M 1984 Mathematical Handbook for Scientists and Engineers: Definitions, Theorems, and Formulas for Reference and Review (Moscow: Nauka)

[8] Sun Wenyue and Hui Mun-Hong 2017 Forecasting and uncertainty quantification for naturally fractured reservoirs using a new data-space inversion procedure 15th Conf. on the Mathematics of Oil Recovery (ECMOR) (Amsterdam, Netherlands) European Assoc Geoscientists & Engineers Computational geosciences 21(5–6) pp 1443–58

[9] Mukhametshin V V, Andreev V E, Dubinsky G S, Sultanov Sh Kh and Akhmetov R T 2016 The usage of principles of system geological-technological forecasting in the justification of the recovery methods SOCAR Proc. 3 46–51

[10] Khakimov A A, Sattarov R I, Kachurin A V and Akimkin A V 2012 Acid treatment technological advancement Oil 3 54–5