Non-conventional methods for oil production in the conditions of the Abdrakhmanovskaya site of the Romashkino oil field

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Abstract. The paper analyzes the existing non-conventional methods for oil production in the conditions of the Abdrakhmanovskaya site of the Romashkino oil field. It describes the methods for well stimulation by swabbing in tubing strings (TS) and production casing (PC). A number of non-conventional production methods are compared to identify the most innovative. Some technical approaches are outlined once used in specific conditions to effectively deploy the operating well stock. The prospects for their use are evaluated.

1. Introduction
Swabbing can be used as an alternative way to put low-production and poorly-equipped wells into production from an idle well stock without spending much money on infrastructure. The method will help not only involve low-production wells from an inactive well stock (unprofitable wells), but also provide additional oil production from new, temporarily unexplored wells [1].

2. Materials and methods
In 2015, a series of theoretical studies, experimental design and field work carried out to swab oil wells resulted in a set of technical requirements outlined for the above method particularly applied in the conditions of the Abdrakhmanovskaya site of the Romashkino oil field.

Swabbing is used in wells (including those to contain highly viscous products) that lack gas and oil inflow (‘brown’ fields, abnormal low pressures at oil fields with a negligible gas factor, etc.). No other way to reduce fluids is yet that effective, or impossible at all, as the one proposed herein.

Prior to applying this set of techniques, all equipment is removed from the well followed by wiper trips. As soon as products accumulate in the well, the rig operator backs the machine, consisting of a winch, cable, swap cups, foldable mast and a pulley at the top, up to the edge of the well. Once the equipment is adjusted, the operator, by way of the winch, lowers the cable with a swab cup into the well down to a predetermined depth below the fluid level. Then the swab is pulled up the PC along with a portion of well fluids. The fluids pulled out of the well are drawn to the flow line and then to the collection system or collection tank. Subject to the mission assigned, swabbing cycles, are repeated until the level in the well decreases to a predetermined depth, or until a predetermined volume of fluid is lifted from the well. The schematic for well stimulation by swabbing in the production casing is shown in Figure 1.
Figure 1. Schematic for well stimulation by swabbing in production casing: 1 – well head; 2 – production casing; 3 – foldable mast; 4 – plummets; 5 – swab cup

PC swabbing benefits:
- high productivity (up to 3 m³ of liquid per a lift);
- minimum labor intensity for fluid removal;
- opportunity to pull oil from the reservoir above the OWI border;
- improved selection of highly viscous products;
- high-performance fluid withdrawal in small diameter wells;
- low metal consumption (absence of tubing string, sucker rods, pumping equipment).

The drawbacks of PC swabbing include the inability to work in wells with oil and gas inflow, as well as in wells with violated PC integrity or local internal bottlenecks.

Swabbing in tubing strings is applied to wells equipped with tubing strings.

Figure 2. Schematic for well stimulation by swabbing in tubing strings: 1 – well head; 2 – production casing; 3 – tubing string; 4 – foldable mast; 5 – plummets; 6 – swab cup

A wiped tubing string is installed in the well. As soon as the oil accumulates in the well, the rig operator now and then backs the machine accommodating the equipment needed to provide swabbing in a tubing string. Herein, swabbing implies pulling some portions of fluid out of the well with a sequential stepwise decrease in fluids and an appropriately changing depth the swab is lowered with each subsequent run. The swab is lowered into the tubing string down to a predetermined depth below the fluid level (measured in hundreds of meters and limited by the strength characteristics of the swab cups or mast and the characteristics of a winch). After that, it rises up the tubing string along with a portion of the well fluid. The liquid lifted to the wellhead is drawn to the flow line and then to the collection system or collection tank. Subject to the mission assigned, swabbing cycles are repeated until the level in the well decreases to a predetermined depth, or until a predetermined amount of fluid.
is pulled out of the well. The schematic for well stimulation by swabbing in tubing strings is shown in the Figure 2.

The benefits can include relatively high productivity, well-articulated applications in the wells with oil and gas income, low labor intensity for fluid lifting.

The drawbacks can include the following:
- the lower end of the tubing string is below the oil-water interface (OWI) boundary, hence, oil extraction procedure first involves water arrival in tubing strings, which, along with OWI lowering to the lower end of the tubing string, is subsequently followed by the oil accumulated in the well getting to the tubing string;
- it is impossible to lower the level in the well more than about 100 m to the lower end of the tubing string, which leads to under-extraction of oil from the well in a volume of up to 1.5 m³;
- reduced selection of highly viscous products (with increasing viscosity it becomes difficult, and sometimes impossible to lower the swab down into the tubing string);
- high metal consumption of swab equipment, since the well permanently houses the tubing string.

3. Results
Non-conventional methods are exploited for oil extraction at the Abdrakhmanovskaya site of the Romashkino field. Oil is produced in unequipped, low-production and exploratory wells by way of one-time pumping through swabbing technique in the tubing string and production casing [3, 4]. Actually, swabbing technique applied for pushing products up the production casing often entails significant leaks.

PC swabbing allowed for the average oil production to be 2.5 t/1 per a single run, while the average annual production was 24.4 tons. Total costs amounted to 895 thousand rubles. Net profit made up 51 thousand rubles.

TS swabbing allowed for the average oil production to be 5.3 t/1 per a single run, while the average annual production was 70.8 tons. Total costs amounted to 1704 thousand rubles. Net profit made up 612 thousand rubles.

By way of comparison, as of 2015, TS swabbing was deemed as the most effective non-conventional method of oil production at Abdrakhmanovskaya site, since PC swabbing resulted in total costs exceeding net profit.

TS swabbing provides:
- fluid withdrawal for a single run was 93.4 m³;
- oil extraction for a single run was 5.3 tons;
- average annual oil production was 70.8 tons;
- total costs amounted to 1704 thousand rubles;
- net profit made up 612 thousand rubles.

The above oil production method reduces operating costs and extends profitable operation terms of low-production, undeveloped and exploratory wells.

With a view to analyzing a non-conventional method of oil production, 5 wells were adequately assessed for PC swabbing throughout 2015 (Table 1).

PC swabbing was deployed in wells No. 10387; 14,129; 6591a; 9293; 3625. The average distance to well sites was 16.6 km.

The maximum fluid withdrawal for a single run from well No. 6591a was 64 m³, the minimum – 7 m³ from well No. 3625.

The maximum oil extraction for a single run from well No. 10387, No. 9293 amounted to 3 tons. In wells No. 14129, No. 6591a, oil extraction for a single run was 2 tons, whereas in well No. 3625, oil extraction for a single run was 0 tons.

The maximum number of repeats to produce oil in one year in well No. 6591a was 23 times, the minimum – in well No. 3625 was 1 time.

The annual oil production in wells No. 10387, 14129, 6591a, 9293 and 3625 averaged 24.4 t.
Total costs for wells No. 6591a amounted to 365 thousand rubles, No. 9293 – 258 thousand rubles, No. 10387 – 154 thousand rubles, No. 14129 – 102 thousand rubles, No. 3625 – 16 thousand rubles.

The maximum net profit for well No. 9293 made up 34 thousand rubles, for well No. 6591a – 21 thousand rubles, and for wells No. 10387, No. 14129, and No. 3625, the total costs exceeded net profit.

Table 1. Technical and economic indices of oil production via PC swabbing

| Well No. | Distance from well site to oil custody transfer, km | Fluid withdrawal per a single run, m³ | Oil extraction per a single run, t | Number of repeats per year | Annual oil production, t | Total costs, RUB, in thousands | Net profit, RUB, in thousands |
|----------|--------------------------------------------------|-------------------------------------|----------------------------------|---------------------------|--------------------------|-----------------------------|-----------------------------|
| 10387    | 10                                               | 27                                  | 3                                | 4                         | 11                       | 154                         | -77                         |
| 14129    | 18                                               | 15                                  | 2                                | 7                         | 12                       | 102                         | -16                         |
| 6591a    | 10                                               | 64                                  | 2                                | 23                        | 56                       | 365                         | 21                          |
| 9293     | 15                                               | 52                                  | 3                                | 14                        | 43                       | 258                         | 34                          |
| 3625     | 35                                               | 7                                   | 0                                | 1                         | 0                        | 16                          | -13                         |
| Total    | 83                                               | 165                                 | 10                               | 49                        | 122                      | 895                         | -51                         |

In 2015, TS swabbing (Table 2) was deployed in wells No. 15439, 20081, 36309, 26508, 147. The average distance to well sites was 9.6 km.

The maximum fluid withdrawal for a single run from well No. 20081 was 184 m³, the minimum – 39 m³ from well No. 26508.

The maximum oil extraction for a single run from well No. 15439, No. 36309 amounted to 6 tons. In wells No. 20081, No. 26508, No. 147 oil extraction for a single run was 5 tons.

The maximum number of repeats to produce oil in one year in well No. 20081 was 26 times, the minimum – in well No. 26508 was 6 times.

The annual oil production in wells No. 15439, 20081, 36309, 26508 and 147 averaged 70.8 t.

Total costs for wells No. 20081 amounted to 616 thousand rubles, No. 15439 – 351 thousand rubles, No. 36309 – 375 thousand rubles, No. 147 – 249 thousand rubles and No. 26508 – 163 thousand rubles.

The maximum net profit for well No. 20081 made up 250 thousand rubles, while minimum for well No. 26508 made up 50 thousand rubles.

Table 2. Technical and economic indices of oil production via TS swabbing

| Well No. | Distance from well site to oil custody transfer, km | Fluid withdrawal per a single run, m³ | Oil extraction per a single run, t | Number of repeats per year | Annual oil production, t | Total costs, RUB, in thousands | Net profit, RUB, in thousands |
|----------|--------------------------------------------------|-------------------------------------|----------------------------------|---------------------------|--------------------------|-----------------------------|-----------------------------|
| 15439    | 7                                                | 108                                 | 6                                | 13                        | 73                       | 351                         | 125                         |
| 20081    | 6                                                | 184                                 | 5                                | 26                        | 133                      | 616                         | 250                         |
| 36309    | 10                                               | 78                                  | 6                                | 12                        | 67                       | 375                         | 113                         |
| 26508    | 15                                               | 39                                  | 5                                | 6                         | 32                       | 163                         | 50                          |
| 147      | 10                                               | 58                                  | 5                                | 10                        | 49                       | 249                         | 74                          |
| Total    | 48                                               | 467                                 | 27                               | 67                        | 354                      | 1704                        | 612                         |
4. Conclusion
Technical and economic indices derived from non-conventional oil production at the Abdrakhmanovskaya site provided the following conclusions:
- PC swabbing is not cost effective as total costs exceed net profit;
- TS Swabbing is by far the most effective non-conventional method of oil production in the conditions of the Abdrakhmanovskaya site of the Romashkino oil field, which, with an unequipped, low-yield, inactive well stock, makes this method promising today.

However, swabbing technique applied for pushing products up the production casing often entails significant leaks.

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