International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 19 (2017) pp. 9018-9022

Development of Technology to Reduce Sand Ingress in Oil Producing Wells

D.S. Leontiev[1], I.I. Kleshchenko[2] and L.V. Dolzhikova[3]

[1,2,3] Industrial University of Tyumen, Volodarskogo, 38, Tyumen, 625000, Russia.
[1,2,3] Orcid IDs: 0000-0001-8124-5955, 0000-0003-1547-8210, 0000-0002-7159-2459

Abstract

It is known that the sand production at the bottom of oil wells is due to various causes, associated mainly with the mechanical properties of the reservoirs. With the decrease in reservoir pressure during the development of deposits, water-oil contact rises and associated to it occurrence of water and sand and also sand deposition on the bottom of the well appear. Over time, the sand arch closes the interval of perforation of the well and prevents the flow of oil to the surface until the production is completely cut off. The most common problems with sand production are observed in the exploitation of formations composed of sandstones with little natural cementation. In this case, already at the initial period of the well operation, intensive uncontrolled sand production is observed, associated with the washing out of sand and the formation of a cavity at the roof of the formation, or in an undamaged (more durable) productive interlayer at an inhomogeneous formation and leading to subsequent destruction of the near-well zone of the formation. Currently, to prevent such complications, the measures are being taken to limit the flow of sand into the well - using of gravel filters, strengthening the bottomhole zone, etc. The paper presents a technology for reducing sand production in oil producing wells, the distinctive feature of which is the already known fact that a sand filter is created directly inside the well. The main physical characteristics of proppants affecting the quality of the downhole filter created are: the shape of the granules (ie, sphericity and roundness) and density. The technical solution offered by the authors allows effectively eliminate sand production in oil producing wells without contamination of the wellbore zone of the formation by creating a hydrophobic sand filter directly inside the oil producing well and using the technology with a coiled tubing installation. To implement the proposed technology, the authors carried out experimental laboratory studies of various fractions of proppants on bulk density, sphericity and roundness.

Keywords: sand plug, sand filter, proppant, bulk density, sphericity and roundness of proppants.

The longest and most important stage in the "life" of an oil or gas producing well is the period of its operation. During this period, a well operates in complex geological and thermobaric conditions, and therefore the extension of its operability requires periodic ongoing repairs and workover.

One of the complications arising during the operation of a well with a semi-consolidated reservoir is the formation of sand plugs at the bottom. The causes of such complications are mainly related to the geological, physical and mechanical properties of the exploited reservoir. Often, when reservoir pressure decreases, an active rise in the oil water contact occurs over the reservoir and the associated intense water and sand production [1].

Over time, the sand plug closes the perforated interval of the well and prevents hydrocarbons from moving to the surface until the production is completely cut off.

Problems of sand production are characteristic of the exploitation of strata composed of loosely cemented sandstones. Field studies have shown that sand removal increases with increasing product recovery, with an increase in the oil water or gas water factor, depletion of the exploited reservoir [2, 3].

Currently, gravel and wire filters, securing of the near-well zone of the formation, etc., are used to combat such complications.

For stable operation of an oil or gas producing well, the sand plug must be periodically removed. To do this, a direct or reverse flushing of the wellbore is used, with the lower end of the tubing being equipped with special tips, or a jet pump is used, and in the most difficult cases, with heavily compacted sand plugs, the hydrodrill is applied [4].

The authors of the article developed a technology to reduce sand ingress of oil producing wells, the distinctive feature of which from the already known is that the sand filter is built directly inside the well [5].

The technology is implemented as follows.

1. A production well (1), in which the perforation interval (2) is blocked by a sand plug (3), is killed by a liquid of a certain density, which prevents oil production (Figure 1).

2. Downhole equipment is extracted from the well (not shown).

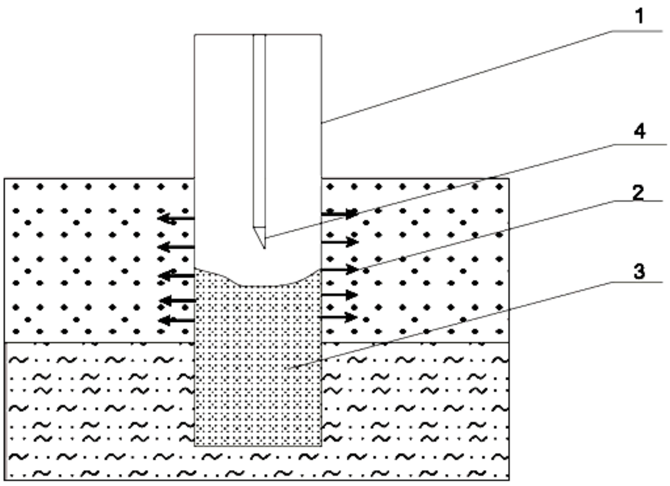
3. An assembly with a shoe on the tubing (4) is lowered down to the head of the sand plug (3) into the borehole and its flushing is carried out.

4. The tubing with the shoe is extracted from the well, a packer plug (5) is lowered 1-2 m below the oil-saturated interval of the formation.

5. A perforated tubing (6) (73 mm or 89 mm diameter) with a packer installed in the upper part (7) descends onto the packer plug (5) and the top packer (7) is unpacked (Figure 2).

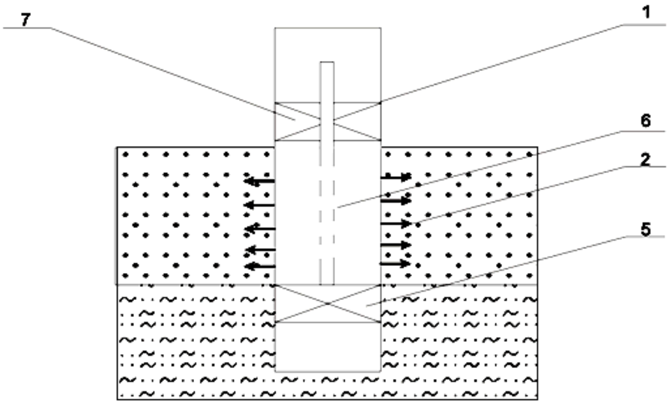
6. A flexible tubing (8) descends into the inside of the perforated tubing (6).

7. Proppant with polymer composition (9) is squeezed into the perforated tubing (6) to fill the interval between the casing string and the perforated tubing, holding time for proppant crosslinking, well completion, and commissioning (Figure 3).



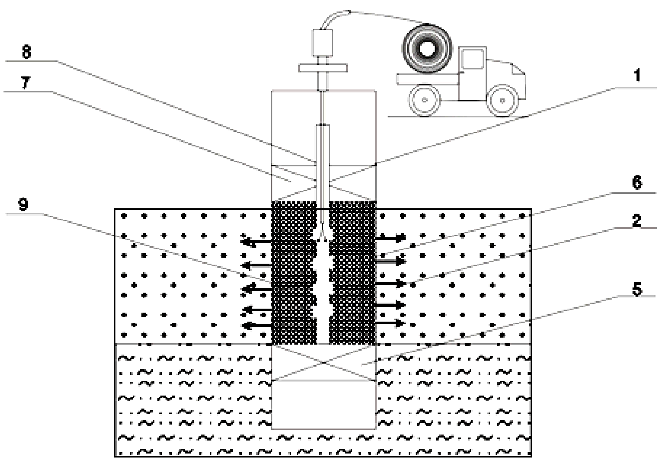
1– production well; 2 – perforation interval;
3 – sand plug; 4– assembly with a shoe on the tubing

Figure 1: Production well with a sand plug at the bottom



1 – production well; 2 – perforation interval; 3 – sand plug;
4 – assembly with a shoe on the tubing; 5 – packer plug;
6 – perforated tubing; 7 – top packer

Figure 2: Assembly with a perforated tubing and a packer



1– production well; 2– perforation interval; 3– sand plug; 4– assembly with a shoe on the tubing; 5– packer plug; 6 – perforated tubing; 7 – top packer; 8 – flexible tubing; 9– proppant with polymer composition

Figure 3: Downhole sand filter

When implementing the technology, the size of the injected proppant must be such that the particles that make up the rock matrix are not carried out through the filter, i.e. the filter should withhold 70 to 80% (by weight) of large particles and pass 20-30% of small particles through itself. Under this condition, the stability of the formation matrix will be maintained.

In general, removal of small particles requires simultaneous observance of the following conditions [3]:

- dimensions of pores formed by proppant grains should be larger than those of the fine particles carried by the filtration flow. The relationship between the size of large and small particles of rock, at which small particles can be carried out, is called a structural criterion;
- the filtration flow velocity must be sufficient to not only shift small particles from the place, but to impart to them on a very small portion of the path a velocity equal to the average flow velocity. The flow velocity satisfying these conditions is called the critical removal velocity (mechanical criterion for removal).

The main physical characteristics of proppants affecting the quality of the created downhole filter are: the shape of the granules (i.e., sphericity and roundness) and density.

Density refers to the physical size of a material, which is defined as the ratio of mass to volume and is measured in g/cm^3 or kg/m^3. For proppants, this characteristic varies depending on the degree of compaction: i.e., the same amount of proppant may occupy a different volume.

The bulk density of the proppant is its density in the unconsolidated state. It takes into account not only the volume of the particles themselves, but also the space between them, so the bulk density is less than the usual density. When the proppant is compacted, its density becomes larger and ceases to be bulk.

Typically, the bulk density is determined by weighing the proppants and calculated by the formula:

$$\rho_{нсп}=\frac{m_{сп}-m_{с}}{V_{п}},\ g/cm^3 \quad (1)$$

where $m_{с.п}$ – mass of a vessel with proppants, g;

m_c – mass of a vessel, g;

V_n – volume of proppants in a vessel equal to 100 cm^3.

The test is carried out on two parallel samples. The value of the bulk density (g/cm^3) is calculated to within the second significant number after the decimal point. The result of the test is taken as the arithmetic mean of the parallel tests.

The permissible discrepancy between the results should not exceed 0.02 g/cm^3. The test result is rounded up to the first significant number after the decimal point.

To implement the proposed technology, we conducted experimental laboratory studies of various fractions of proppants for bulk density, sphericity and roundness.

For the bulk density of the fraction 12/18, the following proppant grades were investigated: ForeLWP, ForeProp RCP, ForeRCP, BorProp light, CARBO LITE, ForeProp, BorProp LT RCP, ForeSand, BorProp RCP (R1), A51, CarboBond, BorProp RCP (R2), TK3, NordProp (2100) RCP, BORPROP, BorProp SSP, YIXING, BorProp RCP, InterProp, CarboProp and CARBO HSP.

The histogram of the bulk density distribution of proppants of fraction 12/18 in ascending order is shown in Figure 4.

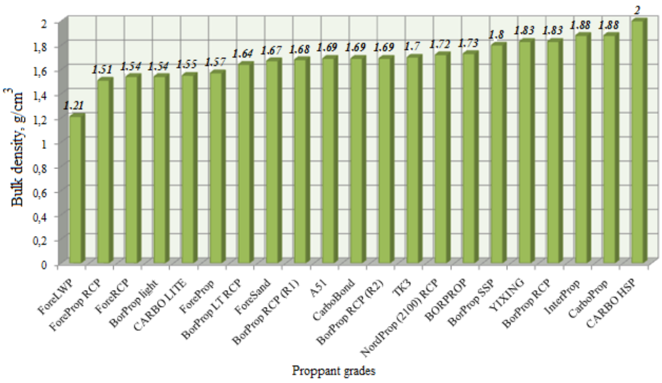


Figure 4: Histogram of the bulk density distribution of proppants of fraction 12/18 of various grades (Bulk density, g/cm^3; Proppant grades)

To determine the bulk density of the fraction 16/20, proppants of the following grades were chosen: BORPROP, ForeRCP, BorProp light, CARBO LITE, ForeProp, ForeProp RCP, BorProp RCP, Sinter LITE, A51, CarboBond, YIXING, CarboProp, BorProp SSP and Sinter Ball.

The histogram of the bulk density distribution of proppants of fraction 16/20 in ascending order is shown in Figure 5.

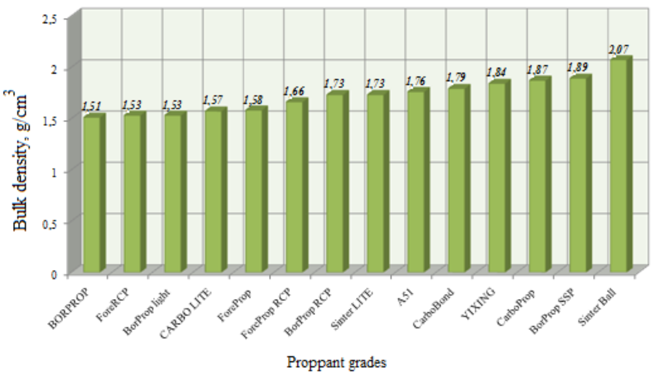


Figure 5: Histogram of the bulk density distribution of proppants of fraction 16/20 of various grades (Bulk density, g/cm^3; Proppant grades)

For the fraction 16/30, the bulk density was determined for proppants: ForeRCP, BorProp light, CARBO LITE, ForeProp, Trekgorney, BorProp RCP (R2), BorProp RCP (R1), Sinter LITE, BorProp SSP, BORPROP, Linhai, KHP, CarboProp, NordProp RCP and Sinter Ball.

The histogram of the bulk density distribution of proppants of fraction 16/30 in ascending order is shown in Figure 6.

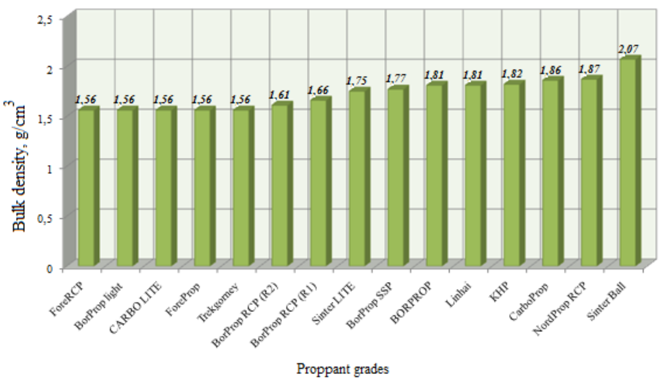


Figure 6: Histogram of the bulk density distribution of proppants of fraction 16/30 of various grades (Bulk density, g/cm^3; Proppant grades)

For the fraction 20/40, the bulk density was determined for proppants: BorProp light, Trekgorney, ForeProp, CARBO LITE, BorProp RCP (R2), BorProp RCP (R1), Sinter LITE, BorProp SSP, BORPROP, CarboProp and Sinter Ball.

The histogram of the bulk density distribution of proppants of fraction 20/40 in ascending order is shown in Figure 7.

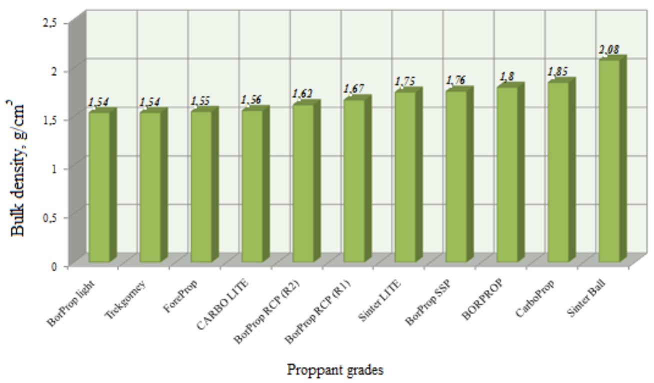


Figure 7: Histogram of the bulk density distribution of proppants of fraction 20/40 of various grades (Bulk density, g/cm^3; Proppant grades)

Further, as already mentioned above, another important physical characteristic of proppants affecting the quality of the created downhole filter is the shape of the granules (i.e., sphericity and roundness).

The roundness and sphericity of proppant granules determines the density of its packaging, as well as the degree of destruction of granules under the influence of rock pressure.

The sphericity and roundness of proppant granules are determined by one of the following methods:

a) using a microscope (method A);

б) using a digital camera (method B).

Method A is based on visual evaluation of the shape of proppant granules magnified with a microscope.

With a relevant magnification of the microscope, the sphericity is determined, and then the roundness of each of the selected granules is determined by comparison with the diagram (Figure 8).

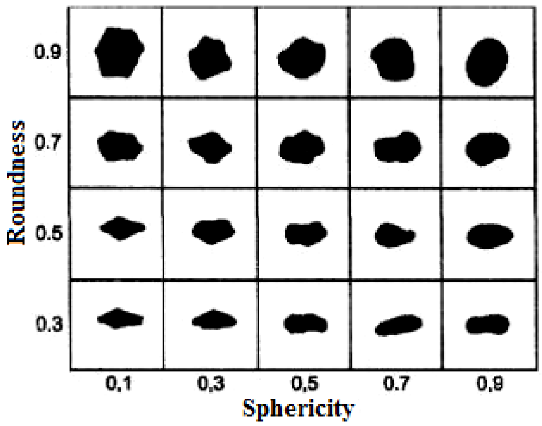


Figure 8: Diagram of visual determination of sphericity and roundness of proppants

Method B is based on visual evaluation of the shape of proppant granules using a digital camera and a personal computer.

Using a computer, the photos are processed and cut so that 20-25 granules of proppant are in the field of view, and the image of the extracted granules is magnified by the multiplicity depending on the proppant fraction (Table 1).

Table 1: Multiplicity of magnification depending on the fraction

Fraction	Multiplicity of magnification
10/14	15
12/18	15
12/20	15
16/20	30
16/30	30
20/40	30
40/70	40

To illustrate the determination of sphericity and roundness using method B, Figure 9 shows a photograph of the proppant of the grade ForeRCP 12/18.

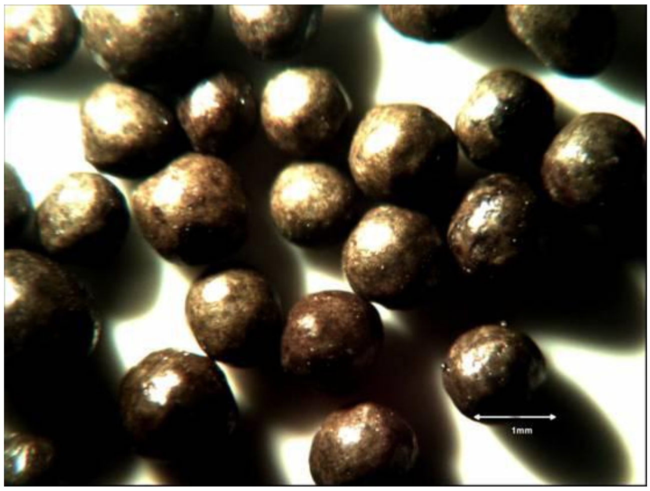


Figure 9: Photo of proppant of grade ForeRCP 12/18

The sphericity values of proppants of different grades by fractions are presented in Table 2.

Table 2: Sphericity values of proppants of different grades by fractions

	6/10	10/14	12/18	16/20	16/30	18/40	20/40
BORPROP	-	-	0.88	0.89	0.87	-	0.86
NordProp (2100) RCP	-	-	0.9	-	-	-	-
ForeRCP	0.84	0.9	0.9	0.9	0.9	-	-
ForeProp	-	0.89	0.88	0.87	-	-	-
CarboProp	-	-	0.84	-	-	-	0.81
CARBO LITE	-	-	0.9	-	-	-	-
BorProp RCP	-	-	0.83	-	-	-	-
TK3	-	-	0.89	-	-	-	-
Versaprop	-	-	-	-	-	0.88	-
KHP	-	-	-	-	0.85	-	-
ForeProp RCP	-	0.9	0.88	0.84	-	-	-

The sphericity values of proppants of different grades by fractions are presented in Table 3.

Table 3: Sphericity values of proppants of different grades by fractions

	6/10	10/14	12/18	16/20	16/30	18/40	20/40
BORPROP	-	-	0.87	0.87	0.84	-	0.77
NordProp (2100) RCP	-	-	0.9	-	-	-	-
ForeRCP	0.84	0.9	0.9	0.9	0.9	-	-
ForeProp	-	0.89	0.87	0.86	-	-	-
CarboProp	-	-	0.82	-	-	-	0.83
CARBO LITE	-	-	0.9	-	-	-	-
BorProp RCP	-	-	0.88	-	-	-	-
TK3	-	-	0.88	-	-	-	-
Versaprop	-	-	-	-	-	0.84	-
KHP	-	-	-	-	0.82	-	-
ForeProp RCP	-	0.9	0.88	0.82	-	-	-

CONCLUSIONS

1. The technical solution offered by the authors allows, with optimal labor costs, elimination of sand ingress in oil producing wells without contamination of the wellbore zone of the formation by creating a hydrophobic sand filter directly inside the oil producing well and using the technology with the coiled tubing installation.

2. The size of the injected proppant must be such that the particles that make up the rock matrix are not carried out through the filter, i.e. the filter should withhold 70 to 80% (by weight) of large particles and pass 20-30% of small particles through itself. Under this condition, the stability of the formation matrix will be maintained.

3. The main physical characteristics of proppants affecting the quality of the created downhole filter are: the shape of the granules (i.e., sphericity and roundness) and density.

REFERENCES

[1] Theory and practice of workover of gas wells in conditions of lower reservoir pressures / M.G. Geikhman et al. - Moscow: IRC Gazprom. 2009. - 208 p.

[2] Bulatov A.I. Coiled tubing technologies for drilling, completion and repair of oil and gas wells. - Krasnodar: Publishing house "Prosveshcheniye-Yug", 2008. - 310 p.

[3] Kleschenko I.I. Theory and practice of repair and insulation work in oil and gas wells: tutorial / I.I. Kleshchenko, G.P. Zozulya, A.K. Yagafarov. - Tyumen, Tyumen State Oil and Gas University - 2010. - 340 p.

[4] Repair of wells using the "Continuous tube" installation: textbook / L.A. Parshukova, D.S. Leontiev - Tyumen: Tyumen State Oil and Gas University, 2015. - 147 p.

[5] Patent 2604100RF. E21B37/00 (2006.01). A method for reducing sand ingress in oil wells./ D.S. Leontiev, A.V. Kustyshev, I.I. Kleshchenko et al (RF).- № 2015148520/03, applied 11.11.2015; published 10.12.2016.

[6] GOST R 51761 - 2005. Aluminosilicate proppants. Technical requirements [Text]. - Introduced 2006-07-01. - Moscow: Publishing house Standartinform, 2006 - 34 p.