Improving the design of a downhole filter for fluid production with an increased concentration of suspended particles

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Abstract. The reliability of the underground equipment of a well sucker rod pump installation will be improved by the use of a new sand filter design, the principle of which is based on the use of centrifugal force of a moving reservoir fluid. To determine the subtlety of cleaning the reservoir fluid from mechanical particles, it should be considered that the fluid velocity is the same as the particle velocity. To do this, we use the universal expression by analogy to our case for the stream function. To develop a specific filter (determination of structural dimensions) taking into account the well conditions, nomograms are developed taking into account all technical and technological conditions. The main advantage of the developed sand filter over other designs is the ability to pass formation fluid even when the cavity for collecting sand and the space between the filter housing and the pipe with radial channels are filled. The presence of the latter also does not affect the performance of the sucker rod pump, in the absence of jamming of the plunger in the cylinder.

1. Introduction
The reliability of the underground equipment of a borehole sucker rod pump installation will be improved by the use of a new sand filter design, the principle of which is based on the use of centrifugal force of a moving reservoir fluid [1].

2. Results and discussion
The structure of the filter design (Figure 1) includes four inlet tubes, which allow creating a swirling liquid flow, as in a hydrocyclone. The reservoir fluid with mechanical impurities flows under pressure from the annulus into the filter. The fluid through the inlet tubes enters the gap between the pipe with radial channels 4 and the central axis 6. Here, the fluid swirls and rises. Further, hitting the walls of the pipe with radial channels, taking into account the friction and gravity forces, the impurities pass through the filtering process through channels 7, which are staggered. The diameters of the filter holes correspond to the size of the impurities. Filtered particles accumulate in the sand collection cavity 2.
3. Experimental

To determine the degree of cleaning the reservoir fluid from mechanical particles, it should be considered that the fluid velocity is the same as the particle velocity. To do this, we use the universal expression by analogy to our case for the stream function \[2 - 7\]. As a result of transformations of the obtained expressions for the fluid flow rates in the filter \[8\], we obtain an expression for determining the diameter of the deposited particles:

\[
d_{\text{ch}} = \frac{60}{\pi n} \sqrt{\frac{3 \mu V_r}{(\rho p - 1) r}},
\]

where \(\mu\) is the dynamic viscosity of the reservoir fluid, Pa·s; \(V_r\) is the radial velocity of the fluid, m/s,

\[
V_r = \frac{4 Q_0}{\pi (d_1^2 - d_2^2)},
\]

where \(Q_0\) is the flow rate of the liquid through the filter, m\(^3\)/s; \(d_1, d_2\) are the diameters of the rod and the inner surface of the perforated pipe, m, respectively; \(n\) is the frequency of rotation of the liquid in the annular gap, min\(^{-1}\); \(\rho_p, \rho_l\) are densities of liquid and particles, kg/m\(^3\); \(r\) is the average radius of the annular gap, m.

To develop a specific filter (determination of structural dimensions) taking into account the well conditions, nomograms were developed taking into account all technical conditions.

Sand filters were installed in 2018 at wells Nos. 1246, 1356, 1623 of NGDU Krasnokholmskneft of OAO Bashneft-dobycha. Before the filter was lowered into the wells, samples were taken that established the presence of mechanical impurities in the product. The concentration of suspended particles exceeded the norm by several tens of times, which can lead to premature failure of the pump. In addition, sludge traps were located between the filter and the shank to increase efficiency (not shown in the figure).

Based on the results of sampling, the operation of the sand filter was analyzed. Figures 2 and 3 show the dependences, both for water and for oil, of the concentration of suspended particles. Figure 2 shows that after installing the filters, there was a sharp decrease in the concentration of suspended particles (EHF) in water. Similarly, in Figure 3, the concentration of suspended particles (EHF) in oil also decreased.
Due to the filtration of the reservoir fluid, no evidence of jamming of the plunger and clogging of the valves was observed. Consequently, the overhaul period increased [9-10]. Figure 3 shows that the SPC in all wells in water and oil grows on average after 8–9 months. This is facilitated by the appearance of larger fractions of other substances that do not pass through the radial channels of the pipe 4. This filter allows the formation fluid to pass through even when the cavity for collecting sand and the space between the filter housing and the pipe with radial channels are filled. The presence of the latter also does not affect the performance of the sucker rod pump.

4. Conclusion
The main advantage of the developed sand filter over other designs is the ability to pass reservoir fluid even when the cavity for collecting sand and the space between the filter housing and the pipe with radial channels are filled. The presence of the latter also does not affect the performance of the sucker rod pump, in the absence of jamming of the plunger in the cylinder.
The use of the new development in conjunction with sludge traps can improve the efficiency of the sucker rod pump in difficult operating conditions.

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