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# СОВРЕМЕННЫЕ ТЕХНОЛОГИИ ВОДОПОДГОТОВКИ ДЛЯ ПОДДЕРЖАНИЯ ПЛАСТОВОГО ДАВЛЕНИЯ НА НЕФТЯНЫХ МЕСТОРОЖДЕНИЯХ

# ADVANCED WATER TREATMENT TECHNOLOGIES TO MAINTAIN RESERVOIR PRESSURE AT THE OIL FIELDS

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**Аннотация.** На нефтяных месторождениях в результате нагнетания в пласт воды с взвешенными глинистыми частицами наблюдается значительное снижение приемистости нагнетательных скважин в результате загрязнения призабойной зоны. Предложен новый способ глубокой очистки пластовой воды от взвешенных частиц глины с использованием эффективного фильтра гранулированных материалов с переменным размером частиц. Представлены результаты экспериментов по определению рациональных параметров и режимов работы рекомендованного фильтра для подготовки пластовой воды.

**Ключевые слова:** скважина, вода, очистка, образование, нефть.

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**Annotation.** At oil fields, as a result of water injection with suspended clay particles into the formations, there is a significant decrease in the injectivity of injection wells due to contamination of the bottomhole zone. The article proposes a new method of deep treatment of formation water from suspended clay particles using effective filter of granular materials with variable particle size. The results of experiments to determine the rational parameters and modes of operation of the recommended filter for the preparation of produced water are presented.

**Keywords:** well, water, treatment, formation, oil.

Currently oil production in the fields of the middle and late stages of development is characterized by the need of water pumping into the reservoir for reservoir pressure maintenance (RPM). It is generally accepted, that waterflooding allows not only to increase the production rate, but also to reach the maximum hydrocarbons recovery factor.

The requirements for oilfield wastewater as for a working agent for water flooding are presented according to three main indicators: the content of emulsified oil (oil products) and solid mechanical impurities particles, microbial and chemical compatibility with brine water and reservoir rock. In order to avoid complications during the pumping of water into the reservoir, the injected water must match certain quality standards according to Standard of the Republic of Kazakhstan № 1662-2007, in which mechanical impurities in petroleum products do not exceed 50 mg per liter.

The main methods of cleaning oilfield wastewater in the industry are mechanical and physic-chemical [1, 2]. The most common is the method of settling as the simplest and cheap, in many cases providing the necessary water quality requirements. On most objects, only this method is used, and on some, in combination with filtration and physicochemical methods. The method of settling, though simple, has drawbacks: the high dependence of the quality of purification on the characteristics of polluting inclusions (dispersion, stability, etc.), the duration of the process, etc. Therefore, in recent years, to improve equipment performance and the depth of wastewater treatment, new tools such as thin-layer settling tanks, with a coalescing filter, filters, three-product hydrocyclones, etc. have been developed.

For example, at Uzen field, where the oil-field waste water that comes from FWKO-1, FWKO-2, CPF are used as the working agent for injection into reservoirs. The technology currently used for the preliminary

discharge of secondary water (FWKO-1, FWKO-2) is complicated by the receipt of large volumes of liquid from oil fields, which exceeds the design capacity of these objects, there is a violation of the product sludge time in technological devices, which leads to deterioration of the parameters of water prepared for FPM, and the quality of the water supplied for injection reservoirs, the requirements of the regulatory documentation of the Republic of Kazakhstan.

The existing problem of treatment of wastewater pumped into the system for maintaining reservoir pressure outlined by Golubev I.A. in his article [3]. Several options for instrumentation of cluster dump objects are considered. The diagrams of the proposed equipment are shown as introduced into production. The expected results, which are planned to be obtained after the introduction of cluster dumping facilities into the development of oil fields in the early stages of oil gathering are taken into account. However, the use of cluster discharge equipment has a number of disadvantages compared to the proposed device for deep purification of formation water. Insufficient efficiency, due to the fact that the quality of water supplied to the injection well is poorly controlled, and its quantity is constant.

In the Kazan State University of Architecture and Civil Engineering, has developed and implemented hydrocyclone installations for the preparation of water used for flooding productive horizons. The disadvantage of this technology is a low degree of separation, the complexity of the removal of pop-up substances [4].

Despite the importance of the problem and a rather large number of publications devoted to the study of deep purification of formation water from suspended solids and its steady injection into the oil reservoir, the above problem still remains relevant for the moment.

We propose a new technology for deep purification of formation water with suspended clay particles [5]. The objective and the technical result of the invention is the increase of the purification efficiency of industrial wastewater and commercial formation water with suspended solids and sulphide-settling bacteria by supplying the purified water 1 from the lower compartment of the plant with the outlet branch pipe vertically from the bottom to the top in series through the perforated baffle and layers of granular material with the variable particle sizes in the vertical direction, the lower layer of which has the maximum overall dimensions of the particles, and the upper layer has the minimum overall dimensions of the particles. At the same time, in the upper compartment of the plant, water purified from suspended solids with sulfide-settling bacteria, are subjected to uniform action of the oxidizing gas, the supply of which is carried out through holes of evenly distributed perforated tubes.

Accumulated in the lower compartment of the installation, suspended solids are periodically discharged through the lower outlet nozzle by water injection. Purified from suspended solids water is sent to maintain reservoir pressure and uniform displacement of oil from the formation.

To establish the rational parameters of the recommended technology for water treatment to maintain reservoir pressure, we conducted experimental studies. The experimental setup (Fig. 1a and b) consists of a vertical cylinder, inlet and outlet nozzles, as well as inlet and outlet plastic pipes. Inside a transparent vertical cylinder made of plexiglass, consistently located lower perforated metal partition, a filter made of granular materials with variable particle sizes and upper perforated metal partition.

The granular filter consists of three layers: the lower and upper supporting layers with variable particle sizes – from 5.0 to 1.0 mm; the middle working layer consisting of river sand with particle sizes from 0.7 to 1.0 mm. These three granular layers are pressed between the lower and upper perforated metal partitions with screws and nuts.

The main criteria for evaluating the operation of a granular filter with varying particle sizes of the experiment were taken: mass in mg of suspended particles in one liter of produced water before and after passing it through the filter, i.e. – concentration of suspended particles in mg / l and the maximum particle size of suspended particles in microns in water before and after passing it through the filter. The thickness of the working layer of the granular filter during the experiments were taken in the following ranges: δ = 100, 200, 300, 400 mm. The concentration of suspended clay particles in the initial water samples was used as the main factor.: $C_{susp}$ = 0.8 … 1000.0 g/l.

As a result of the analysis by weighing on an analytical balance, it was found that the weight of mechanical impurities averaged 1,0 g/l before water treatment and after water treatment an average of 0,005 g /l (Fig. 2).

On the Zetasizer device was accomplished na№ measurement of the radius of mechanical impurities in the formation water before and after treatment on filter. The results of water measurements «before cleaning on the filter» showed (Fig. 3, a) that particles with sizes from 0.08 to 0.09 μm – 6 %, from 0.5 to 0.7 μm is about 45 %. These sizes of solid suspended particles are comparable with the sizes of pores and capillaries. The results of measurements on water «after cleaning on the filter» (Fig. 3, b) showed that particles with sizes from 0.04 to 0.05 μm – 8 %, from 0.08 to 0.1 μm is about 55 %.

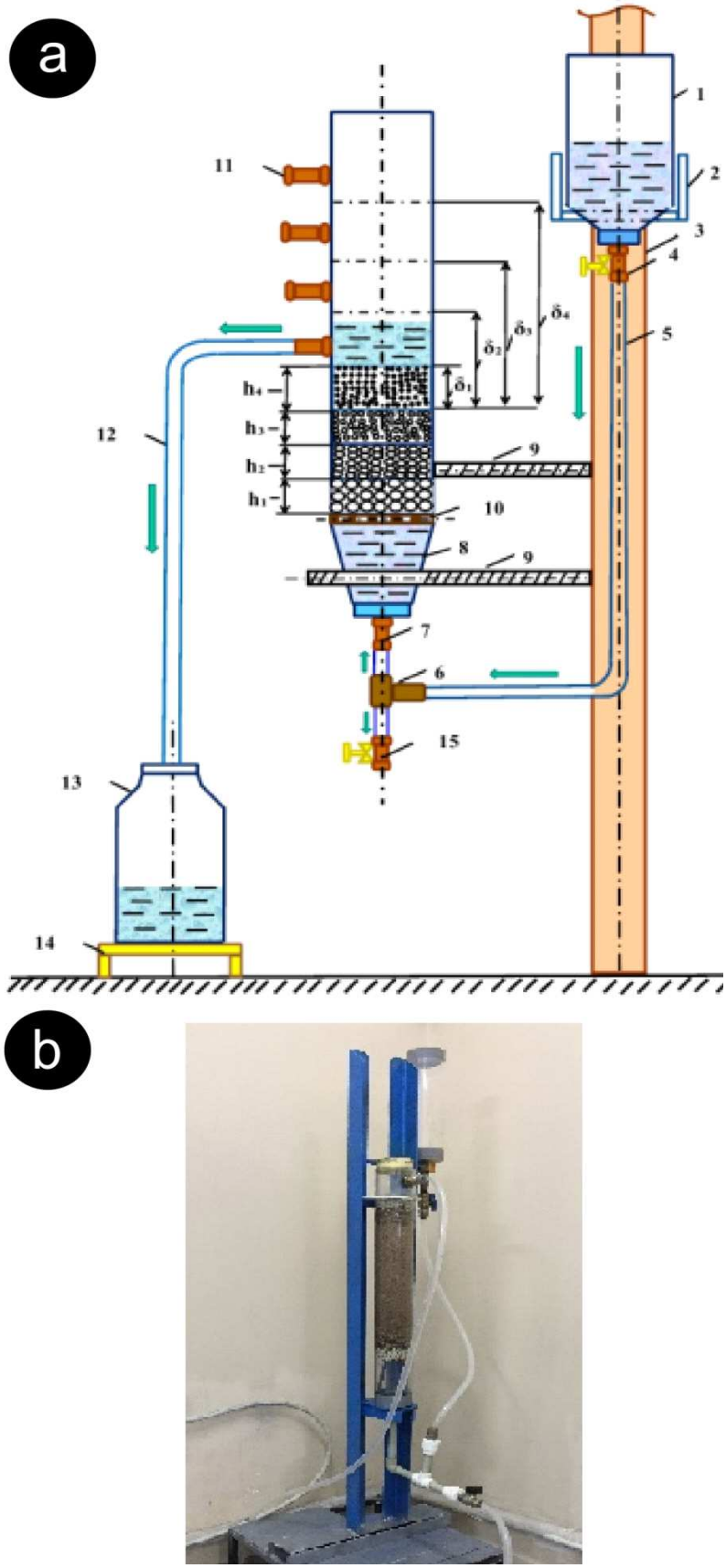


**Figure 1** – General view (a) and schematic diagram (b)
of an experimental installation for cleaning produced water from suspended clay solids:
1 – receiving tank, 2 – metal mount, 3 – metal support structure, 4 – connecting tap, 5 – water inlet tube, 6 – tee, 7 – connector, 8 – tank-water purification filter, 9 – metal mount, 10 – mesh, 11 – connections, 12 – tube outlet, 13 – tank-collector for purified water, 14 – pan-collector tank

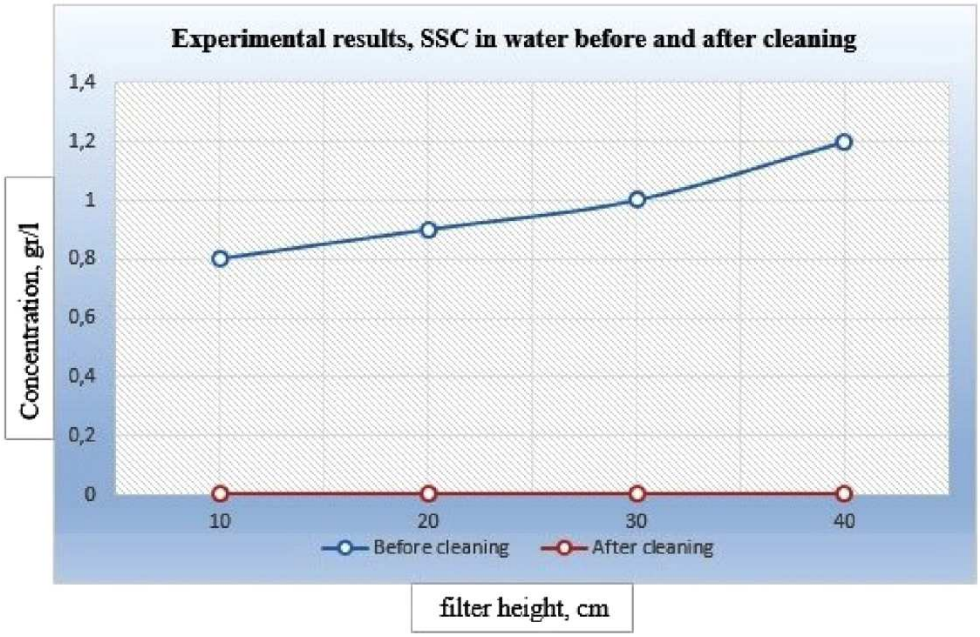


**Figure 2** – Diagram of concentration suspended clay particles from the height of the filter before and after water treatment

The results of the experiments showed that with an increase in the height of the working layer over 200 mm, the concentration of suspended particles in the reservoir water decreases significantly reduced by about tens of times, and the maximum sizes of suspended particles do not exceed 100 microns. This suggests that increasing the height of the working granular layer to 300–400 mm, and reducing the particle size of grains less than 0.7 mm, and compacting the working layer of the filter can achieve complete purification of produced water.

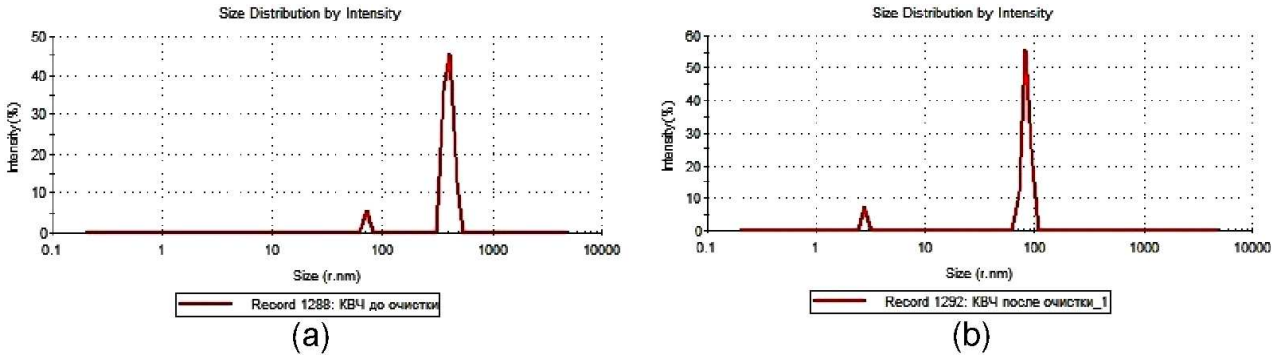


**Figure 3** – The intensity of the size distribution of solid suspended particles in the water injected into the reservoir before (a) and after (b) cleaning

Thereby, experimentally established, that purified water the supply vertically from the bottom to the top in series through the perforated baffle, granular material layers and oxidizing gas, significantly enhance the efficiency of water purification from suspended solid particles, prevent plugging of pores with suspended solids and significantly increase the water-intake capacity of injection well.

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