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INTENSIFICATION OF TECHNOLOGICAL SCHEMES OF COMPRESSOR STATIONS, WASTEWATER TREATMENT DEVICES AND PROTECTION OF WATER RESERVOIRS (ON THE EXAMPLE OF THE BALTIC OIL AND GAS PRODUCTION DEPARTMENT)

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Abstract. The paper studies the intensification of the technological schemes of wastewater treatment facilities at the compressor stations of the Shurtan Oil and Gas Production Department, and water-body protection on this basis. The shortcomings of existing treatment schemes are analysed, and an intensified scheme including coagulation-flocculation, thin-layer settling and pressure flotation is proposed. The advantages of a thin-layer settler over a conventional one (2.5-3 times smaller footprint) are substantiated. It is shown that intensification provides a high degree of treatment for oil products, suspended solids and COD, protecting water bodies from pollution.

Keywords: wastewater, treatment facilities, intensification, thin-layer settler, coagulation, flotation, water-body protection, MPC.

1.Introduction

Traditional structures (gravity settling tanks, simple filters) are used to treat oil-containing wastewater generated at gas compression compressor stations. However, such structures occupy a large area, do not sufficiently retain emulsified and dissolved oil products, and do not operate stably under variable load conditions. As a result, the quality of treatment does not always meet regulatory requirements, which poses a risk of water pollution.

The solution to this problem is to intensify existing technological schemes, namely, the introduction of modern methods such as reagent processing, thin-layer sedimentation and pressure flotation. Intensification increases the degree of treatment, reduces the area of the structure, and thus becomes a reliable means of protecting water bodies. This issue is directly related to the direction of water body protection.

The advantage of intensification is that it allows you to increase the efficiency of existing structures without completely rebuilding them. Reagent processing enlarges small and emulsified particles, thin-bed modules reduce the settling area, and pressure flotation quickly separates light oil products. All this is especially important in conditions of limited space and variable loading.

The purpose of the article is to justify ways to intensify the technological schemes of wastewater treatment facilities of compressor stations of the Shurtan Department and thereby assess the effectiveness of water body protection.

2.Research object and methods

The object of the study is the wastewater treatment facilities of the compressor stations of the Shurtan Oil and Gas Production Department. The theoretical basis is the regulatory documents and scientific literature in the field of water treatment, as well as the requirements of the MPC (permissible limit concentration) established for water discharged into water bodies. The work uses methods for comparative analysis of existing and intensified schemes, assessment of the possibilities of intensifying the settling process and determining the degree of purification by pollutants. The indicators are taken on the basis of generalized (typical) values in accordance with the theoretical description of the topic.

Intensification of the purification process is understood as increasing the productivity and degree of purification per unit volume or area of the existing facility. This is achieved by three groups of methods: hydrodynamic (improving the flow regime, thin-bed modules), reagent (adding coagulants and flocculants) and physicochemical (pressure flotation, sorption, membrane). This article considers the application of these methods in the conditions of a compressor station.

3.Results and their discussion

3.1. Existing cleaning schemes and their disadvantages

The traditional treatment scheme usually consists of a sand trap, a gravity oil trap and a filter. The main disadvantages of such a scheme are: the large area required by the gravity settler, the failure to separate emulsified oil, a decrease in efficiency when the load changes, and the absence of a deep cleaning stage. As a result, the concentration of oil products at the outlet can be 40 mg/l and higher, which is much higher than the standards established for discharge into a water body.

The peculiarity of compressor station wastewater is that its composition and consumption change sharply over time: during equipment washing, periodic preventive maintenance and precipitation, the level of pollution can increase several times. Traditional gravity structures cannot adapt to such “shock” loads and the quality of cleaning decreases. The intensified scheme, however, is resistant to such fluctuations due to reagent adjustment and multi-stage operation, and provides stable cleaning quality.

The main indicators of traditional and intensified schemes are compared in Table 1. Intensification increases the level of purification while significantly reducing the area of the facility.

Table 1. Comparison of traditional and intensified cleaning schemes

Indicator	Traditional scheme	Intensified scheme
Type of treatment	gravity ostoynik	thin-layer sedimentation
Reagent treatment	no	coagulation-flocculation
Deep cleaning	no	sorption-membrane
Output oil products	40 mg/l and above	< 0.5 mg/l
Facility area	large	2.5–3 times smaller

3.2. Intensified technological scheme

The intensified scheme includes the following stages: a sand trap, a coagulation-flocculation unit, a thin-film clarifier, a pressure flotation unit, and a sorption membrane filter (Figure 1). Reagent processing (addition of a coagulant and flocculant) enlarges small and emulsified particles and accelerates their separation. Each stage is aimed at the effective separation of a specific pollutant.

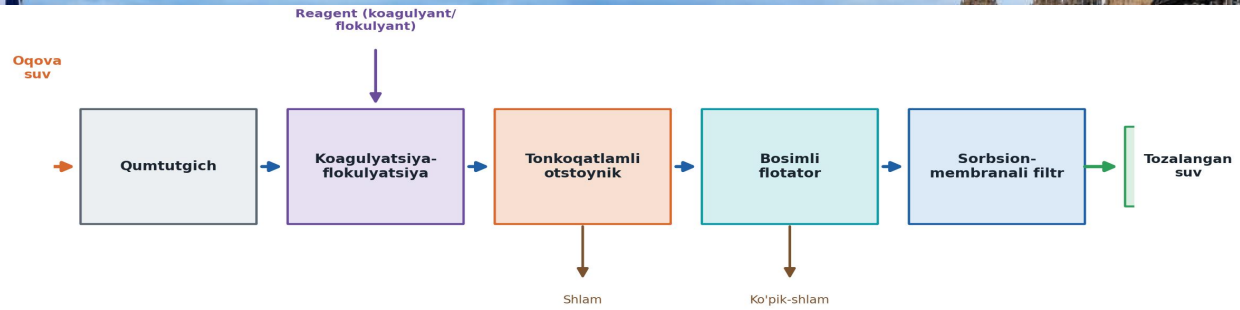


Figure 1. Technological scheme of an intensified treatment plant

3.3. Intensify the curing process

The most effective way to intensify the settling is to use a thin-bed (multi-layer inclined plate) settler. In it, the flow is divided into thin layers, the sedimentation path of particles is shortened and the settling is accelerated. It requires 2.5–3 times less area than a conventional settler with the same productivity and reduces residual oil products from 40 mg/l to 15 mg/l (Fig. 2). The spatial structure of a thin-bed settler is shown in Fig.

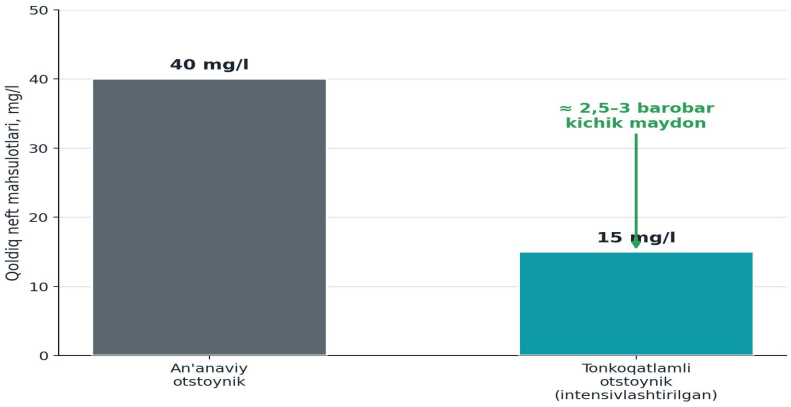


Figure 2. The effect of intensification of the still (residual oil products)

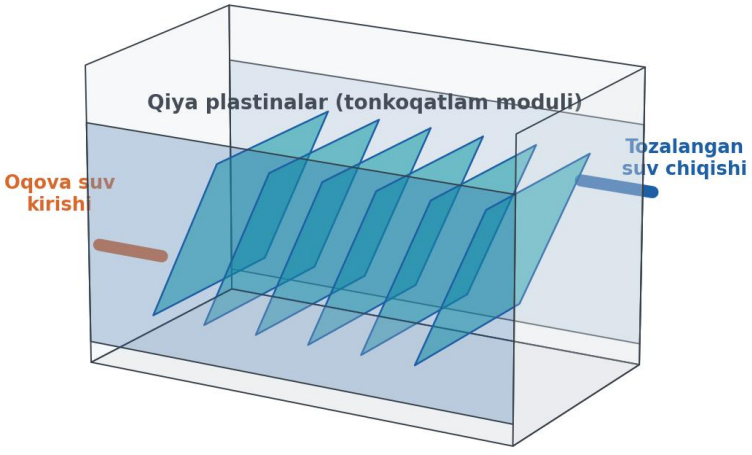


Figure 3. Spatial (3D) view of a thin-layered ostoynik

3.4. The effectiveness of watershed protection

The intensified scheme significantly reduces the indicators of suspended solids and organic pollution (COD) along with oil products. A comparison of concentrations before and after treatment is shown in Figure 4: the degree of purification is achieved by ≈99.9% for oil products, ≈97% for suspended solids, and ≈95% for COD. These indicators make the treated water suitable for discharge into water bodies or reuse and reliably protect the basins from pollution.

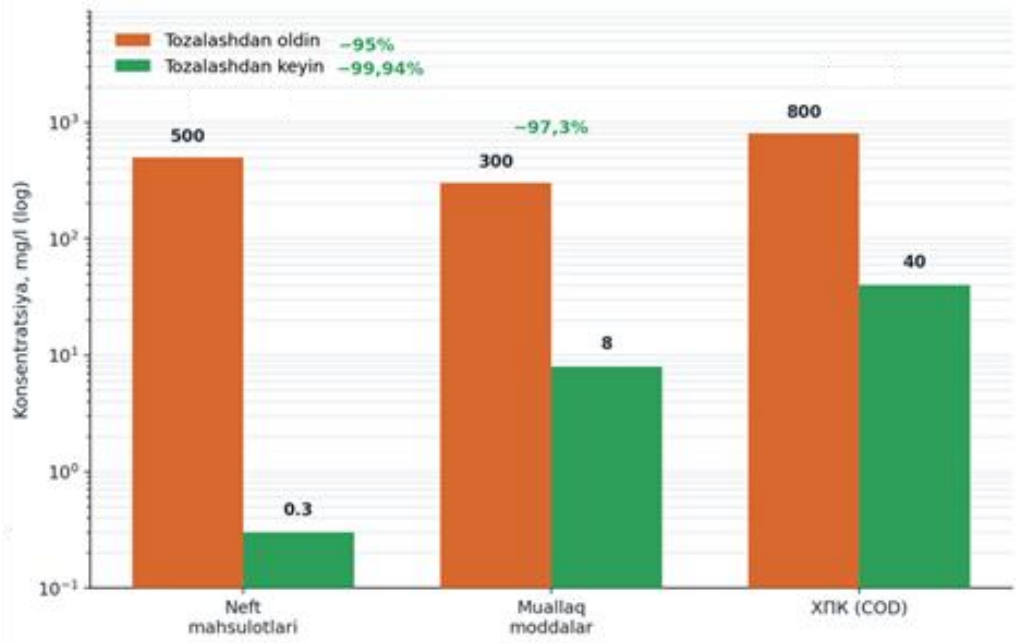


Figure 4. Pollutant concentrations before and after cleaning

Thus, the intensification of treatment facilities not only increases the quality of treatment, but also sharply reduces the pollutant load on water bodies, creating an engineering basis for environmental protection.

3.5. Technical and economic efficiency of intensification

Intensification is effective in several ways. First, due to thin-bed modules and pressure flotation, the area of the facility is reduced by 2.5–3 times, which reduces construction and land costs. Second, an increase in the quality of treatment eliminates environmental fees for discharge into the water body. Third, by returning deeply treated water to the circulation system, fresh water consumption and fees are reduced. Fourth, reagent and automated control ensure process stability and maintain the required quality even with variable loads. These factors together significantly improve the technical and economic performance of intensified facilities compared to the traditional scheme. Most importantly, intensification becomes a reliable and economically justified method of protecting water bodies from pollution, which fully corresponds to the main goal of the specialty 05.09.04

Conclusions

1. Traditional treatment schemes require a large area, do not separate emulsified oil and do not operate stably under variable loads, which poses a risk of pollution of water bodies.
2. An intensified scheme combining coagulation-flocculation, thin-bed sedimentation and pressure flotation increases the quality of treatment.
3. A thin-bed clarifier requires 2.5–3 times less area than the traditional one, reducing residual oil products from 40 to 15 mg/l.
4. Intensification provides a high degree of purification of oil products (≈99.9%), suspended solids (≈97%) and COD (≈95%), protecting water bodies from pollution

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