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Estimation of efficient operation of the monoblock unit and treatment of the sewage waters

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ABSTRACT: The article describes the estimation of the efficiency of the operation of each section of the combined monoblock unit together with the recommendations in increasing the quality of the treatment of the sewage waters at the increased concentration of the oil products and suspended particles in the initial water by installation of a thin-bed clarifier with down-ward and up-ward flow of the liquid.

KEYWORDS: thin-bed unit, filtration, sorption, sewage treatment unit, oil product and suspended substances.

I. INTRODUCTION

The sewage waters of the railway service enterprises are related to the environmentally hazardous substances. They are mostly contaminated by oil products, suspended substances, ions of heavy metals, alkali, acids and other compounds. Based on the results of the statistics treatment, the bulk number of the facilities have the capacity from 100 to 500 m3/day with extremely primitive local treatment structures that do not allow the reuse of the water. Hence, the development of chip standard compact highly efficient structures of factory readiness, that provide the required treatment quality of the sewage waters, is of high interest at this time in the Republic of Uzbekistan.

A compact monoblock unit [1] and a process diagram of the treatment of the sewage waters with regeneration of the sorption filter filled up with the aluminosilicate absorber is developed for the local treatment of the sewage waters of the railway transportation enterprises patented by prof. E.G. Petrov [2].

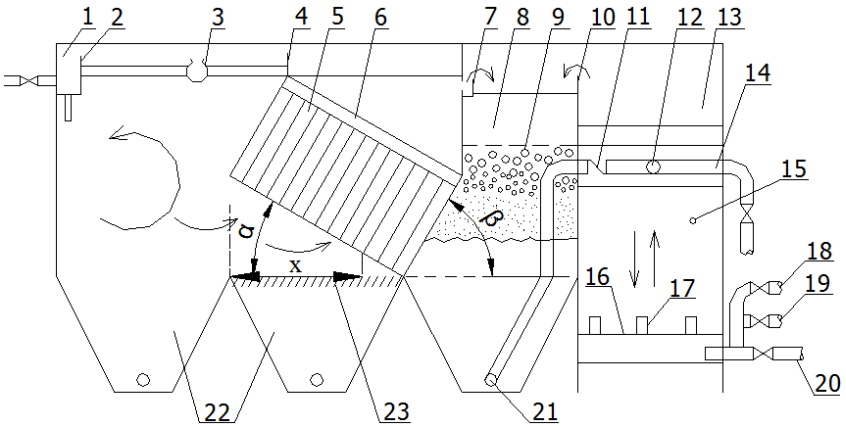

Figure 1. Scheme of a compact monoblock unit for treatment of the sewage waters

The sewage water treatment unit contains: a tank 1, water supply device 2, rotating pipe for removal of oil products 3, limiter of the oil products accumulation zone 4, a unit with thin-bedded elements 5, channels 6, bypass device 7, mechanical filter 8, floating load 9, water drain dividing wall 10, bypass piping with check valve 11, distribution-water accumulating header of sorption filter 12, sorption filter 13, piping for draining of a regenerating

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solution 14, loading of activated aluminosilicate adsorber15, filter bottom 16, disc distribution devices (option drainage screen nozzles) 17, piping for supply of regeneration solution 18, piping for supply of flush water 19, piping for draining of the treated water 20, water-collecting drainage system of a floating filter and draining of a flush water 21, a bin for the sediments 22 with the piping for its removal, louvered grate 23.

The unit has a zone of rough mechanical treatment, thin-bedded sedimentation zone, zone of a floating mechanical filter with polystyrene load and the sorption filter.

To evaluate the efficiency of the operation of the relevant sections of the monoblock unit, let's revise the peculiarities of its operation based on some average data on contamination of the industrial and surface sewages which are generated by the railway transportation enterprises. Particularly the concentrations on oil products of the railway transportation enterprises make up: for motive-power and railroad car sheds upto 500mg/l, wagon maintenance stations upto 100mg/l, surface sewages from the territories of the receiving-departing tracks, as well as of motive-power and railroad car sheds - 300 mg/l, and on suspended substances the contamination of the sewages is in the range from 100 to 400÷500mg/l.

Based on our experience-based data for Uzbekistan, the initial concentration on oil products for the motive-power depots and other enterprises mainly make up 150-300mg/l and on suspended substances - 200÷400mg/l.

To evaluate the efficiency of the operation of the blocks of the unit, the contamination of the sewages with oil products (ether-soluble substances) of $C^{н}_{исх}$=300mg/l is accepted, on suspended substances $C^{вв}_{исх}$ =400 mg/l. The capacity of the unit is Q=20 m^3/hour.

The hydraulic size of the caught particles in the zone of the thin-bedded sedimentation U_o, mm/s, complying with the required effect E,% is determined based on the results of the study of the kinetics of the thin-bedded sedimentation of the sewage water (pic.1) [6].

The calculation of the thin-bedded block of the mechanical treatment of the unit (pic.2) is done for catching of the particles with minimum hydraulic size U_o that define the required degree of catching of the oil products and suspended substances with consideration of the performed researches on distribution of the treated liquid in the thin-bedded block, depending on,

$$U_o = \varphi_{0.cp}\frac{V_0 \cdot 2h}{L_{II} \cdot Cos\alpha} = \varphi_{0.cp} 3{,}6\frac{Q}{S \cdot Cos\alpha}, \quad (1)$$

where $\varphi_{o.cp}$– the factor that considers the hydraulic parameters of the unit that depends on the inclination angle of the thin-bedded elements block β, $\varphi_{0.cp}$ =1.24;

V_o – average velocity of water within the thin-bedded elements block, mm/s, V_o=3mm/s;

$2h$ – depth of the thin-bedded elements, mm, 2h=25mm;

$L_п$– length of the thin-bedded elements, mm, $L_п$=1500mm;

α – inclination angle of the elements against the horizon that provides the sliding of the sediments and emulsified particles of the oil products in the zone of inclination and removal, degree, α=60°;

Q – flow rate of sewage waters, Q=20 m3/hour;

S- total area of the efficient surface of the thin-bedded elements block. S=30m2.

At capacity of the unit of 20m3/hour, the hydraulic size makes upU_0≈0,124mm/s.

Based on the received values of U_0 the effect of treatment from emulsified oil products E from pic.1 is being determined. The residual content of the soluble and emulsified oil products that get to the mechanical filter with the polystyrene foam core.

$$C^{н}_{осm} = C_I + C_{II} \cdot \frac{100 - Э}{100}, мг/л, \quad (2)$$

where C_I - concentration of the dissolved oil products in the initial sewage water; for the industrial sewage waters from the railway transportation enterprises makes up, as a rule, not more than 2÷10mg/l;

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C_{II}-concentration of emulsified oil products in the industrial sewage waters (d_o<100mm); usually C_{II} does not exceed 100÷150mg/l, and for the surface sewages C_{II} =40÷70mg/l.

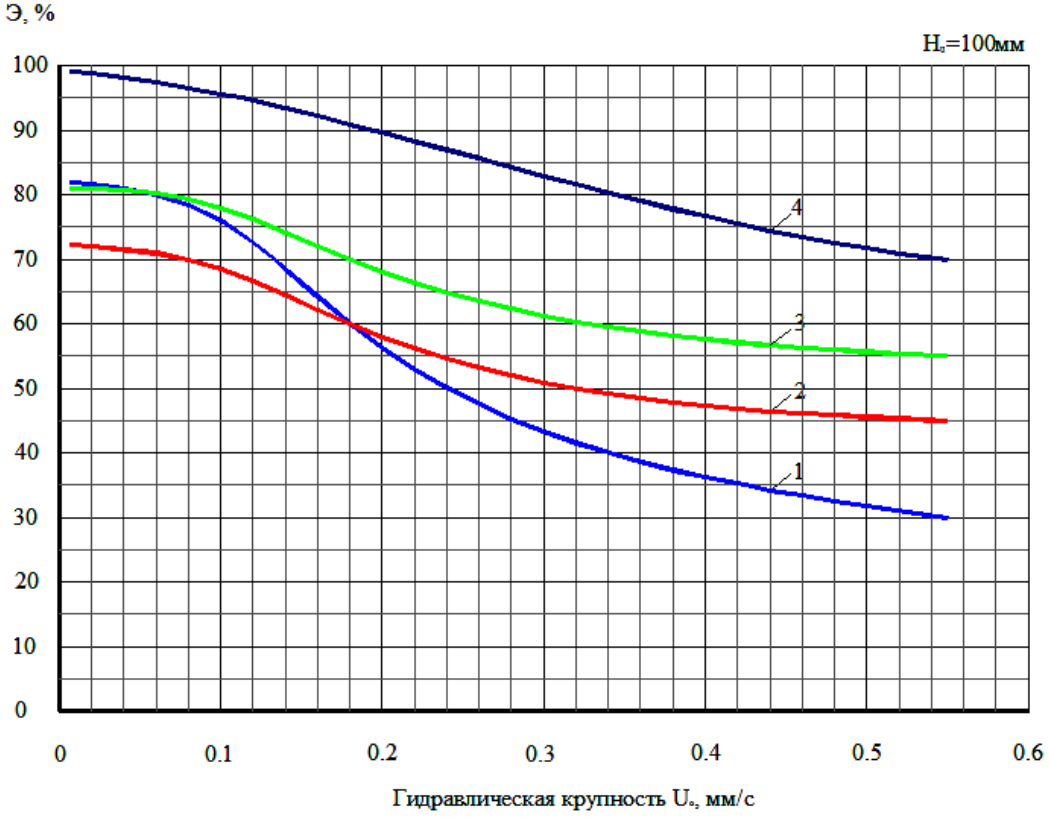

Figure 1. Kinetics of the thin-bedded sedimentation of the emulsified oil products:
1-Industrial sewage waters of the depot, $C_{исх}$=100-150mg/l;
2-surface sewage waters, $C_{исх}$=40 mg/l; 3- the same, $C_{исх}$=70mg/l;
4-industrial sewage waters with the preliminary treatment with aluminum sulphate of 100-300mg/l.

The effect of catching of the suspended substances during thin-bedded sedimentation makes up not less than 80%, hence the sewage waters with concentration of suspended substances get to the filtration

$$C_{ост}^{вв} \cong C_{исх}^{вв} \cdot \frac{100-80}{100}, мг/л. \quad (3)$$

After the thin-bedded sedimentation the industrial sewage waters contain mainly emulsified and dissolved oil products. Hence the average concentration makes up:

$$C_{ост}^{н} \cong 6+125 \cdot \frac{100-Э}{100}, мг/л. \quad (4)$$

At the content of the dissolved oil products C_I=6mg/l, without treatment with the reagents E=70% $C_{ост}^{н} \leq$ 43.5mg/l, and if treated with the reagents E=90% $C_{ост}^{н} \leq$ 18.5mg/l.

Based on the literature data [6, 7 and others], at the initial content of the oil products from 30 to 300mg/l, depending on their dispersed content and conditions of formation, the sedimentation can provide the decrease of the concentration of the oil products upto 1-3mg/l, which is in many other cases remains within the ranges from 2 to

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15mg/l. At fine-bedded sedimentation during 20-30 minutes in the water layer of the depth $H_ц$=100mm, the concentration of the emulsified and dissolved oil products in the surface sewage decreases upto 8-12mg/l, that relates to the hydraulic size of the caught particles of U_o=0.1mm/s, the suspended oil products surface within 1-2 min. It is believed that the quantity of the dissolved and emulsified oil products in the surface sewage water running from the territory of the railway transportation enterprises and similar ones make up not more than 30-70mg/l at the general content of the oil products of 500-300mg/l. In the production sewage there are upto 400mg/l of the suspended substances and not more than 100-150mg/l of the emulsified and dissolved oil products with particle diameter < 100mc. Thus, at the initial concentration of the oil products upto 300mg/l, the thin-bedded oil catchers, based on the experience of operation, provide the cleaning of the general sewage from 10 to 40mg/l, that allows, based on the above provided calculation, to forecast the following initial parameters for the calculation of the filtration block of the monoblock unit

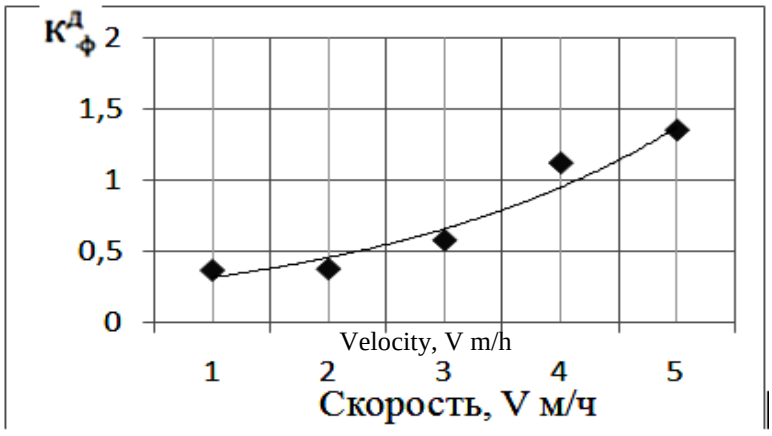
$$C^{н}_{исх} \cong 43{,}5 мг/л;\ C^{вв}_{исх} \cong 80 мг/л.$$

To calculate the efficiency of the filtration block, let's tentatively accept the effect of treatment on oil products $C^{н}_{ф.п} = 80\%.$ and on suspended substances $C^{вв}_{ф.п} = 90\%.$. Then the residual content of the relevant contaminants that get to the sorption block without injection of the reagents, will approximately make up not more than

$$C^{н}_{исх} \cong 8{,}7 мг/л;\ C^{вв}_{исх} \cong 8 мг/л.$$

The experimental researches provided the possibility to determine the level of the breakthrough concentration of the oil products in the filter. A real sewage water taken after the sedimentation drums of the Tashkent locomotive-repair plant were taken as the initial sewage water.

As a result of the mathematic processing of the experimental data, obtained based on the short beds of the absorber, the average values of the dynamic factors of the decrease of the efficiency were found $K^{Д}_{ф}$ (pic.2) for the concentration of the oil products in the initial water $C^{н}_{исх}$≤10mg/l at the temperature of 20-25°C and the range of filtration speed from 1 to 5m/h. Later the data were taken for the re-calculation of the received data for the real height of the bed of the sorption filter.



Pic.2. The dynamic factor of decrease of the treatment efficiency against the speed of filtration.

Based on the approximate dependence $K^{Д}_{ф}$ the dependence of the relevant concentration of the oil products in the filter was determined, that is valid for the recalculation for the real height of the bed of the sorption filter at the recommended height of the adsorption bed in the sorption filter $H_{с.ф}$ from 1 to 1.6m and concentration of the oil products $C^{н}_{исх}$≤10mg/l.

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$$\frac{C^{н}_{осm}}{C^{н}_{исх}} = \left(\frac{K^{Д}_{ф}}{1 + K^{Д}_{ф}} \right)^{3,33 H_{с.ф}} \quad (5)$$

where $C^{н}_{исх}$ and $C^{н}_{осm}$ - initial and residual concentration of the oil products in the sewage water, mg/l; $C^{н}_{исх}$ =8.7mg/l

$H_{с.ф}$ - operating height of the sorbent layer, m; $H_{с.ф}$=1.2m.

$K^{Д}_{ф}$ - the efficiency decrease factor of the treatment o the sewages from oil products in the dynamic conditions, depending on other equal conditions from speed of filtration, $K^{Д}_{ф}$ =0.9 at V_o=4m/hour.

Taking into consideration of catching of the dissolved oil products in the sorption section, their output with the treated water is calculated as provided above, and the suspended substances approximately are defined at the effect of catching in the sorption filter of not less than 80%. Hence, in the treated water it can be found upto $C^{вв}_{исх} = 1{,}6 мг/л$ and $C^{н}_{исх} = 0{,}5 мг/л$.

II. CONCLUSION

The monoblock solution of all the unit considerably decreases the area for allocation of all the complex of the sewage water treatment, which is profitable for the refurbishment of the treatment facilities of the existing enterprises and construction of the units for the treatment of the sewages from the territories of the industrial enterprises, particularly of the railway transportation enterprises, which is the primary plan on protection of the environment.

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