STUDYING OF OPTIMAL PARAMETERS OF EXPLOITING ULTRAFIITRATING SYSTEMS DURING WASTE WATER TREATMENT

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Abstract: This work is the analis of modern systems of ultrafiltrations, wich are used in wastewater treatment. As a result of our researches we've got theoretically motivated and practically elaborated techology of wastewater treatment, wich contains iron asparaginat (III). On the base of fact, recived experemtally, the type of plugging memebrane′s pores was established, in deppending from decreasing productivity of memebrane from time; the influence of fallont mass on membrane work was invastigated too. Experimentally optimum datas of woking process of ultrafiltration were conducted; according to that minimal ammouht of rinsate and maximum concentration is created. The mathematic model of ultrafiltrated binetics was made, which allows to forcast the amount of permiate in diffrent concentrations. On the base of itemes above, the installation of wastewater treatment was designed.

Keywords: Ultrafiltration, pollution, reverse leaching, decreasing productivity forecast, biologocal pollution of membrans, fallout, pollution extraction, rinsing water.

INTRODUCTION

For today wastewater treatment, their rational use, meaning extraction of important components and using of modern technologies – is he main task for the scientific works. Ultrafiltration is going to be used more and more like a method of clearing and precleanig for recieving drinking and technical water all over the world.

Ultrafiltration – is the process of membrane separation, and also concentrating and fractionation of high-molecular compounds solutions. It happends under the pressuse from both sides of membrane, that is the starting force of the process and means 0,05 – 0,5 MPa. Depending from the aim of ultrafiltration membranes skip:

- solvent and often (or only) low – molecular compounds (separation of high- and low - molecular compounds and concentration of high - molecular compounds);
- only the solvent (concentration of high - molecular compounds);
- solvent and fractions of high - molecular compounds with certain molecular mass or size of macromolecular tangle (fractionation of polimer compouds).

Ultrafiltration is used for separation of systems, is which molecular mass of soluted components is much higher than the molecular mass of the solvent (water). In practice ultrafiltration is used when even on of the components of the solvent has the molecular mass more then 500 daltons. The solving of the specific task of saparated ultrafiltration is often in compromise decision: using of less permeable membrane, but these one which has high grade of monodispercity of pores, certain surface change or level of gydrofility.

Ultrafiltration – is a new technology. The result of separation are two solutions: one is enriched, anothor is inriched with soluted stull, which is owalluable in the outgoing solution, that is under the separation. Using of this process during separation of the staffs, that are very sensitive to the temperature, are of a great importance, because ultrafiltrated solution are not heated and do not have chemical relationship. According the losses are very low, nearly 20-60 times less, then during distilation.

Ultrafiltrating membranes are taken away very effectively slimdisperce and colloid admixtures, high-molecular solvent, olgeas, axenics, bacteriosand, viruses. At the same time the do not change the solted impact of water.

The principle of ultrafiltrating technological wastewater treatment is in the periodical taking off with the help of hygravlik cleaning of the pollutions. This procces is conducted by "back current", similary to filters with corn loading. That's why "reagentless" technology of ultrafiltrating considers as a "future technology" in the whole world [1-7].

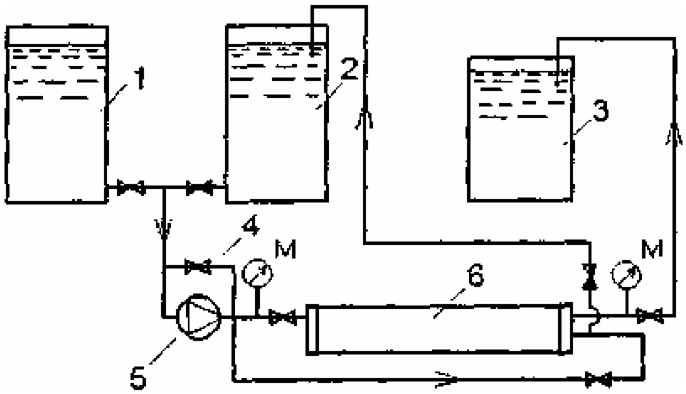
The task, we put - is clearing of wastewater, that are formed in the process of recieving iron compound, like a medicine for iron treatment of (for iron-deficiency anaemic treatment). In this case the wastewater is produced, which has compound - asparginate Fe, the amount is much more then MPC-maximum permissible concentration (concentration of iron asparaginat (III) – 26,6 mg/l, MPC (Fe) – 0,5 mg/l.). It is impossible to let the water to the sewerage facilities, because even with the concentration of Fe in the water more then 5 mg/l has the negative influence to the micro system of the biologycal cleaning. Compounds of iron are very toxic and have a negative influence to the stomak of humans.

Dissertation of General methodics and of main methods of investigations.
In the investigation process of ultrafiltrated separation of wastewater, the model solution was the iron asparaginat (III). It was necessary to prepare the methodics of analysis in teaching iron asparaginat (III) in water solution. As the analytic method of analysis was chosen method of spectrophotometry.

Methodics of theaching of kinetics' process of ultrafiltration.
Studying kinetic process of wastewater treatment from iron compound by ultrafiltrating method is provided on the lab plant (Fig. 1), which consists of the pomp, UF element in the case, the capacities for outgoing water, permiat and concentrate, estimated-measuring equipment. During the experiment the content of polutions of outgoing water end rinsate, the productivity of membrane, volume of the filtrate and rinsing water are investigated.

So, the experiments are provided during three different concentrations of the exeminated solution. (10 mg/l, 15 mg/l, 25 mg/l)

Methodics of investigation is so: 50 ml of outgoin solution (from waste water, which contains iron compounds, i.e. iron asparaginat) from the capacity of outgoing water 1 goes to main module (ultrafiltrating apparate, which consists of membrane (d=43mm capillary type)-6, where the process of separating of liquid for two streams concentrate, which goes to capacity for collecting concentrate- 3 and permeate which goes to capacity for collecting permiate -2.



1. the capacity of outgoin water;
2. the capacity of permiate;
3. the capacity of concentrate;
4. pulling line;
5. pump;
6. UF apparate

Figure 1. The scheme of ultra filtrating lab. Equipment.

From the beginning of the experiment we can see the time of loading of ultra-filtration. After some period of time the volume of permiate is measured, which comes from capacity 6. the same operations are conducted for two other concentrations.

This mechanism is based on the principle of "screening", it means the diametr of pores of membranes is so to let the molecules of the water (solvent) and to keep the molecules of the dissolved substance. This process is going as a result of costant differenceof pressure, that is equal 1 atm (Fig. 1, pump 5).

The results of Calculations.

Math.model equal: $V = (V^* - C^p) \cdot [1 - \exp(-k \cdot t)]$

$V^* = 19.20$; $p = 0.857$; $k = 0.0159$

Adequate dispersion Da = 0.23372 ; Middlesquare evasion Sv = 0.4835

Table 1. Comparison of Experimental and Calculated Results

t_i	C=10 mg/l		C=15 mg/l		C=25 mg/l	
	V ij (calc.)	V ij (exp.)	V ij (calc.)	V ij (exp.)	V ij (calc.)	V ij (exp.)
5	0.9175	0.9000	0.6890	0.6000	0.4714	0.4000
15	2.5475	2.8000	1.9132	2.3000	1.3090	1.1000
30	4.5544	4.5000	3.4204	4.0000	2.3402	2.0000
60	7.3810	7.5000	5.5432	5.7000	3.7926	3.7000
90	9.1354	9.0000	6.8607	6.6000	4.6941	5.3000
120	10.2242	10.0000	7.6784	7.0000	5.2535	6.0000
150	10.8999	11.0000	8.1859	7.3000	5.6008	6.1000
180	11.3193	11.5000	8.5009	7.6000	5.8163	6.1500
240	11.7412	12.0000	8.8177	7.9000	6.0330	6.2000
300	11.9037	12.5000	8.9397	8.2000	6.1165	6.2500
360	11.9663	13.0000	8.9867	8.5000	6.1487	6.3000

Discussion of the Results.

So, the solution, that comes to the machine is separated by the membrane for two parts: permiate (the water, that has iron asparaginate in less concentration), and concentrate.

On the base of reciwed datas we have a drawing of dependance of the volume of permiate from time of going the process (Fig.2). As we can see from the drawing, with the time the volume of permiate is growing up similary to three concentrations.

At the beginning the volume of permiate increasing rapidly which characterized by the curve from point 5 to point 150 min., and then from point 160 min. its volume increasing not significantly by permanent equal amount. It means that in time the productivity of membrane decreases as a result of plugging of pores by iron asparaginat, as described below. The more concentration is, the less volume of permiate is at the same time of the process.

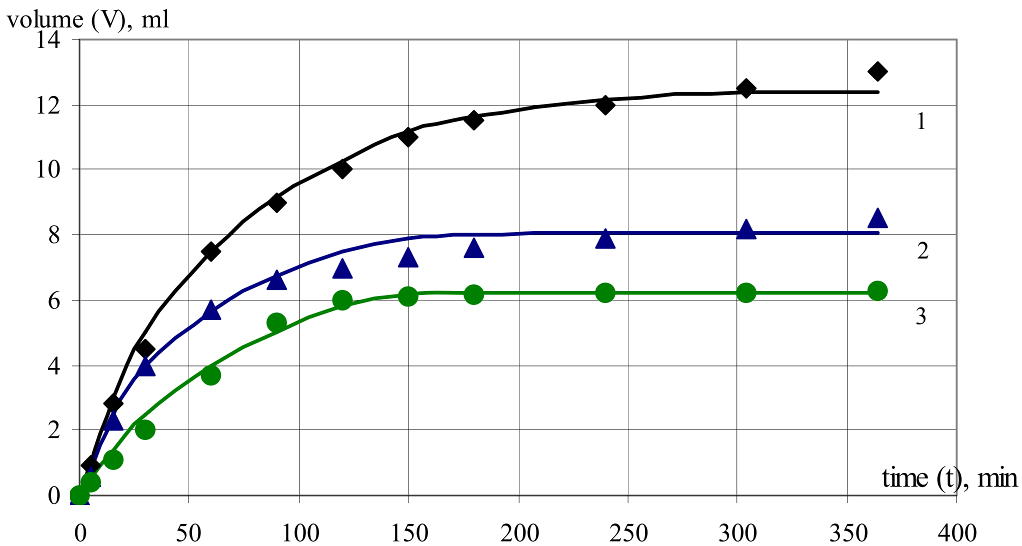


Figure 2. Drawing of Dependance of the volume of Permiante from the Time of the Process. (*1*-10 mg/l, *2*-15 mg/l, *3*-25 mg/l)

On the beginning stages of membrane pollutions the process of falling of productivity is under the influence of external and internal pores of membranes the presence of corporated pores. That's why it is quite difficult to assess which mechanism does the process of ultrafiltrating on membranes follows.

The investigation of dependence of productivity of ultrafiltration from time, shows that after primary fast lowness, further lowness of stream through the membrane comes very slowly, because of the growth of fallout. This stage is responsible to lineal cut in coordinates t/q-q or t/q-t, which can be inclined or parallel to the axis of abscissa. Figure 3 shows typical dependence of ultrafiltration suspensions in coordinates t/q-q for membranes with different sizes of pores.

With the existence of the stage of plugging of pores, the sketch on the primary segment is going up rapidly, as a result of fast reduction of productivity in the first moments of ultrafiltration. The length of linear segment depends on temps of growth of fallout and relationship of the strength of the membrane and of the coat of the fallout. The fall of productivity, caused by growth of fallout on the surface of membrane machine and as a result of not full cleaning of fallouts after reverse rinsing [9-10]

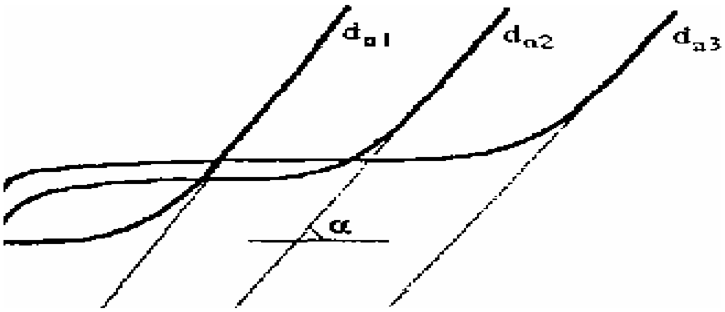


Figure 3. Sketches of ultrafiltration on membranes with different sizes of pores with permanent (permeate) concentration of suspended particles in outgoing waters. According to the literature [8].

1-the sketch of ultrafiltration with plugging each pore with one part;
2-with step- by- step of one pore with several parts;
3-filtration by interval type.

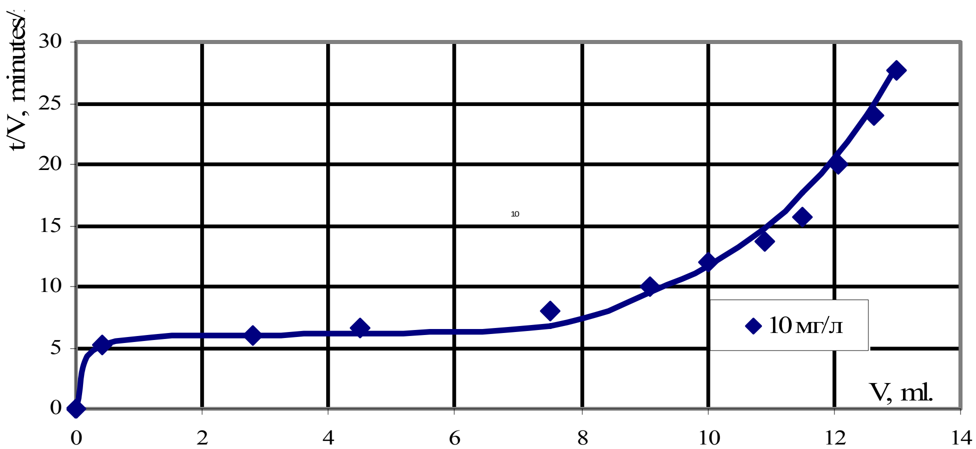


Figure 4. Drawing of Dependence t/V-V
Concentration of investigated liquid-10 mg/l

In comparison received experimentally drawing (Fig.4 t/V-V) with the drawing given in literature (Fig.3. – drawing of comparison), we can see, that relation of height (h) to length (l) is equal lik 1:2; except this the received sketch is similar to the sketch 3 (Figure 3), it means that in this process of ultrafiltration the type of buffer filtration is present (when size of pores proportionate with the sizes of particles), which is convoyed by plugging of the pores with further increasing of fallouts (precipitate) on the surface of membrane.

Plugging of the pores and accumulating of precipitate on the surface of membrane lead to falling down of productivity in time which represents in gradual increasing of the curve from the point 50 min., i.e. the real time of the filter cycle, when the process of regenerating of membrane is carried an by rinsing with distilled water, varies from 40 min. to 50 min. After 50 min. of carrying out of the process the membrane is regenerated by so called chemical rinsing, i.e. already with using of chemical substances. After falling down of the membrane productivity, it became useless for carrying on the process.

As was marked above, the productivity of membrane becomes lower, which is connected with the plugging of fallout on the walls of pores of membrane.

On the base of received calculation, we built the drawing of dependence of productivity (Q ml/min) from time (t, min) for three different concentrations (10,15,25 mg/l)-(Fig. 5) where decreasing of average productivity of membrane equipment during certain time for different concentrations of iron asparaginat in outgoing solution is shown.

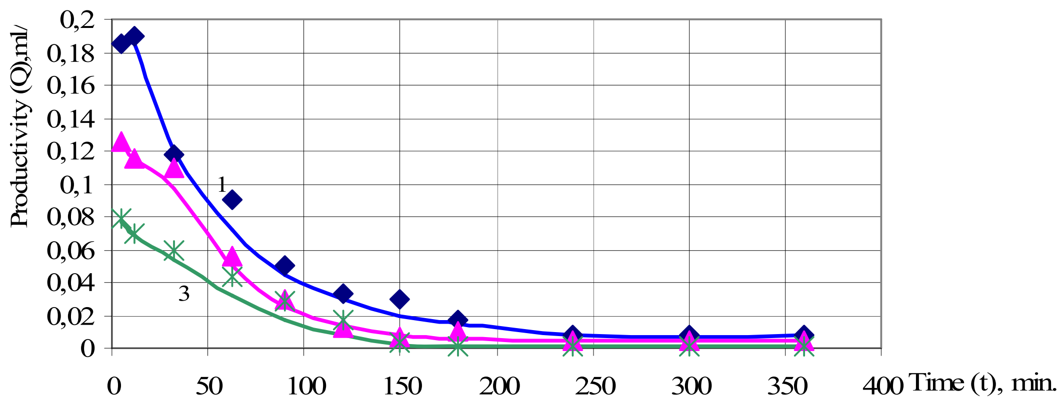


Figure 5. Drawing of dependence of productivity of membrane from time of the process of ultrafiltration (*1*-10 mg/l, *2*-15mg/l, *3*-25 mg/l).

On the drawing we can see that the regime of work, that was chosen, doesn′t provide effective removal of precipitate with Fe(3+) - 25mg/l in the outgoing water, because the productivity of membrane is falling down and on the minute 180 the process of ultrafiltration practically is not provided; the membrane becomes not workable, because of plugging of its pores and because of the fallout on its surface (this process is on the min. 200-240) in dependence of concentration, etc.

For productivity falling prognosis, we need to know which amount of pollutions would be left on membrane after each cycle of filtration, and after which period of time the amount of pollutions would be quite enough to provide falling down of productivity maximum acceptable for such system.

The paces of growing of fallout depend on regime of ultrafiltration plant – time of filtre cycle tf , intensity of back washing, concentration of outfall water pollutions. With the given time tf effectiveness of machine′s work depends on length of trins : the more trins., the more effectively the washing of membrane from pollution, but more rinsing water created with that. From the other side with the growth of filter cycle tf , the frequency of washings becomes less, but in that case the average productivity of equipment decreases. The research on optimization aims to find out such values of tf and trins. for different compound of water cultivated, which would correspond to maximum amount of purified water received during certain amount of time.[11-12]

The filtration pressure was 1 atm; time of filtration (filter cycle) was 15-50 minutes. The back washing was provided by turning of membrane to other side and by its further washing by clean water, washing out of polluted particles, which plugging pores. The process is provided for concentration 10 mg/l of polluted contents in wastewater. The experiments are provided in 15, 30, 40, min. time of ultrafiltration and in 30 seconds of washing. In the process of investigation the volume of permiate for three cases and volumes of rinsing water are considered.

Optimal relation of length of filtration (filter cycle) and washing is produced under max. useful productivity of membrane machine.

Vus = Vf-Vrins , Vrins–volume of rinsing waters, ml; Vf-volume of filtrate (permeate), ml; Vus - volume useful, ml

Based on carried out researches we built up a drawing of determine of optimal duration of filter cycle using the duration of rinsing time 30 seconds (Fig.6).

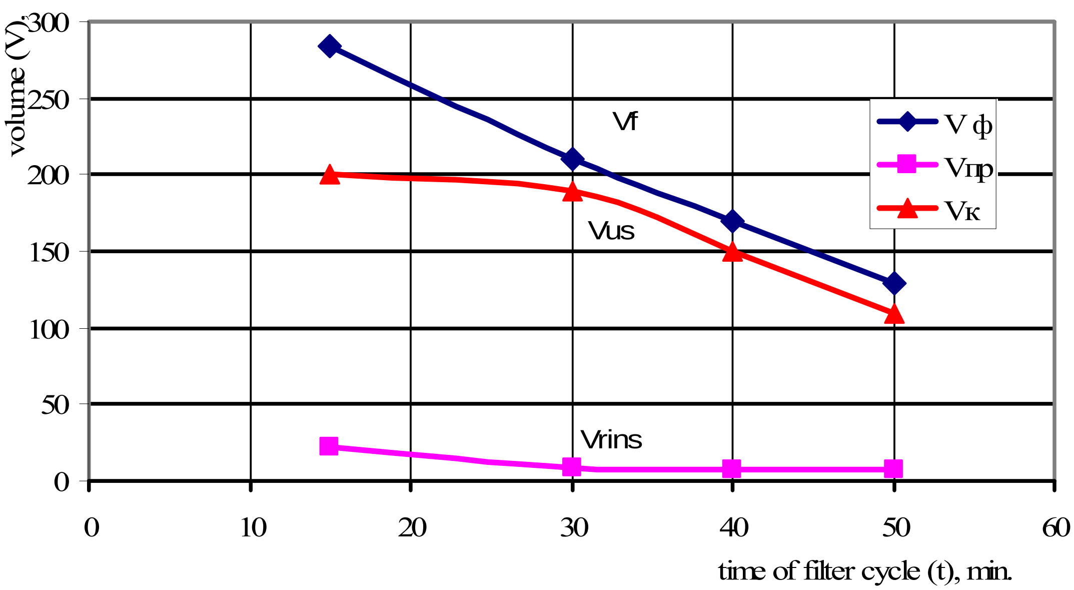


Figure 6. Drawing of optimal length of filtration (filter cycle) when the length of washing (rinsing) is 30 seconds.

Analyzing this drawing we see that the point of bend of the sketch of useful volumes is the point of optimum of the given process; it means that with the length of filtration in 30 seconds the minimal amount of washing waters (rinsing water) will be provided and max. amount of concentrate, which later on returnes for recycling.

Also using the same duration of filter cycle, i.e. after each 30 min. of filtrating process and 30 sec. of rinsing, the membrane would continue to work as long, as it could without chemical regeneration, which is unwanted for that process, the chemical regenerating of membrane is carried out by washing it with hydrochloric acid excess, and this in due course leads to obtaining acid wastewaters, which have to be neutralised, i.e. the question of additional cleansing of wastewaters arising.

Basing on upper questions, the calculation of industrial plant was provided – it was marked the amount of membranes, that will be needable for effective process of cleaning (12 membranes).

CONCLUSIONS

1. In the result of theoretical and practical investigations the technology of cleaning wastewaters that include iron asparaginate (III) was producted, that is the final product in inductry of ironed compounds and optimal regimes of ultrafiltration process was provided.
2. Based on experimentaly received datas – the type of plugging membranes′ pores was produced, that allouds to mark theoretical time of filtration of the process, and also shows the time of falling down the productivity of membrane .
3. Experimentally was marked that the amount of permeate is growing with the time, and the productivity of membrane is fallen down in dependence from concentration.
4. The influence of the mass of fallout that occurs in the result of plugging of pores was investigated too: the more is the mass – the less is the productivity
5. Optimal parameters of the working process where chosen experimentally, during which the minimal amount of washing waters and max concentrate (30 minutes) are produced. This will be the best time for membrane to work, without chemical regeneration.
6. Mathematical model of ultrafiltration kinetics was conducted. According to the results the adequancy of the model was provided. Relative error in math and theoretical models is 9 %.
7. It was provided industrial plant calculation, the calculations of the process on the base of laborant datas. According to this datas the working surface is equal to 2,96 m^2. Just this surface lets this scheme of cleaning to be provided with the concentration of iron 0,38 mg/l, that is not more then MPC-maximum permissible concentration (0,5 mg/l).

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