DOI: 10.2429/proc.2015.9(2)060 2015;9(2)

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APPLICATION OF THE TRIAL RESEARCH SET FOR PRETREATMENT OF CASINGS PROCESSING WASTEWATERS

WYKORZYSTANIE PILOTAŻOWEGO ZESTAWU BADAWCZEGO DO PODCZYSZCZANIA ŚCIEKÓW Z JELICIARNI

Abstract: The designed research set of capacity up to 1.0 m^3/h for testing physicochemical methods of raw industrial wastewaters pretreatment directly at the source of their origin or storage was presented. The installation built on the mobile pallet is equipped with the cylinder-conical central flotation chamber with the surface flotation fodder, pipe reactors, where the chemical reagents are dosed from the preparation and dosing stations and processing units where the dispersed air flotation or dissolved air flotation or oxidation aided with hydrogen peroxide in accordance with own invention. The subject set can be used to optimize different physicochemical pretreatment methods, including coagulation, chemical precipitation and final separation of dispersed phases with the use of the mentioned above flotation methods. The experimental conditions and the obtained reductions of indicator values with the application of the subject research installation were set for the selected wastewaters from casings processing.

Keywords: mobile research installation, pretreatment of wastewaters from casings processing department, flotation

Introduction

Technological wastewaters generated by a conventional casings processing department mainly originate from the degumming process on frames, during which grinding, softening in wash water, burnishing, final grinding, degumming and debonding are frequently used [1-4]. The second important process generating the essential pollutants load is intestines sorting which includes the quality control from the point of view of the occurrence of perforation, measurements and sorting in accordance with the size, arrangement in bunches and salting as well as final packaging [1-4]. Also, general technological wastewaters may sometimes contain the pollutants load originating from the incomplete or inadequately run process of their preliminary treatment and cleaning of animal intestines from the remains of the easily decomposed feed, the remains of fat and entrails which should be removed at the stage of slaughtering [1, 4]. The typical pollutants load in general technological wastewaters generated by casings processing departments contains significant amounts of salts (mainly NaCl), total suspended solids (TSS), etheric extract (EE) and significant concentrations of loads of chemical and biochemical oxygen demand (COD & BOD_5), mainly originating from intestinal mucus [1, 2]. The known methods of physicochemical pretreatment of technological wastewaters from such production are mainly based on the application of coagulation [5] and microcoagulation methods induced by electrolysis [6, 7], the application of membrane processes [8, 9] or these methods additionally aided with oxidation [10-13]. However, the known methods of full treatment generally consist in physicochemical stages of preliminary pretreatment as the ones mentioned above, and at the

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[*] Contribution was presented during ECOpole'15 Conference, Jarnoltowek, 14-16.10.2015

second stage in the application of biological methods based on for example the activated sludge with the low concentration [14] or other active sludge variants cleaning in the conditions with the high concentrations of chlorides [4, 9]. The other known method of neutralizing are agroutilization processes which consist in their application in order to hydrate and to a smaller extent for the fertilization features of the subject wastewaters [15]. In order to work out the detailed wastewaters treatment technologies from such productions, apart from choosing the optimum method, the key aspect is the determination of sequence of work of particular processing bonds and their efficiency. Many operations and unit processes applied to processing of wastewaters from the tested casings processing department in laboratory scale, undergo the problem of scale - up during their practical use - at the stage of implementation. In case of low-tonnage quantities of wastewaters, to which wastewaters generated by casings processing departments belong, the key issue before the stage of project work is to assume the treatment conditions selected in laboratory scale and verified during the next processing scales.

The aim was to work out the effective method of physicochemical pretreatment of wastewaters generated from the degumming and sorting processes of animal intestines as well as the processing conditions on the self - constructed experimental installation for testing the methods, including the ones used in conditions concerning the flow technology [16, 17].

Experimental part

Construction of experimental installation

The mobile experimental installation for testing physicochemical methods of industrial wastewaters pretreatment was presented in a detailed form in paper [17]. The experimental set was constructed on the moveable palette and consisted in the following processing bonds: a) central air dispersed flotation chamber equipped with surface flotation fodder and two pipe reactors, b) the self-invented saturation - dispersion scheme [16] and the pressure saturation chamber, c) the operating panel for steering and process optimization, d) stations for preparing and dosing chemical reagents. In case of the variant with continuous work of the experimental installation, the raw wastewaters after exact averaging were directed to the pipe reactor (or two pipe reactors), where reagents were introduced in a form of flow. In case of such mode of work, the cylinder - conical volume functions as a dispersed chamber for the flotation scheme at the same mechanically separating of the concentrated by flotation dispersed phases with the use of surface flotation fodder. The flocculant in this option is dosed at the intake to the dispersed chamber. Depending on the applied flotation technique, the saturation tank is used (DAF technology) or the scheme of connected in rows aeration modes (to the volumes to which air is pumped under pressure) consisting in permanently concentrically arranged cylindrical membrane aeration devices and external cylindrical pump chambers, to which wastewaters are introduced with the linear speeds enabling optimum air saturation (IAF technique) [16]. The exemplary experimentally set parameters regarding physicochemical pretreatment with the use of the mentioned above flotation techniques were set in Tables 1 and 2.

Analytical part

The elimination efficiency of particular loads was determined in accordance with standards for water and wastewaters: reaction (pH) (PN-EN ISO 10523:2012), total suspended solids (TSS) (PN-EN 872:2007), determination of chemical oxygen demand COD by dichromate method (PN-ISO 15705:2005 and PN-ISO 6060:2006), determination of biochemical oxygen demand BOD_n by the dillution method (PN-EN 1899-1:2002 and PN-EN 1899-2:2002), determination of total nitrogen (TN) (PN-EN 25663:2001), total phosphorus (TP) (PN-EN ISO 6678:2006) and etheric extracte (EE) PN-ISO (PN-86/C-04573.01). In case of application of hydrogen peroxide, the value correction was introduced for the determination of COD. The value of real chemical oxygen demand was given after correcting its value by subtracting the mass participation introduced by the residual hydrogen peroxide on the basis of the following relation $COD_r = COD_p - f \cdot c$ (COD_r - real, COD_p - determined in the sample after the reaction is over, c - H_2O_2 concentration in a sample determined iodometrically, $f = 0.25$ - correction ratio, assumed on the basis of literature data [18, 19]).

Results and discussion

During the period of time of carrying out tests, basic parameters concerning raw wastewaters from degumming and sorting processes were registered at typical levels of values (Tables 1 and 2) comparable with the available literature data [1, 15]. The aim was to find out such a physicochemical method of pretreatment for the flow conditions, which apart from high efficiency of reduction of the basic TSS, EE, COD & BOD_5 and TN & TP loads would allow to eliminate the potential loads of microbiological charges, which presence in such streams cannot be excluded. On the basis of preliminary samples, one-stage coagulation with final flocculation with the use of flocculant Praestol 859 BC (Stockhausen) was selected for the physicochemical pretreatment of raw wastewaters. The application of flocculation before the stage of separation by flotation results in measureable reductions in basic indicator values. However, they are at relatively low level and within the wide range of percentage reductions (Tables 1 and 2). It is induced mainly by condensation of the dispersed phases of colloidal and suspension protein and fatty complexes as well as oligo- and/or polysaccharides, especially in the form of components of raw intestines mucus and the remains of viscera. In case of such type of pretreatment, the differences in the reduction levels of particular parameters according to the applied flotation technique are vague for wastewaters from the process of degumming or sorting. Additional aiding the flotation with aggregated hydrogen peroxide pollutants results in a slight increase in effectiveness of the separation level of TSS, EE, COD & BOD_5 loads. Separated flotates are resistant to gravitational and pressurized dehydration. Lime milk in form of 7.5% solution was selected from the group of coagulants tested in a laboratory as the most effective one to accomplish the assumed processing and sanitary aims. The application of this coagulant and flocculation with the mentioned polyelectrolyte results in significant improvement in quality parameters at the installation outlet and the evident increase in the reduction level of the indicator values (Tables 1 and 2) while the deposits sediments can be distinguished by the beneficial susceptibility to their gravitational or

pressurized dehydration, which is connected with the increase in CaO, $Ca_3(PO_4)_2$ and lime soaps participation in these flotates' dry mass.

Table 1

Examples of wastewaters from the casing separating plant for which methods of physicochemical pretreatment have been developed to be applied for verifying the process in semi-technical scale of the presented here testing set

No.	Pretreatment method	Raw effluent parameters (concentration)	Reduction levels [%]	Used flotation type[b)]
1	final flocculation (Praestol 859 BC)	COD (2650-6740 mg/dm^3) BOD_5 (1070-2590 mg/dm^3) EE (149-310 mg/dm^3) TN (173-283 mg/dm^3) TP (22-58 mg/dm^3)	19-32 15-27 57-74 6-14 2-6	IAF (pH = 6.69-7.33) (air pressure: 200-210 kPa, recirculation level 10%)
2	final flocculation (Praestol 859 BC)	COD (3440-5370 mg/dm^3) BOD_5 (1460-2140 mg/dm^3) EE (117-299 mg/dm^3) TN (132-201 mg/dm^3) TP (11-48 mg/dm^3)	23-34 16-30 65-84 5-10 3-7	OxIAF (pH = 6.80-7.40) [a)] (air pressure: 200-220 kPa, H_2O_2 dose - 120-140 g/m^3, recirculation level 5%)
3	final flocculation (Praestol 859 BC)	COD (2960-4680 mg/dm^3) BOD_5 (1220-1840 mg/dm^3) EE (88-303 mg/dm^3) TN (92-227 mg/dm^3) TP (17-55 mg/dm^3)	24-35 19-28 71-86 4-9 3-7	DAF (pH = 6.73-7.27) (saturation pressure: 300 kPa, recirculation level 5%)
4	final flocculation (Praestol 859 BC)	COD (2450-3820 mg/dm^3) BOD_5 (980-1570 mg/dm^3) EE (126-211 mg/dm^3) TN (109-166 mg/dm^3) TP (23-39 mg/dm^3)	29-35 26-31 77-88 6-12 3-8	OxDAF (pH = 6.94-7.51) [a)] (saturation pressure: 300 kPa, H_2O_2 dose - 90-110 g/m^3, recirculation level 5%)
5	coagulation and precipitation with lime milk and final flocculation (Praestol 859 BC)	COD (3070-4310 mg/dm^3) BOD_5 (1280-1770 mg/dm^3) EE (137-244 mg/dm^3) TN (64-199 mg/dm^3) TP (26-38 mg/dm^3)	60-66 48-59 > 98 9-17 76-80	OxIAF (pH = 8.75-9.14) [a)] (air pressure: 200 kPa, H_2O_2 dose - 50-65 g/m^3, recirculation level 10%)
6	coagulation and precipitation with lime milk and final flocculation (Praestol 859 BC)	COD (2790-4010 mg/dm^3) BOD_5 (1070-1620 mg/dm^3) EE (141-341 mg/dm^3) TN (92-227 mg/dm^3) TP (14-54 mg/dm^3)	67-71 51-63 > 98 12-20 78-81	OxDAF (pH = 8.64-9.05) [a)] (saturation pressure: 300 kPa, H_2O_2 dose - 50-55 g/m^3, recirculation level 5%)

[a)] flotation technique acc. to Author's solution [16]

[b)] different types of applied flotation techniques for final separation of the dispersed phases are marked as follows: IAF - induced air flotation, DAF - dissolved air flotation, OxIAF or OxDAF - flotation using induced air and dissolved air enhanced by the oxidation with hydrogen peroxide

Aiding the flotation with hydrogen peroxide does not significantly influence the efficiency of the processes of charges' reduction but it only allows to change the process parameters (for instance lower levels of saturation pressure, lower recirculation levels). However, this aiding reagent needs to be dosed within the concentrations range and the range of reaction values preventing its sudden decomposition together with the liberation of molecular oxygen. Lime milk components and hydrogen peroxide are the reagents significantly increasing the sanitary safety of industrial wastewaters processing, which is

also the notable aspect concerning such productions that must satisfy the determined veterinary criteria.

Table 2

Examples of wastewaters from the mucous stripper plant for which methods of physicochemical pretreatment have been developed to be applied for verifying the process in semi-technical scale of the presented here testing set

No.	Pretreatment method	Raw effluent parameters (concentration)	Reduction levels [%]	Used flotation type[b)]
1	final flocculation (Praestol 859 BC)	COD (1560-2770 mg/dm^3) BOD_5 (850-1430 mg/dm^3) EE (97-211 mg/dm^3) TN (214-297 mg/dm^3) TP (25-38 mg/dm^3)	18-26 12-21 49-78 6-15 2-5	IAF (pH = 7.15-7.63) (air pressure: 200-220 kPa, recirculation level 10%)
2	final flocculation (Praestol 859 BC)	COD (1830-2910 mg/dm^3) BOD_5 (1120-1750 mg/dm^3) EE (132-187 mg/dm^3) TN (155-198 mg/dm^3) TP (8-31 mg/dm^3)	22-31 14-24 76-85 5-14 3-6	OxIAF (pH = 7.27-7.77) [a)] (air pressure: 300-310 kPa, H_2O_2 dose - 210-220 g/m^3, recirculation level 5%)
3	final flocculation (Praestol 859 BC)	COD (2210-2630 mg/dm^3) BOD_5 (1180-1480 mg/dm^3) EE (140-170 mg/dm^3) TN (277-349 mg/dm^3) TP (34-43 mg/dm^3)	22-32 12-25 81-93 6-11 2-6	DAF (pH = 7.70-8.21) (saturation pressure: 300 kPa, recirculation level 10%)
4	final flocculation (Praestol 859 BC)	COD (1870-2730 mg/dm^3) BOD_5 (980-1610 mg/dm^3) EE (249-407 mg/dm^3) TN (264-295 mg/dm^3) TP (14-39 mg/dm^3)	24-32 16-23 89-95 8-13 3-7	OxDAF (pH = 7.06-7.38) [a)] (saturation pressure: 300 kPa, H_2O_2 dose - 90-110 g/m^3, recirculation level 5%)
5	coagulation and precipitation with lime milk and final flocculation (Praestol 859 BC)	COD (1880-2540 mg/dm^3) BOD_5 (940-1510 mg/dm^3) EE (130-244 mg/dm^3) TN (187-203 mg/dm^3) TP (21-38 mg/dm^3)	52-64 45-53 79-91 8-15 63-78	OxIAF (pH = 8.80-9.33) [a)] (air pressure: 200 kPa, H_2O_2 dose - 50-60 g/m^3, recirculation level 10%)
6	coagulation and precipitation with lime milk and final flocculation (Praestol 859 BC)	COD (2380-2660 mg/dm^3) BOD_5 (1270-1470 mg/dm^3) EE (177-431 mg/dm^3) TN (152-201 mg/dm^3) TP (12-34 mg/dm^3)	60-73 54-69 82-96 10-16 76-80	OxDAF (pH = 8.81-9.23) [a)] (saturation pressure: 300 kPa, H_2O_2 dose - 50-60 g/m^3, recirculation level 10%)

[a)] flotation technique acc. to Author's solution [16]

[b)] different types of applied flotation techniques for final separation of the dispersed phases are marked as follows: IAF - induced air flotation, DAF - dissolved air flotation, OxIAF or OxDAF - flotation using induced air and dissolved air enhanced by the oxidation with hydrogen peroxide

The mixed wastewaters from the process of degumming and the process of sorting were subject to physicochemical processing with lime milk with final flocculation at the comparable level of reduction of the basic indicator values, where the increase in the participation of the wastewaters volume from the sorting process indicated the tendency to lower the reduction decrease levels of the analyzed indicator values. The deciding factors were also the intensity of mixing and the influence of salts concentration on the efficiency of the separation processes - the significant influence of these parameters on the phenomenon and intensity of foaming during the flotation release of the condensed pollutants were observed. The increase in salts concentration and the intensity of mixing

(for example due to pumping through the system consisting in two series of pipe reactors) probably resulted in the increase in the concentration of sodium soaps in the volume of the treated wastewater, which resulted in periodic disturbances in the coagulation process and precipitation of insoluble lime soaps.

Conclusions

Physicochemical pretreatment of technological wastewaters generated by conventional casings processing department may consist in the application of coagulation based on lime milk combined with flocculation with the extremely cationic flocculant. Then at the doses above 50 g H_2O_2/m^3, the process of separation of the aggregated pollutants by flotation can be additionally aided with this reagent. The additional, beneficial result of applying the alcaic coagulation reagent and the oxidant in form of hydrogen peroxide is hygienisation of the pretreated stream, which can significantly eliminate or reduce the incidental microbiological infections [20].

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WYKORZYSTANIE PILOTAŻOWEGO ZESTAWU BADAWCZEGO DO PODCZYSZCZANIA ŚCIEKÓW Z JELICIARNI

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Abstrakt: Przedstawiono skonstruowany zestaw badawczy o przepustowości do 1,0 m^3/h do testowania fizykochemicznych metod podczyszczania surowych ścieków przemysłowych bezpośrednio u źródła ich powstawania lub gromadzenia. Zbudowana na mobilnej palecie instalacja jest wyposażona w cylindryczno-stożkową centralną komorę flotacji z powierzchniowym zgarniaczem flotatu, reaktory rurowe, do których dozowane są reagenty chemiczne ze stacji ich przygotowania i dozowania, oraz zespoły procesowe do prowadzenia flotacji technikami zdyspergowanym lub rozpuszczonym powietrzem albo z zastosowaniem wspomagania utlenianiem nadtlenkiem wodoru według własnego wynalazku. Za pomocą przedmiotowego zestawu można optymalizować różne metody fizykochemicznego podczyszczania z zastosowaniem między innymi koagulacji, strącania chemicznego oraz do finalnego wydzielania faz zdyspergowanych wymienionymi technikami flotacji. Dla wytypowanych ścieków powstających podczas przetwórstwa jelit przedstawiono ustalone doświadczalnie warunki oraz uzyskiwane wyniki poziomów redukcji wielkości wskaźnikowych z zastosowaniem omawianej instalacji badawczej.

Słowa kluczowe: mobilna instalacja badawcza, podczyszczanie ścieków z jeliciarni, flotacja