Современная наука и инновации.
2023. № 2(42). С. 95-101
Modern Science and Innovations.
2023; 2(42):95-101

ТЕХНОЛОГИЯ ПРОДОВОЛЬСТВЕННЫХ ПРОДУКТОВ /
TECHNOLOGY OF FOOD PRODUCTS

Научная статья / Original article

УДК 663.86.054.2
DOI: 10.37493/2307-910X.2023.2.9

Марина Александровна Новикова
[Marina A. Novikova]**,**
Максим Владимирович Гончаров
[Maksim V. Goncharov]**,**
Дмитрий Владимирович Сызранцев
[Dmitrij V. Syzrancev]**,**
Геннадий Валентинович Алексеев
[Gennadij V. Alekseev]

Интенсификация процесса очистки сточных вод для ее вторичного использования на пищевых предприятиях

Intensification of the wastewater treatment process for its secondary use in food enterprises

[1] Национальный исследовательский университет «МЭИ» (филиал) г. Смоленск, Россия / Moscow Power Engineering Institute (branch) Smolensk, Russia, mar.novikova@ro.ru
[2] Национальный исследовательский университет ИТМО, Санкт-Петербург, Россия / ITMO University, St. Petersburg, Russia, romanchikovspb@mail.ru

Аннотация *На сегодняшний день вопросы ресурсосбережения все больше волнует человечество, в связи с этим становиться перспективными вопросы вторичного использования сырья и вспомогательных материалов. В среднем на пищевых предприятиях используется около 50 м^3 воды в смену, эта вода помимо основного технологического процесса используется на вспомогательные операции. В статье были проанализированы стандартные методы очистки сточных вод от загрязнений и современные способы повышения качества очистки.*

Ключевые слова: ресурсосбережение, экология, вторичное использование, очистка воды, сточные воды, производственный цикл.

Для цитирования: Новикова М. А., Гончаров М. В., Сызранцев Д. В., Алексеев Г. В. Интенсификация процесса очистки сточных вод для ее вторичного использования на пищевых предприятиях // *Современная наука и инновации. 2023. №2 (42). С. 95-101. https://doi.org/10.37493/2307-910X.2023.2.9*

Abstract *To date, the issues of resource conservation are of increasing concern to mankind, in this regard, the issues of the secondary use of raw materials and auxiliary materials are becoming promising. On average, food enterprises use about 50 m^3 of water per se, this water in addition to the main technological process is used for auxiliary operations. The article considered standard methods of wastewater treatment from pollution and modern ways to improve the quality of treatment*

Key words: resource conservation, ecology, recycling, water purification, waste water, production cycle.

For citation: Novikova M. A., Goncharov M. V., Syzrantsev D. V., Alekseev G. V. Intensification of the wastewater treatment process for its secondary use in food enterprises. *Modern Science and Innovations. 2023;2(42):95-101. https://doi.org/10.37493/2307-910X.2023.2.9*

According to the definitions, wastewater is water obtained after human activities and supplied for treatment at treatment facilities. At the moment, wastewater is one of the main sources of pollution of the biosphere. Due to the large amount of wastewater and the heterogeneous

composition of contaminants at wastewater treatment plants, it is necessary to use a variety of treatment methods [1,2].

Most often, at enterprises, the resulting wastewater is discharged for treatment into citywide wastewater treatment plants; pollution generated at food enterprises requires additional treatment.

Wastewater received after technological processes at industrial enterprises can be divided into three categories:

- contaminated, containing fats;
- contaminated lean;
- uncontaminated.

Wastewater from food enterprises is characterized by high levels of BOD, COD, nutrients, and fats (Table 1). These indicators do not allow the discharge of wastewater, without prior treatment, into general utility systems.

Table 1. The composition of wastewater from some food industries

Indicators	Branches of the food industry				
	Meat processing	Dairy processing	Fish processing	Confectionery	Brewery
Suspended solids g / dm ^{3}	1.5-2.0	0.30-0.60	1.30-1.35	1.38	0.50-0.60
pH	6.5-8.5	6.0-8.0	7.0-8.0	7.0-7.5	7.0-7.5
COD g/dm ^{3}	1.60-2.00	1.50-3.00	1.08-2.00	2.50-3.00	1.20-1.50
BOD g/dm ^{3}	0.80-1.50	1.20-1.40	0.59-1.30	2.00-2.50	0.80-1.00
Fat content g / dm ^{3}	0.20	0.10	0.98-0.10	0.11	-

The requirements that apply to the quality of wastewater can be very different and are determined by the intended purpose.

The treatment facilities use multi-stage cleaning, at each stage of cleaning the main quality indicators are monitored. According to regulatory documents, the maximum allowable concentrations of treated water do not depend on the degree of initial pollution and must correspond to the established figures (Table 2).

Table 2. Maximum permissible concentrations of the main indicators of the quality of treated wastewater

Indicators	MPC for discharge from urban wastewater treatment plants (GOS)
Suspended solids g / dm ^{3}	0.30
pH	6-9
COD g/dm ^{3}	0.50
BOD g/dm ^{3}	0.30
Fat content g / dm ^{3}	0.05

The degree of wastewater pollution at modern industrial enterprises provides for the presence of preliminary wastewater treatment by the enterprise itself. Economic pressure from the municipal water utilities and the state, in the form of increased tariffs and fines, puts before the specialists of industrial enterprises the task of using effective cleaning methods and combining standard methods with modern ones.

The following standard methods are used for wastewater treatment:

- mechanical;
- biological;

- chemical;
- physical and chemical;
- electrochemical.

Scientists from different countries are actively engaged in the development of a technological scheme for wastewater treatment from organic pollution, however, despite the fact that the prospects for the use of multi-stage technologies for complex wastewater treatment for food production have been proven, it is necessary to develop a technologically efficient and economically sound treatment scheme.

As experience shows, standard methods do not always allow obtaining a degree of wastewater treatment that would be acceptable for the recycling of these waters in enterprises.

When solving the problems of wastewater treatment, the problems of separation of emulsions are most often considered. Emulsions are a heterogeneous system of two liquids, one of which is distributed into the other, in the form of immiscible droplets.

The theoretical basis for the separation of emulsions is the Stokes law, which determines the laws governing the movement of particles during centrifugation.

$$\mathrm{Re} = \frac{W_{oc} d \rho_c}{18 \mu_c} \le 2 \quad (1)$$

In accordance with the Stokes law, the velocity of particles in a centrifuge for a laminar mode can be defined:

$$W_{oc} = \frac{d^2 (\rho - \rho_c) W^2 R}{18 \mu_c} \quad (2)$$

Where

d — particle diameter, m;

ρ– density of suspended particles, kg/ m^3 ;

ρ_c is the density of the liquid medium, kg/ m^3 ;

μ_c is the coefficient of dynamic viscosity of the liquid medium. Pa ·c ;

W is the angular velocity of rotation, 1/ c ;

R – radius of rotation, m.

To determine the properties of the emulsion that affect the parameters of the separation process, a value equal to:

$$\frac{(\rho - \rho_c)}{\mu_c} \quad (3)$$

If the value of this value increases, then the speed of movement of particles in the centrifuge increases.

to put this into practice, the liquids are heated, resulting in its viscosity decreases [3-4].

When particles are deposited in a centrifugal field, the rate of settling increases by n times compared to the rate of settling under the action of gravity.

$$n = \frac{W^2 R}{g} \quad (4)$$

The index n is the main characteristic that determines the patterns of particle settling under the influence of centrifugal forces, it is also called the separation factor, which, in essence, is the Froude centrifugal criterion

$$Fr = \frac{W^2 R}{g} \quad (5)$$

The separation factor is one of the main parameters that determine the conditions for the deposition of particles under the action of centrifugal force [5].

The diameter of the particles that are separated during centrifugation (separation) is directly dependent on the performance of the equipment. And it is determined by the formula:

$$d = \left(\frac{V\mu_c 10^6}{5.55 n^2 R_б^2 h^2 z(\rho - \rho_c)\cos\alpha_1} \right)^{0,5} \quad (6)$$

Where

V - productivity, m ^{3} / s;

n is the frequency of rotation of the drum;

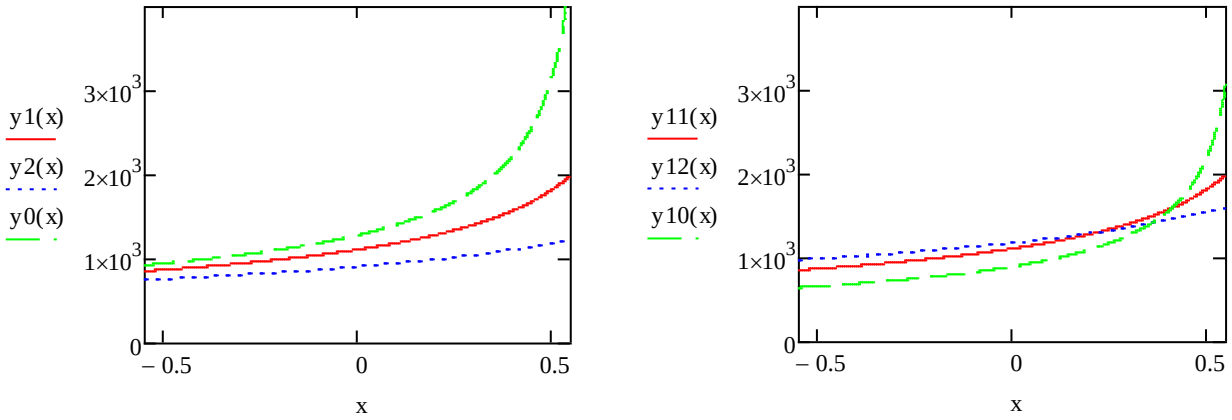
R $_b$ - the maximum radius of the plate, m;

h is the distance between the plates according to the norms, m;

z is the number of plates;

α- the angle of inclination of the surface of the plate (α= 45°-40°).

The results of experimental studies of determining the size of separated particles are shown in Fig.1.



a) b)

Figure 1. Characteristic features of the change in the size of the separated particles

ITMO researchers have developed a universal plant for the purification of wastewater from food production from oil and fat contamination.

The use of the installation will allow to obtain a sufficiently high level of wastewater treatment. The device provides for the separation of liquids depending on their density (Fig. 2).

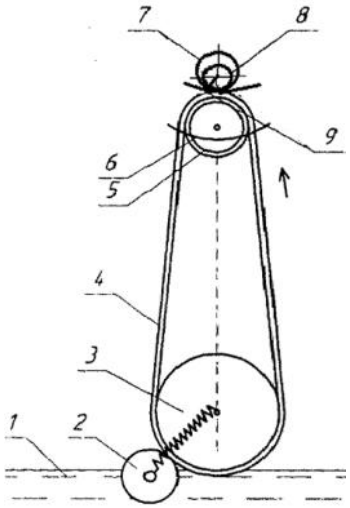


Figure 2. Device for separating liquids by density

When the device is operating, a porous tape (pos. 4) is placed in a container with a liquid to be separated (pos. 1) between two wolves (pos. 2 and 3). The belt absorbs the lighter fraction, when the belt passes between the upper conveying wolf (pos. 5) and the squeeze roll (pos. 7), the previously absorbed particles of the light fraction are removed from the pores of the belt. The thickness of the tape is selected depending on the characteristics of the liquid to be separated.

The collected fraction is directed through the holes on the roll to the collection tray located inside the roll. From the collection tray, the liquid enters for further processing.

As the belt advances, it is compressed between the conveying roll and the lower squeeze roll; during compression, air is removed from the pores of the belt.

The described device has been tested both in the separation of water and oil products, and in the purification of water from confectionery enterprises. The processing of experimental data allows us to draw the following conclusions: when separating a suspension with an increase in the density of the medium being separated, larger particles are separated (Fig. 1a), the same pattern can be traced with an increase in the viscosity of the separated component (Fig. 1b) [5].

The described device can be included in the standard technological scheme of wastewater treatment, which will significantly increase the degree of purification. Water purified by this method can be used for technological purposes in food enterprises. Closed cycles of industrial water supply make it possible to completely eliminate wastewater discharged into surface water bodies, and use fresh water to replenish irretrievable losses.

Improvement of the standard method of mechanical wastewater treatment using the proposed method will increase the efficiency of the treatment process and the environmental friendliness of the resulting water.

ЛИТЕРАТУРА

1. Алексеев Г. В., Егошина Е. В., Башева Е. П., Верболоз Е. И., Боровков М. И. Оценка конкурентоспособности инновационного технического решения // Научный журнал НИУ ИТМО. Серия: Экономика и экологический менеджмент. 2014. № 4. С. 137-146.

2. Куликова М. Г., Новикова М. А., Методы усовершенствования очистных сооружений на примере г. Смоленска // Сборник трудов V Международной научно-технической конференции «Энергетика, информатика, инновации – 2015». В 2-х т. Т. 2. Смоленск, 2015. С. 37-39.

3. Новикова М. А., Куликова М. Г. Техническое обеспечение методов очистки сточных вод от биогенных элементов // Сборник трудов VI Международной научно-технической конференции «Энергетика, информатика, инновации – 2014». Смоленск, 2014. С. 222-225.

4. Новикова М. А., Романова О. Н., Куликова М. Г. Характеристика биологических систем очистки сточных вод // Сборник трудов 4-й Международной научно-практической конференции «Техника и технологии: пути инновационного развития». Курск: Юго-Западный государственный университет, 2014. С. 207-210.

5. Пат. 2646423 РФ/ Алексеев Г.В., Калинина Е.В. Устройство для разделения жидкостей по плотности. Заявлено 07.04.2017. Опуб. 05.03.2018.

6. Herdiansyah M. I., Yuliwati E., Ismail M. F., Ismail A. F. Mathematical Model of Optimum Composition on Membrane Fabrication Parameters for Treating Batik Palembang Wastewater // Journal of Engineering and Applied Sciences. 2017. Vol. 12. P. 797-802.

7. Mokhtar N. M., Lau W. J., Ismail A. F., Kartohardjono S., Lai S. O. The potential of direct contact membrane distillation for indust rial textile wastewater treatment using PVDF-Cloisite 15A nanocomposite membrane// Chemical Engineering Research and Design. 2016. Vol. 11. P. 284- 293.

8. Maab H., Francis L., Alsaadi A. S., Aubry C., Ghaffour N., Amy G. L., Nunes S. P. Synthesis and fabrication of nanostructured hydrophobic polyazole membranes for low-energy water recovery// Journal of Membrane Science. 2012. Vol.11-19. P. 423-424.
9. Pat. 3508652A US/ John E Woolley. Method of and apparatus for separating oil from water. App. 01.11.1968. Pub. 28.04.1970.
10. Pat. 2419315 FR /George Greig,Michael Peter Broadribb/ Oil removal from oily sludge - by filtration on precoated surface filter. App. 1978-03-10. Pub. 1979-10-05.
11. Pat. 0148444A3 EP /Frank Fischer, Gerhold Reitmeier. Verfahren und Vorrichtung zum Trennen eines Öl-Wasser-Gemisches/App. 1985-07-17. Pub. 1985-09-18.

REFERENCES

1. Alekseev G. V., Egoshina E. V., Basheva E. P., Verboloz E. I., Borovkov M. I. Otsenka konkurentocpocobnocti innovatsionnogo tekhnicheskogo resheniya, Nauchnyi zhurnal NIU ITMO. Seriya: Ehkonomika i ehkologicheskii menedzhment. 2014. No. 4. P. 137-146.
2. Kulikova M. G., Novikova M. A., Metody usovershenstvovaniya ochistnykh sooruzhenii na primere g. Smolenska // Sbornik trudov V Mezhdunarodnoi nauchno-tekhnicheskoi konferentsii: v 2 t. «Ehnergetika, informatika, innovatsii - 2015». Smolensk. 2015. P. 37-39.
3. Novikova M. A., Kulikova M. G., Tekhnicheskoe obespechenie metodov ochistki stochnykh vod ot biogennykh ehlementov. // Sbornik trudov VI Mezhdunarodnoi nauchno-tekhnicheskoi konferentsii «Ehnergetika, informatika, innovatsii - 2014». Smolensk, 2014. P. 222-225.
4. Novikova M. A., Romanova O. N., Kulikova M. G. Kharakteristika biologicheskikh sistem ochistki stochnykh vod. // Sbornik trudov 4-i Mezhdunarodnoi nauchno-prakticheskoi konferentsii «Tekhnika i tekhnologii : puti innovatsionnogo razvitiYA» - Yugo-Zapadnyi gosudarstvennyi universitet. Kursk, 2014. P. 207-210.
5. Pat. 2646423 RF / Alekseev G. V., Kalinina E. V. Ustroistvo dlya razdeleniya zhidkostei po plotnosti. Zayavleno 07.04.2017. Opublikovano 05.03.2018.
6. Herdiansyah M. I., Yuliwati E., Ismail M. F., Ismail A. F. Mathematical Model of Optimum Composition on Membrane Fabrication Parameters for Treating Batik Palembang Wastewater // Journal of Engineering and Applied Sciences. 2017. Vol. 12. P. 797-802.
7. Mokhtar N. M., Lau W. J., Ismail A. F., Kartohardjono S., Lai S. O. The potential of direct contact membrane distillation for indust rial textile wastewater treatment using PVDF-Cloisite 15A nanocomposite membrane// Chemical Engineering Research and Design. 2016. Vol. 11. P. 284- 293.
8. Maab H., Francis L., Alsaadi A. S., Aubry C., Ghaffour N., Amy G. L., Nunes S. P. Synthesis and fabrication of nanostructured hydrophobic polyazole membranes for low-energy water recovery// Journal of Membrane Science. 2012. Vol.11-19. P. 423-424.
9. Pat. 3508652A US/ John E Woolley. Method of and apparatus for separating oil from water. App. 01.11.1968. Pub. 28.04.1970.
10. Pat. 2419315 FR /George Greig,Michael Peter Broadribb/ Oil removal from oily sludge - by filtration on precoated surface filter. App. 1978-03-10. Pub. 1979-10-05.
11. Pat. 0148444A3 EP /Frank Fischer, Gerhold Reitmeier. Verfahren und Vorrichtung zum Trennen eines Öl-Wasser-Gemisches/App. 1985-07-17. Pub. 1985-09-18.

ОБ АВТОРАХ / ABOUT THE AUTHORS

Новикова Марина Александровна - старший преподаватель, кафедры «Технологические машины и оборудование» филиала федерального государственного бюджетного образовательного учреждения высшего образования «Национальный исследовательский университет «МЭИ» в г. Смоленске, 214013, Россия, г. Смоленск, тел. 8-951-698-61-02, e-mail: mar.novikova@ro.ru

Novikova Marina Aleksandrovna - senior lecturer, department "Technological machines and equipment", branch of federal state budgetary educational institution of higher education "National research university "MPEI" in Smolensk, 214013, Russia, Smolensk, tel. 8-951-698-61-02, e-mail: mar.novikova@ro.ru

Гончаров Максим Владимирович - к.т.н, доцент, кафедры «Технологические машины и оборудование» филиала федерального государственного бюджетного образовательного учреждения высшего образования «Национальный исследовательский университет «МЭИ» в г. Смоленске, 214013, Россия, г. Смоленск, тел. 8-910-788-11-33, e-mail: goncharovmaxv@yandex.ru

Goncharov Maksim Vladimirovich - Candidate of Technical Sciences, Associate Professor, Department "Technological Machines and Equipment", Branch of Federal State Budgetary Educational Institution of Higher Education "National Research University "MPEI" in Smolensk, 214013, Russia, Smolensk, tel. 8-910-788-11-33, e-mail: goncharovmaxv@yandex.ru

Сызранцев Дмитрий Владимирович - аспирант, Национальный исследовательский университет ИТМО, 197101, Россия, г. Санкт-Петербург, тел. 8-911-209-49-67, e-mail: romanchikovspb@mail.ru

Syzrancev Dmitrij Vladimirovich - Graduate student, National Research University ITMO, 197101, Russia, St. Petersburg, tel. 8-911-209-49-67, e-mail: romanchikovspb@mail.ru

Алексеев Геннадий Валентинович - д.т.н., профессор, доцент, Национальный исследовательский университет ИТМО, 197101, Россия, г. Санкт-Петербург, тел. 8-921-3350796, e-mail: Gva2003@mail.ru

Alekseev Gennadij Valentinovich - D. in Engineering, Professor, Associate Professor, National Research University ITMO, 197101, Russia, St. Petersburg, tel. 8-921-3350796, e-mail: Gva2003@mail.ru

Дата поступления в редакцию: 12.04.2023
После рецензирования: 18.05.2023
Дата принятия к публикации: 19.06.2023