THE ANALYSIS OF METHODS AND THE EQUIPMENT FOR CLEARING OF THE DAMP DISPERSE WASTE OF FOOD PRODUCTIONS

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Abstract: *The analysis of methods and the different types of equipment for clearing of a damp disperse waste of food productions (spirit bards, a beer pellet, beet exhausted cossettes, coffee and barley slime) is presented in this article. The scheme of installation with a hydraulic pulse drive for realization of an offered method of flow vibro-blowing filtering, that provides in comparison with known methods, higher and stable productivity in course of working process, low power consumption and sufficient quality of a filtration of a waste also presented. Formulas for definition of the main working parameters of considered process on which its productivity depends are presented.*

Keywords: *flow vibro-blowing filtering, hydraulic pulse drive*

1. Introduction

In a number of the countries of Europe of one of serious environmental problem is the problem of recycling of a damp disperse waste of the food-processing industry – spirit bards, beer pellet, beet exhausted cossettes, coffee and barley slime etc. In most cases the given waste pours out on a ground or in the nearest reservoirs that leads to environmental contamination, besides, demands additional expenses for their transportation. It is more expedient to carry out division of a waste into firm and liquid phases, with the further clearing of last to admissible level of chemical and biological impurity. After that the liquid phase represents ordinary water, which can be already returned in the nature without negative consequences for it, or repeatedly be used on production.

2. Main part

To this moment the many methods of clearing of damp disperse materials on the equipment of different types are known. All this methods can be divided conditionally on mechanical, electrolytic, thermal, chemical and biological.

Process of mechanical filtering, is based on a delay of firm particles of a processed material by porous partitions, disk or tubular filtering elements [1]. The known equipment for filtering is static filters, the filter-presses, separators, hydraulic cyclones and centrifuges [1]. However at use of the given equipment its filtering elements rather quickly are contaminated by firm particles of a material that lead to reduction of productivity of working process and to its periodic stops are caused by necessity of clearing of filtering elements. Thus, in the cases of considerable volumes of the waste at the enterprise, especially in the conditions of a flow production given equipment is not enough effective [1].

Last years was extended a method tangential flow filtering through tubular ceramic or metal-ceramic membranes [1], that also refer to mechanical methods. Under its realization (Fig. 1) the filtrate's stream continuously circulates under pressure up to $10{,}5 \cdot 10^6$ Pa and with a speed up to 2 m/s on membrane's channels. The liquid phase is superseded through pores in membrane walls, is

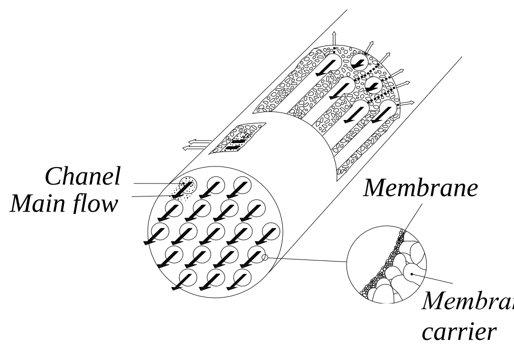

Figure 1: *The tubular ceramic membrane for tangential flow filtration*

filtered and taken away, firm particles are delayed by membrane. Thus, unlike of static filtering, the thickness s_s of a layer of sediment on internal surfaces of a membrane is remained to a constant (Fig. 2) as its significant part is washed off by main stream Q_m [3]. Therefore, the expense of filtered liquid Q_f and productivity of process are decreased not so intensively [2, 3]. But also in this case membrane's pores are eventually contaminated by firm particles that results to stop of process and to carry out of washing of membrane. Besides, for maintenance of the set productivity of process it is necessary to support simultaneously high enough speed of the main stream and high pressure in his environment [2, 3]. In conditions of flow production it leads to the great expenses of the electric power.

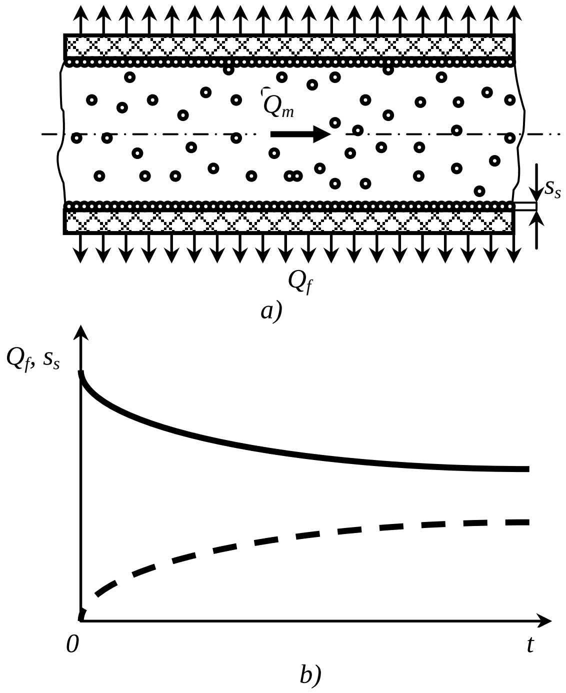

Figure 2: *Scheme of realization (a) and diagram of change of main parameters of tangential flow filtration*

Depending on the sizes of separated firm particles of a material, are distinguished membranes for micro-filtering (detains particles in the sizes 0,1 ÷ 10 μm), ultra-filtering (detains particles in the sizes 0,01 ÷ 0,1 μm), nano-filtering (detains particles in the sizes to 10^{-3} μm) and for the return osmosis (provide clearing of a material from 95 % ÷ 99,9 % of the dissolved salts with molecular weight from above 100) [2]. In most cases clearings of damp disperse materials, including a considered waste, for maintenance admissible content in them of chemical and biological impurity, that allows to return a liquid phase in the nature without negative consequences for it, there are enough of stages mikro-, ultra- and nano-filtering, without realization of the return osmosis [2]. Use with that aim of membranes of known firms «Membraflow filtersysteme», «Aaflow systems», «Tami», «Della Toffola», etc guarantees sufficient quality of waste's clearing [4].

Electrolytic methods of clearing [5] are based on material passage through a working zone between electrodes, that leads to electrolyze, polarization of firm particles and to their removal from a liquid phase. Advantages of the given method are: simplicity of the technological scheme and absence of necessity for expenses of valuable chemical reagents. Lacks are: rather low productivity and the raised expenses of the electric power. For example, in the course of water clearing, with the maintenance of impurity from 250 mg/l to its admissible maintenance of 5 mg/l, energy expenses reach 7 kWh/m^3 [5].

Thermal methods – evaporation, freezing out, crystallization, liquid-phase and para-phase catalytic oxidation, fire clearing [5, 6] – demand at realization of the greatest expenses of energy. One of the most effective methods of the given group is vacuum evaporation in multi-corpse installations. However productivity of evaporation is essentially decreased at the process final stage, with increase in viscosity of a material. That is connected with deterioration of passage of steam between of material's firm particles. Thus on surfaces of heating elements is intensified a soot's formation [5]. The equipment for evaporation is expensive, complex and bulky [5, 6]. For its automated control and handle are used complex devices and apparatuses. In that number are: vacuum gauges, thermometers, pressure gages, vacuum gages, electronic refractometers, gauges and electronic regulators of level, electromotor valves, air cranes, pneumatic automatics [5, 6]. For manufacturing of the vacuum-devices corpses, its heating elements and other details are used expensive materials (copper, bronzes, brasses and the alloyed steels) [5]. For prevention of deformation and destruction of walls corpses in the course of evaporation, they should have a sufficient thickness (safety factor), with observance of rigid requirements on roundness.

Among known chemical methods, that suitable for clearing of food productions waste, it is necessary to name: coagulation, flocculation, flotation, adsorption and extraction [6].

Coagulation and flocculation it is an artificial integration of firm particles of a processed material by their association in units. It is provided at the expense of addition to a material of particles of coagulant or flocculant, that have electric charges opposite to charges of firm particles of a material. Thus, there is a pulling of particles, their association and more intensive subsidence. Advantages of presented methods are simplicity of process and equipment [6].

Flotation it is sticking of material's firm particles to blisters of air or gas entered into it. Than particles with blisters are emerged and removed. Advantages are: small capital and operational expenses for realization, simple equipment, universality of application, high speed of process in comparison with upholding. A lack is: for increase of probability of sticking of firm particles to blisters it is necessary preliminary to enter reagents-collectors in a material (oils, fat acids, amines, etc. [6]).

Adsorption is applied in the presence of cheap adsorbent (ashes, slag, sawdust) which after use is destroyed together with the absorbed firm particles of a material. In other case adsorbent it is necessary to direct on regeneration, but that is connected with additional expenses of steam and other energy carriers.

Extraction provides mixing of a material with extragent (organic substance), separation of the received mix and regeneration of extragent. An essential lack of a method except considerable expenses of energy for regeneration is necessity in careful (taking into account many factors and parameters) a choice of extragent. Besides, the liquid phase after finishing of working process is necessary for clearing from of extragent [1, 6].

Also common faults of chemical methods are: in some cases low enough productivity, expenses for expensive chemical reactants, impossibility of removal from a material of all firm particles, necessity for the further filtration of a liquid phase.

Biological methods of clearing are realized by addition to a damp disperse material of some microorganisms. For it firm parts of a material is product of ability to live [6]. As a result material's firm parts are partially collapsed, partially are turned to a biomass. However bacteria excrete in a material other substances from which it also needs to be cleared. During aerobic clearing are used microorganisms for which ability to live is necessary oxygen, whereas anaerobic clearing is carried out without air access.

Methods of biological clearing and the equipment for their realization can be divided also on natural and artificial [7].

Natural methods are realized in open ponds by means of the seaweed, that growing beside of water's surface. Productivity of working process in ponds depends on temperature and light exposure of a cleared material, that in natural conditions can be small enough. Therefore, for processing, for example, brewing drains in volume $5 \cdot 10^3$ $м^3$ per day are necessary oxidising ponds with general area 5 ÷ 10 hectares [8]. Thus, despite simplicity and cheapness in the realizations, the given methods are ineffective, besides, are not suitable at the considerable maintenance in a processed material of firm particles [8].

Artificial biological methods, in comparison with natural, provide the on some orders higher specific productivity, are suitable for realization of clearing of materials with the high content of a firm phase, but more expensive in realization [7]. The known equipment for realization of artificial aerobic clearing are aerotanks, biofilters and biotanks [7]. For artificial anaerobic clearings are used methanetanks and septitanks [7]. Aerobic clearing in comparison with aerobic – is more productive, but also more energy-intensive; besides, demands for realization of the additional areas and, in some cases – biogene elements (nitrogen and phosphorus) [7]. Anaerobic clearing is realized by means of great volumes of chemical additives, is insufficiently stable and does not provide full clearing of a processed material [7].

In last decades have been developed and have started widely to use new intensive energy conservative methods of anaerobic clearings, that deprived of lacks of technologies, realized in septitanks and methanetanks, and on productivity – coming nearer to methods of aerobic clearing. Under its realization reagents almost are not applied and does not remain great volumes of a unprocessed material. For realization of the given methods biological reactors of different types and kinds are used: UASB-reactors (Upflow Anaerobic Sludge Blanket); EGSB-reactors (Expanded Granular Sludge Bed); IC-reactors (Internal Circulation); ABR (Anaerobic Baffled Reactor); anaerobic filters AF (Anaerobic Filter) and anaerobic filters with ascending stream UAF (Upflow Anaerobic Filter); DSFF-reactors (Downflow Stationary Fixed Film Reactor); BAS-reactors (Biofilm airlift suspension); BFB-reactors (Biofilm Fluidized Bed), AFB (Anaerobic Fluidized Bed) - reactors with pseudo-liquified layer; SMPA-reactors (Staged Multi-Phase Anaerobic); SBR (Sequencing Batch Reactor) and other [9]. The given reactors are bulky, multi-corpse, complex and expensive on a design and in operation technological complexes equipped with devices for distribution, hashing, heating, clearing, the control, management and circulation. Reactors are intended mainly for removal of chemical impurity. As to biological impurity and suspended substances, their considerable part (20 ÷ 50 %) remains in the cleared liquid. Duration of clearing 10 ÷ 40 h [9].

As a whole it is necessary to notice, that processes of biological clearing often demand long preparation (till one year [7 - 9]), are multiphasic and power-intensive, and the equipment for their realization – very bulky and material-intensive. Besides, efficiency of process of biological clearing is substantially defined by stability of physic-mechanical characteristics of a processed material, its structure and a condition.

Taking into account the above-stated, for clearing of a damp disperse food waste we are offered the method of flow vibro-blowing filtering on installations with a hydraulic pulse drive (HPD) [4]. According to results of experiments [4], productivity of flow vibro-blowing filtering of spirit bards, beet exhausted cossettes and coffee slime on 18 ÷ 31 % higher and stable in time, than productivity of their flow unaccented filtering, at use of similar tubular membranes of firm “Tami” [10] and on optimum operating regimes. In comparison with electrolytic, thermal, chemical and biological methods of the clearing, the offered method is less power-intensive and the equipment for its realization – much less bulky, complex and expensive.

On Fig. 3 the hydro-kinematic scheme of the installation with HPD for flow vibro-blowing filtering is present. For maintenance of necessary high efficiency of working process in the corpse 12 at once several parallel tubular ceramic membranes 5 are mounted (see Fig. 1), that are condensed with fluoroplastic rings 4. A filtered waste from a tank 8 continuously moves by centrifugal pump 6 in a direction specified by arrows: through the membrane return valve 7, the crane 13, on channels of membranes 5, the crane 14, hydraulic line 9 and further again on the same system. By means of cranes 13, 14 in the environment of a waste, that is passing on channels of membranes, necessary resistance and pressure are created. As a result, liquid phase of a waste is superseded through a pores of membrane’s walls, filtered and on taps 10 flows down in a tank 11. Firm particles are detained by walls of membranes. Plunger 1 it is located in the corpse 3, coaxial with the corpse 12. Cavities of both corpses connected with the help of a short rubber-fabric sleeve 15. Movements of plunger 1 from above are limited by a spring 2. The top cavity A of corpse 3 connected with HPD’s delivery hydraulic line, thus pressure of a working liquid in it periodically changes from p_2 = $=2\cdot10^6$ Pa to $p_1 = 10\cdot10^6$ Pa (values p_1 and p_2 it is possible smoothly and precisely to regulate). As a result plunger 1 carries out vertical reciprocating movements with frequency ν up to 150 Hz and amplitude z_a up to 2 mm, creating in the environment of waste a shock waves of pressure and deformations. That leads to periodic increase of pressure p_w in the environment of a waste (in 3 ÷

4 times – in comparison with pressure in process of flow unaccented filtering [11]) and to increase of speed v_w it movements (on 10 ÷ 12 % [11]). The shift tensions, that influencing on a waste at passage of each next shock wave, provide periodic

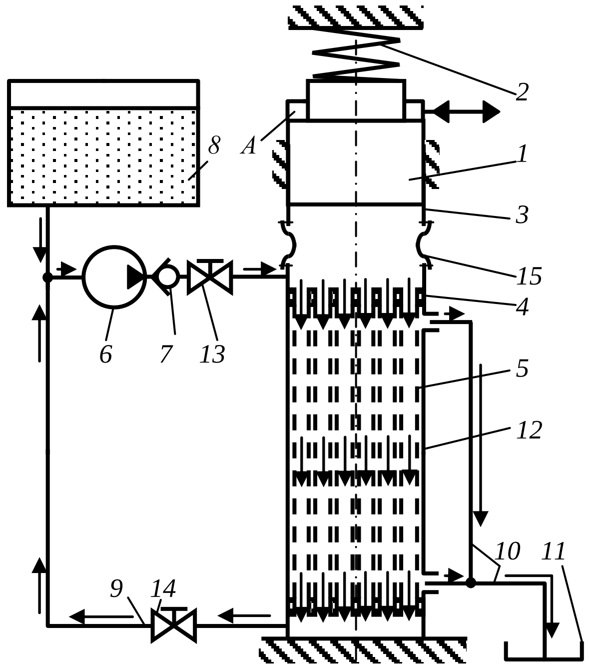

Figure 3: *The principal hydro-kinematical scheme of hydraulic pulse installation for flow vibro-blowing filtering of a damp disperse waste*

high-frequency destruction of the smallest arch formations of firm particles on internal surfaces of membranes. Thus, the thickness of a deposit's layer on the membrane's surfaces and a contamination of it pores decreases, productivity of working process raises and stabilizes in time. Return of plunger 1 in the top position at stages of pressure drop of a working liquid in a cavity A is provided with a spring 2. The sleeve 15 prevents transfer of vibrations from the corpse 3 to membranes 5. Size ν and z_a smoothly and separately regulated for realization of optimum regimes of loading of a waste and for maintenance of the highest productivity of working process.

The main working parameters of processes of flow filtering, on which depends their productivity, are pressure p_w and speed v_w [10].

In process of flow vibro-blowing filtering the maximum value of pressure $p_{w.max}$ in the environment of a waste at a stage of movement of plunger 1 downwards (see Fig. 1) can be found under the formula [11]

$$p_{w.max} = p_w + \Delta p_w = p_w + 2 \cdot \nu \cdot l_p \sqrt{K_w \rho_w},$$

in which Δp_w – a pressure increment in the environment of waste at a considered stage; ν – frequency of reciprocating movement of plunger 1; l_p – amplitude of its movement; K_w – the module of volume elasticity of a waste; ρ_w – density of a waste.

Speed v_w it is defined as [11]

$$v_{w.max} = v_w + v_p = \frac{2Q_p}{\pi \cdot d_m^2 \cdot n_c \cdot n_m} + l_p \nu,$$

where v_p – average speed of movement of plunger 1 downwards; Q_p – supply of the pump 6; d_m – hydraulic diameter of the channel of a membrane 5; n_c – number of channels of one membrane; n_m – number of membranes in the corpse 12.

3. Conclusions

1. Known methods of clearing of damp disperse materials can be conditionally divided on mechanical, electrolytic, thermal, chemical and biological.

2. Known mechanical methods of clearing, including tangential flow filtering, do not provide of stable productivity of working process as filtering elements used at their realization are contaminated in due course by firm particles of a processed material. Electrolytic methods are unproductive, thermal – are power-intensive, chemical – demand expenses of expensive reactants and do not provide full clearing, biological methods – are realized on the bulky and expensive equipment.

3. The offered method flow vibro-blowing filtering on hydraulic pulse installations provides in comparison with flow unaccented filtering on 18 ÷ 31 % higher and stable in time productivity of working process at sufficient quality of clearing of a damp disperse food waste. In comparison with electrolytic, thermal, chemical and biological methods the offered method is less power-intensive and material-intensive in realization.

4. High efficiency flow vibro-blowing filtering is caused by creation in the environment of a processed waste under its realization of shock waves of pressure and deformations. Periodic increases in the environment of waste of pressure (in 3 ÷ 4 times) and speed of it movements (on 10

÷ 12%) provide high and stable productivity of working process.

References

[1]. Драгилев А. И., Дроздов В. С. *Технологические машины и аппараты пищевых производств*. – М.: Колос, 1999. – 376 с.

[2]. Валентас К. Дж., Ротштейн Э., Сингх Р. П. *Пищевая инженерия: справочник с примерами расчетов*/. – СПб.: Профессия, 2004. – 848 с.

[3]. Braun M. Practical Short Course on *Membrane Separations in Food Processing*/ Braun M.// Review of Commercial dairy applications. – Texas: Food Protein Research and Development Center. - Texas A&M University. - College Station, 1994.

[4]. Севостьянов І. В., Іскович-Лотоцький Р. Д., Любин В. С. *Експериментальні дослідження процесів потокового віброударного фільтрування вологих дисперсних матеріалів // Промислова гідравліка та пневматика*, 2010. - №4. – С. 89 – 92.

[5]. Дикис М. Я., Мальский А. Н. *Технологическое оборудование консервных заводов*. – М.: Пищевая промышленность, 1969. – 777 с.

[6]. Ветошкин А. Г., Таранцева К. Р. *Технология защиты окружающей среды (теоретические основы)*. – Пенза: Изд-во Пенз. технол. ин-та, 2004. – 249 с.

[7]. Аткинсон Б. *Биохимические реакторы*. – М.: Пищевая промышленность, 1979. – 280 с.

[8]. Репин Б. Н. *Биологические пруды для очистки сточных вод пищевой промышленности*. - М.: Пищевая промышленность, 1977. – 208 с.

[9]. *Биологические способы очистки и биореакторы. Современность и перспективы*. Available from: http://vikings.wicca.ru/page.php?id=110.

[10]. *Техническое руководство по трубчатым керамическим мембранам INSIDE CéRAM*. Document B. BL. Handbuch Ru, 2004, Rev. 23, 36 с.

[11]. Севостьянов І. В., Іскович-Лотоцький Р. Д., Обертюх Р. Р. *Теоретичні основи процесів фільтрування вологих дисперсних матеріалів під впливом ударних хвиль напруг та деформацій* // Промислова гідравліка та пневматика, 2008. - №2. – С. 40 – 43.