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Technology of Transition to the Business Model of the Economy of Multiple Use of Resources on the Example of the Operation of Paint Chambers with Hydrofilters

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Abstract: The article is devoted to resource-saving technologies that make it possible to switch to a business model of a cyclical economy in areas for applying PVC in spray booths with hydrofilters. The technology of saving resources is considered in detail: wastewater treatment of hydrofilters to the requirements of circulating water supply, as well as a scheme for the subsequent regeneration of sludge, as a secondary resource, to obtain additional products. The conditions under which sludge regeneration is more profitable than disposal are calculated and determined, and the areas of industrial application of the products obtained are proposed. Immanent assessment of the payback period of capital investments for the purchase of new equipment for the purpose of reusing resources. On the basis of the calculations performed, the authors prove the effectiveness of the proposed approach, which makes it possible to eliminate the costs of water consumption, wastewater disposal and sludge disposal and obtain the possibility of additional profit from the sale of the regenerated product. In conclusion, there is the inevitability of the transition of Russian industry to a cyclical economy, as a defining task for the development of society on the path of sustainable development and conservation of the natural environment.

Keywords: circular economy; circulating water supply system; electroflotation-coagulator; recycling; sludge regeneration; spray booth with hydrofilters

1 INTRODUCTION

It should be noted that of all the biological species that exist on the planet, only man, in the course of his life activity, leaves a huge amount of poorly decomposed in the natural environment, hazardous and toxic waste. For a relatively short period of existence on the planet, humanity has managed to accumulate billions of tons of garbage in the biosphere, which catastrophically change the quality of natural environments and threaten all living things [1].

The main reason for this is the traditional linear economy, which ensures the production of a useful product according to the traditional scheme: matter, energy and information are removed from the environment, and waste is released into the environment. Over time, the proportions of this scheme are positively changing towards resource and energy savings and waste volumes (Fig. 1).

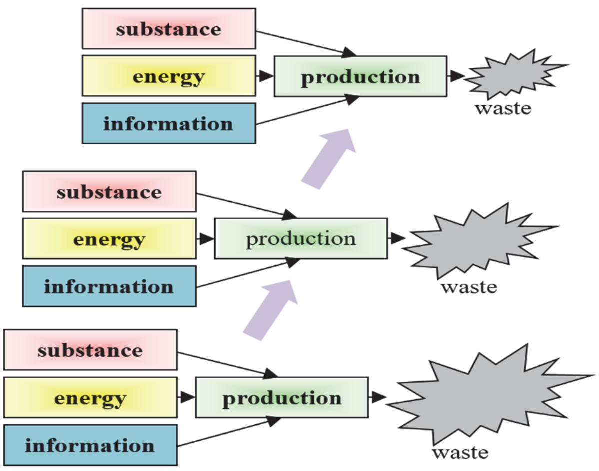

Figure 1 Evolution of structural changes in the proportions of useful product manufacturing

However, these positive changes do not change the general negative trends. Everywhere there is a backlog of environmental science from the growing power of production, consumption and amount of generated waste.

This is due to many reasons, including Hegel concept of efficient development based on constant growth and expansion, as well as Smith notion that all prosperity is measured by economic profit.

Thus, for a long time humanity rested on an oxymoron: for the continued existence it is necessary to reduce the consumption of resources, reduce emissions and discharges and at the same time increase production, as it makes profit.

Over time, it became obvious that it was necessary to change the very structural scheme of the production of a useful product, focusing on the natural processes of the circulation of substances and their multiple use.

Undoubtedly, this task is very difficult and requires a complete systemic restructuring of the entire interaction scheme: resources-production-consumption-utilization [1, 2]. The philosophy and logic of the new economy and its true essence are much deeper than the traditional issues of recycling and waste disposal. The cyclical economy assumes a closed and non-depleting natural resources circulation of substances that are returned to production and do not enter the environment, similar to the natural cycles of substances in the biosphere (Fig. 2).

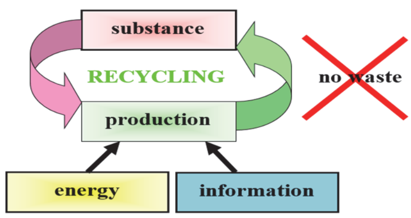

Figure 2 Circular economy business model

The authors propose to demonstrate the possibility of modernizing traditional production and moving to a new closed cyclic model using the example of one of the most common technological processes of any production, which is the application of paint and varnish coatings (PVC) on products.

2 THEORETICAL BASIS

It should be noted that the process of painting products is characterized by serious negative impacts on humans and environment. This is due to the use of toxic components of PVC, the formation of paint aerosols in the air of the working area and the release of solvent vapors during the preparation of paints, the application and drying of coatings.

PVC are complex multi-component mixtures that perform many functions: protective, anti-corrosion, insulating, decorative, etc.

Despite the numerous ways of staining and the continuous development of new ones, pneumatic spraying remains the most common. Due to the versatility and simplicity of the method, about 70% of coatings are currently applied with pneumatic paint sprayers. Forecasts for the future show that this ratio will remain on average for the coming years [2, 3].

The most popular and safest for those working in the paint shop is pneumatic spraying in spray booths with hydrofilters and water curtain, with bathtubs located in pits under the floor gratings of the booths (Fig. 3).

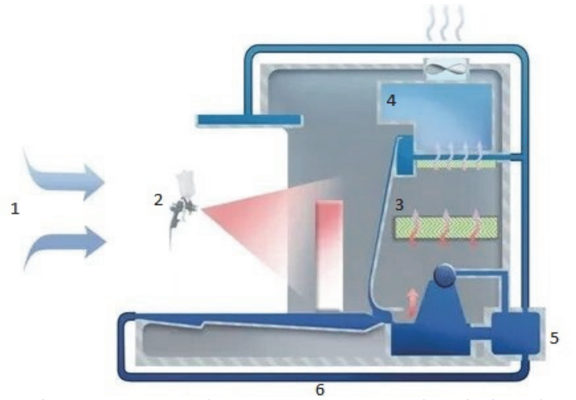

Figure 3 Conditional scheme of the spray booth with hydrofilter [2]: 1 - air flow, 2 - water curtain, 3 - hydrofilter, 4 - exhaust fan, 5 - circulation pump, 6 - bathtubs

Hydrofilters effectively cope with air purification and ensure maximum explosion and fire safety of painting installations and painting areas and workshops.

Toxic paint aerosol is deposited on the surface of the water, the purified air is released into the atmosphere and, if necessary, undergoes post-treatment from solvent vapors.

The recirculating water of the painting equipment is periodically (about 2 times a week) discharged to the treatment plant and then to the sewer. The sediment from the painting chamber is removed by pumping and transferred to an organization specializing in the management of waste of hazard class 3.

The prohibition of the discharge of sewage and sludge from hydrofilter systems into the city sewer makes it necessary to take measures to organize and design drainless circulating water supply systems.

The discharge of water into the city sewerage network is limited by the sanitary authorities due to the high toxicity of wastewater to biota [3-5].

In this regard, highly effective treatment is needed to discharge water into the urban sewer. However, after the discharge, there is an irretrievable loss of water. At the same time, the bathtub is periodically replenished with fresh water to maintain the required level [2, 3], since the calculated loss of water for evaporation for hydrofilters with water curtain is taken to $k_{evap} = 0.015$ m^3/hour.

The scheme of the technological cycle of dyeing with the disposal of production waste is shown in the Fig. 4 [6].

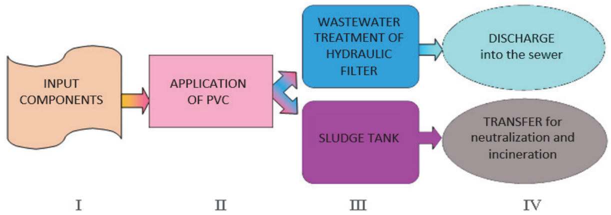

Figure 4 Traditional scheme of 4 stages of production and waste management in a paint shop with spray booths with hydrofilters

As we can see from the presented scheme, as a result of the technological cycle, resources that need to be replenished are irretrievably lost. These include water and PVC waste in the form of sludge.

3 METHODOLOGY

The concentration of pollutants in the water at the outlet of the treatment collector of hydrofilters, taking into account the efficiency factors of the treatment plants, is determined by formula 1 [2, 7]:

$$C_{cont}^{COW} = \frac{M_{cont}^{COW}}{Q_1}\left(1-\eta_{ww}\right) \tag{1}$$

where: C_{cont}^{COW} concentration of contaminants in the outlet water, M_{cont}^{COW} mass of contaminants in the outlet water, Q_1 is the hydrofilter recirculating water volume, η is the degrwee of wastewater treatment.

In the wastewater of the spray booths, a dispersed system is formed, in which one part settles under the influence of gravity (titanium dioxide, iron compounds), the other part retains a uniform distribution over the volume of the dispersed phase (soot, aluminum powder) [6].

Among other things, one part of the wastewater pollution is represented by ions contained in colors:
- anion (hexavalent chromium CrO_7^{2-} cyanide ion CN)$^-$;
- cation: (Zn^{2+}, Fe^{3+}, Al^{3+}).

Threshold limit value of these substances can be exceeded hundreds of times. The greatest danger is represented by hexavalent chromium, which has a hazard class 3, but is a carcinogen of the first group, as well as cyanide: ion and an aluminum ion, which belong to the second class [6].

To save water as a resource, after its purification, it is necessary to return water to the production cycle, that is, to create a circulating water supply for spray booths, bringing production closer to the business model of the cyclical economy of reuse of the resource [7, 8].

Due to the diverse phase composition of contaminants, a combination of methods is required, including mechanical (settling) and physicochemical (electroflotation combined with coagulation) cleaning (Fig. 5). Comparison of the obtained data with the water quality standards for the recycling water supply of electroplating shops, taken as a purification criterion, showed the effectiveness of the proposed technological schemes.

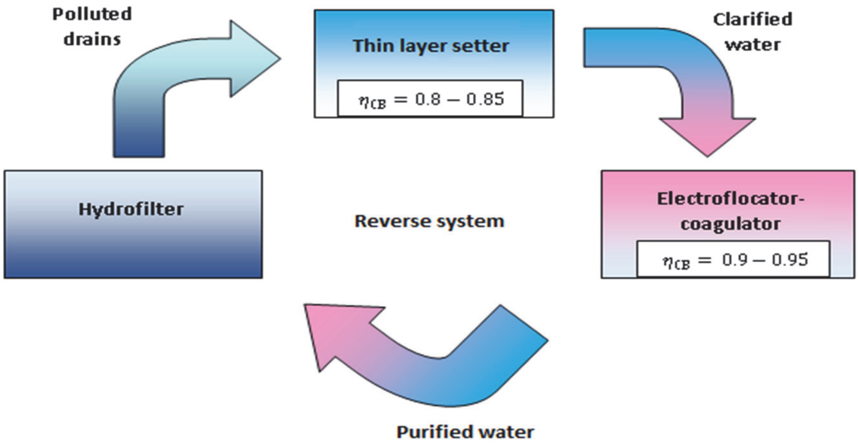

Figure 5 Hydrofilter wastewater treatment system providing the required water quality for the water recycling system

At the end of the operation of hydrofilters, the settled PVC are removed by a pump into the sludge collector. Next, the water is sent to a thin-layer tubular sump, which allows faster sedimentation of the suspension; the collected impurities slide by gravity under the action of gravity along inclined tubes into the sediment compaction zone. The optimal slope is 45 - 60°. The dimensions of the thin-layer module are 1x1 m, which is optimal from the point of view of installation and operation.

Since the water after settling is classified as slightly polluted, it is preferable to use tubular thin-layer sedimentation tanks with a daily flow rate of 100 m^3/day. The settling period alternates with the period of cleaning the tubes from sediment. The tubular periodic settling tank is characterized by a cleaning efficiency of 80 - 85%. In this regard, the concentration of substances in suspension will decrease. When they settle, the ions sorbed on suspensions and solvent molecules will partially fall into the precipitate.

However, settling is not effective enough to remove them. It is necessary to use physico-chemical methods.

In this regard, water after a thin-layer sump is sent to an electrocoagulator: flotator. In this installation, the destruction of toxic substances occurs by their oxidation at the anode (cyanide ions) or reduction at the cathode (metal ions, including hexavalent chromium).

When direct current is passed through waste water, electrolysis occurs. At the anode, anions and water molecules are discharged with the release of oxygen.

The cyanide ion is oxidized to form non-toxic gaseous products by the reactions:

$$\begin{Bmatrix} CN + 2OH - 2\bar{e} \rightarrow CNO + H_2O \\ 2CNO + 4OH - 6\bar{e} \rightarrow 2CO_2 \uparrow + N_2 \uparrow + 2H_2O \end{Bmatrix} \quad (2)$$

Water molecules are discharged by the reaction:

$$2H_2O - 4\bar{e} \rightarrow O_2 \uparrow + 4N \quad (3)$$

If the anode material is a metal (for example, aluminum), then during the electrolysis process, its anodic dissolution occurs:

$$Al - 3\bar{e} \rightarrow Al^{3+} \quad (4)$$

When reacted with water, a hydroxide with a developed flaky surface is formed:

$$Al^{3+} + 3OH \rightarrow Al(OH)_3 \downarrow \quad (5)$$

When settling, it captures suspended particles and metal ions, and coagulation occurs. Hydrogen is released at the cathode during the electrolysis of water:

$$2H_2O + 2\bar{e} \rightarrow H_2 \uparrow + 2OH \quad (6)$$

Hexavalent chromium is reduced to trivalent and precipitates as hydroxide:

$$\begin{Bmatrix} Cr_2O_7^{2-} + 6\bar{e} + 14H \rightarrow 2Cr^{3+} + 7H_2O \\ Cr^{3+} + 3OH \rightarrow Cr(OH)_3 \downarrow \end{Bmatrix} \quad (7)$$

During electrocoagulation, sedimentation of contaminants occurs due to the formation of aluminum hydroxide during the dissolution of the anode, and during electroflotation, sludge is formed on the surface of the water due to bubbles of oxygen and hydrogen.

The main advantage of electroflotation is: ease of manufacture of the installation and the simplicity of its maintenance; ability to regulate the degree of wastewater treatment depending on the phase-dispersed state by changing only one parameter: current density; additional mineralization of soluble organic compounds with simultaneous disinfection of water due to the electrolysis product formed at the anode: atomic oxygen [9].

Flotation sludge, which is a paste-like mass, consists of particles of PVC (including pigments) and film-forming components, which can be used as modifying additives in putties, mastics and primers for painting less critical parts, as well as in repair and painting work in construction.

Electroflotation is carried out with the following parameters: current density: 100 - 150 A/m^2; pH: 6 - 8.0. The cleaning effect is: for chemical oxygen demand: 95 - 98%, for suspended solids: 98 - 99% [9].

The next stage, which ensures the multiple uses of resources, is the regeneration of paint production waste and its transformation into a product that can be reused in the production cycle.

The technology for processing waste from PVC production was developed by the Research Institute of Technology of PVC of the Research and Production Association Lakokraspokrytie (Khotkovo, Moscow Oblast). Since its foundation in 1960, it has been dealing with problems related to technology and equipment for industrial painting.

The technology of regeneration of sludge from the painting industry is considered in detail, the scheme of the technological process of regeneration of PVC is shown in Fig. 6.

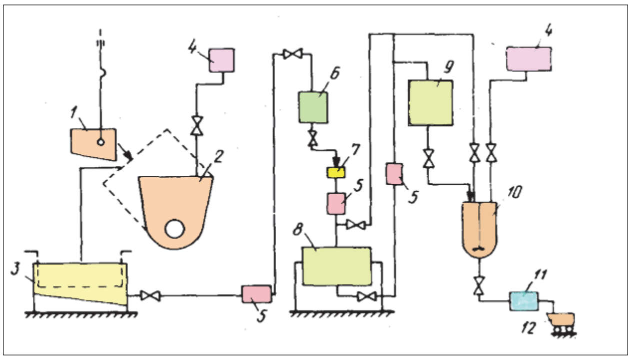

Figure 6 Scheme of the technological process of PVC regeneration: 1 - container sludge accumulator; 2 - mixer; 3 - coarse filter; 4 - dispenser; 5 - pumps; 6 - dissolver; 7 - mesh filter; 8 - ball mill; 9 - bead mill; 10 - bladed mixer; 11 - fine filter; 12 - receiving capacity

Recycling process includes collecting, heating to remove moisture, mixing with a solvent, dispersing, cleaning, diluting to a desired viscosity and packaging. It will be necessary to purchase additional equipment: mixer with Z-shaped blades or vertical planetary mixer, bead mills, centrifuge and filters (Fig. 6) [9].

The sludge to be regenerated is usually in a pasty state and needs to be dissolved or diluted. Therefore, they, together with the solvent, are loaded into the mixer, where they are stirred for 4 - 5 hours, as a result of which the paste swells and obtains a fluid consistency.

The resulting mixture is passed through a mesh filter with a mesh size of 10×10 mm^2. Then the mixture, cleared of large inclusions, enters the dissolver (high-speed mixer), where dispersion takes place for 2 - 3 hours and then filtration through a mesh with a mesh size of 1 mm.

From the dissolver, the resulting suspension is pumped to a ball mill and the paint is further dispersed within 4 - 8 hours.

If after that the resulting product has the necessary dispersion, then it enters the paddle mixer from the mill, where, if necessary, it is diluted to the desired consistency with a solvent and then drained into a receiving container for subsequent prepackage and package.

It should be noted that the regeneration of sludge and their return to the production cycle has become possible in modern production with the use of new generation dyes used in pneumatic spraying in spray booths with hydrofilters. Oil-based dyes of previous generations used for painting with brushes and rollers are not considered, since they are not subject to regeneration due to the specifics of oils aging during sludge dehydration.

Regenerated PVC are used for painting parts that are less critical in terms of technological properties and appearance, as well as for applying intermediate layers of paint in multi-layer painting in construction, in the production of road surfaces and in landscaping. Reclaimed primer and putty are used for their intended purpose.

A modernized production cycle that ensures the multiple use of water and PVC, including physical and chemical treatment of industrial wastewater to the requirements of circulating water supply and simultaneous regeneration of sludge, can be schematically represented in the recycling scheme shown in Fig. 7.

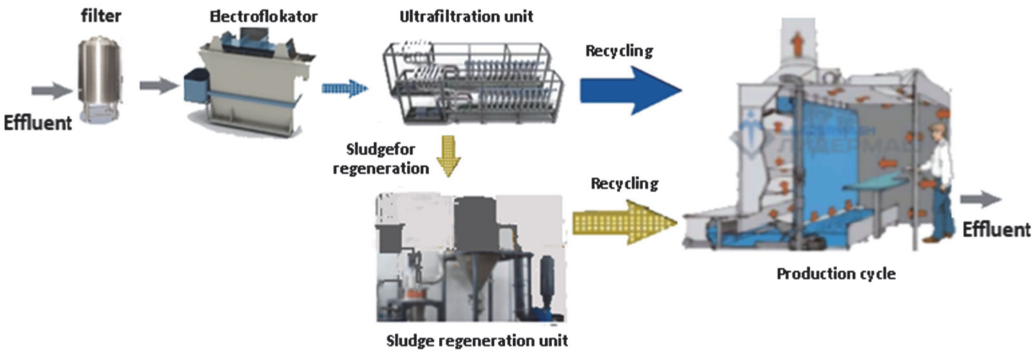

Figure 7 Scheme of modernized production including wastewater treatment, water recycling and sludge regeneration

4 RESULTS AND DISCUSSION
4.1 Problem One

One of the problems is the variety of coatings used in the painting industry, therefore, incompatible combinations of various PVC with each other should be taken into account. Neglect of these rules is fraught with the fact that instead of the expected decorative and protective effect, we can get the result of complete disappointment with the painted coating, and sometimes completely ruin the product.

Therefore, it is necessary to take into account the compatibility of PVC not only when painting products, but it is also unacceptable to mix them during regeneration of PVC in order to exclude the possibility of obtaining unsatisfactory quality of the regenerated final product. Compatibility of different types of enamels is shown in the Tab. 1.

As we can see from the table, not all PVC are compatible, and therefore, for an efficient process of processing and regeneration of spray booth waste, it is advisable to divide spray booths into categories in accordance with the types of PVC used. Thus, it is possible to avoid the problems of mixing incompatible components and carry out the processes of regeneration of PVC without mixing wastewater from hydrofilters of various categories.

Table 1 Compatibility of PVC

PVC categories and abbreviations	Primers categories and abbreviations				
	Polyacrylate	Alkyd-acrylic	Polyvinyl acetal	Pentaphthalic	Melamine alkyd
Copolymer vinyl chloride	x		x	x	
Perchlorovinyl	x	x	x	x	x
Organosilicon	x				
Melamine	x		x	x	x
Nitrocellulose	x		x		
Pentaphthalic	x		x	x	
Epoxy	x		x	x	
Alkyd-acrylic	x	x	x	x	

In this case, the processing of waste from spray booths can be carried out according to a periodic technology with preliminary washing of the equipment before moving on to incompatible waste.

It may be more expedient to have three production lines for the processing and regeneration of waste with primers (Polyacrylate, Polyvinyl acetal и Pentaphthalic) having the largest number of compatible dyes and one line operating according to a periodic scheme with pre-washing before switching from Alkyd-acrylic primer to Melamine alkyd primer.

4.2 Problem Two

The second problem is the economic feasibility of sludge regeneration. For economic reasons, it is considered that the regeneration of the sludge generated during the sedimentation of wastewater should be formed at least 20 kg per day and its components should be compatible in order to obtain a satisfactory quality of the final product.

When considering the constantly growing industrial production, this factor can be considered negligible, however, for artisanal and small-scale private paint shops, this is a criterion that should be taken into account.

4.3 Problem Three

The third problem that arises in the physical and chemical treatment of industrial wastewater and sludge regeneration should be considered that it is impossible without the acquisition of a Waste Management License, which will also increase costs during the modernization of production.

4.4 Problem Four

The fourth problem is the need to purchase additional equipment. All of the listed equipment at the initial stage will require additional material costs, which will initially reduce the profitability of production. It should be noted that the process of sludge regeneration will also entail the cost of electricity during the operation of the equipment.

4.5 Immanent Assessment of Expected Costs and Payback Periods

Analyzing the listed difficulties in the modernization of production, it should be noted that, considering the entire life cycle of a resource (PVC) from production to disposal, it becomes obvious that with repeated use of the resource after regeneration, the stage of utilization with the costs of transportation, disinfection and disposal at the landfill is eliminated [10, 11].

When water is purified to the requirements of circulating water supply and the organization of its repeated use in the production cycle, the costs of its purification are compensated by reducing water consumption and wastewater disposal (at the same time, the risks of paying fines for discharging polluted water into the city sewer disappear, which, in the event of a primary violation, are 2 times higher than the cost of water disposal, and with repeated they are 5 times higher).

In order to conclusively approve not only the environmental, but also the economic efficiency of the proposed measures for the modernization of production and recycling of basic resources, it is advisable to conduct an immanent assessment of the expected costs, taking into account current prices for equipment, water treatment, wastewater disposal and obtaining a license for waste management is carried out taking into account the processing of the minimum possible amount sludge.

Table 2 Cost of equipment for recycling water supply and sludge regeneration

No.	Name of main equipment	Price per one / EUR	Quantity	Amount / EUR
1	Electroflotation - coagulator	6500	4	26000
2	Thin layer settler	1000	4	4000
3	Dissolver	1000	4	4000
4	Bead mill	1000	4	4000
5	Paddle mixer	3500	4	14000
6	Filters, pumps, electric motors, heater and tanks	2000	4	8000
7	Waste management license	2500	1	2500
TOTAL:				62500

Table 3 Data sheet of the technical passport and the cost of resources for 2021

No.	Resource	Designations and units	Data sheet ratings	Tariff per resource unit / EUR
1	Water consumption	B_1 / m^3	14 m^3/hour	0.2453 EUR/m^3
2	Drainage	K / m^3	14 m^3/hour	0.2991 EUR/m^3
3	Waste disposal of 3 hazard class	WD_{hc3} / t	85 EUR/t	85 EUR/t
4	Power consumption of spray booth with hydraulic filter	S_{pc} / kW	17 kW	0.0543 EUR/kWh
5	Power consumption of electroflotator - coagulator	S_{pc} / kW	0.3 kW	0.0543 EUR/kWh
6	Power consumption of healter	S_{pc} / kW	0.2 kW	0.0543 EUR/kWh
7	Power consumption of technological chain of sludge regeneration	S_{pc} / kW	5.5 kW	0.0543 EUR/kWh

For the assessment, we use the data of Tab. 2 and Tab. 3. Due to the fact that the prices for equipment may vary depending on the manufacturer, capacity and market conditions, we will take the current average costs in 2021 for the main equipment and the acquisition of a Waste Management License.

To carry out an immanent assessment, we agree that the calculation will be carried out using PVC of Pentaphthalic-115 type, which has 45% of the volatile part, and losses during painting in the form of an aerosol of 30%.

According to the methodology for calculating the volumes of waste generation Methodology for Calculating Volumes (MCV)-3-99. Waste generated during the use of PVC, amount of sludge removed from the hydrofilter baths of spray booths is calculated by the following formula:

$$M_{\text{waste}} = m_c \cdot \delta_a \cdot (1 - f_a) \cdot k_r / (1 - w), \text{ t/year} \tag{8}$$

where m_c is the consumption of paint used for coating (t/year); δ_a is the percentage of paint lost in aerosol form (%/100); f_a is the proportion of the volatile part (solvent) in PVC (%/100); k_r is the coefficient of air purification in hydrofilter (%/100), taken from the passport for the hydrofilter (0.86 - 0.97); w is the moisture content of the sludge extracted from the hydrofilter bath (%/100), it is assumed to be B = 0.6 - 0.7.

The painting will be carried out in an Altmaler-type spray booth with a hydrofilter and a wet floor, and parts will be painted in the booth with 66 kg of paints.

The percentage of air purification from aerosol with a hydrofilter in the Altmaler spray booth, according to the data sheet, is 98%.

To fulfill the condition of 20 kg/shift, we calculate the amount of paint ($m_к$), which must be applied per shift:

$$\begin{aligned} m_c &= (20/0.3) \cdot (1 - 0.45) \cdot 0.98 \cdot (1 - 0.6) = \\ &= 20/0.06 = 286 \text{ kg} \end{aligned} \tag{9}$$

To obtain such an amount of sludge per shift, at least 4 spray booths must operate with a load that allows them with 70 kg of paints.

Based on Tab. 2, we have the volume of initial investments in new equipment, which will amount to 62500 EUR.

Using the data of Tab. 2 and Tab. 3, we calculate the cost in EUR of consumed resources if the paint shop operates according to the old linear scheme, where B_1, K_1, S_1 and WD_{hc31} are, respectively, the costs of water consumption, drainage, electricity and waste disposal of hazard class 3 for one work shift (8 hours). The total cost of using resources will be Q_1.

$$\left\{ \begin{array}{c} B_1 = 4 \cdot 8\left(14\text{ m}^3 \cdot 0.2453\text{ EUR/m}^3\right) = 109.89\text{ EUR} \\ K_1 = 4 \cdot 8\left(14\text{ m}^3 \cdot (1 - 0.015) \cdot 0.2991\text{ EUR/m}^3\right) = 134.27\text{ EUR} \\ S_1 = 4 \cdot 8\left(17\text{ kWh} \cdot 0.0543\text{ EUR/kWh}\right) = 29.54\text{ EUR} \\ WD_{hc31} = 0.02\text{ t} \cdot 85\text{ EUR/t} = 1.7\text{ EUR} \end{array} \right\} \tag{10}$$

Total for turn:

$$W_1 = B_1 + K_1 + S_1 + WD_{hc31} = 275.4\text{ EUR/turn} \tag{11}$$

Using the data in Tab. 3, we calculate the consumption of resources during the transition to a cyclic model of painting production:

$$\left\{ \begin{array}{c} B_2 = 4 \cdot 8\left(0.015\text{ m}^3 \cdot 0.2453\text{ EUR/m}^3\right) = 0.12\text{ EUR} \\ K_2 = 0.0\text{ EUR} \\ S_2 = 4 \cdot 8\left(17\text{ kWh} + 0.3\text{ kWh} + 0.2\text{ kWh} + 5.5\text{ kWh}\right) = 3996\text{ EUR} \\ WD_{hc32} = 0.0\text{ EUR} \end{array} \right\} \tag{12}$$

Total for turn:

$$W_2 = B_2 + K_2 + 2 + WD_{hc32} = 40.08\text{ EUR/turn} \tag{13}$$

As a result of the regeneration of the sludge of the spray booths, paint will be produced, the sale of which will also bring profit.

The cost of PVC obtained during the regeneration of sludge will be taken as the minimum, equal to the cost of economy enamel, not more than 1 EUR/kg.

Therefore, rounded up, this will be the following income per turn (I_{turn}):

$$I_{turn} = 20 \cdot 1 = 20\text{ EUR} \tag{14}$$

We calculate the amount of saved resources (R_s) in EUR when switching to a cyclic model:

$$R_s = W_1 - W_2 + I_{turn} = 255.32\text{ EUR/turn} \tag{15}$$

Knowing the volume of initial investments, it is possible to calculate how long the funds for the transition to the resource reuse model will pay off:

$$\begin{aligned} T &= (62500.00\text{ EUR} + 109.89\text{ EUR})/255.32\text{ EUR/turn} = \\ &= 245\text{ turn} \end{aligned} \tag{16}$$

Which will be 10 - 11 months at the rate of 21 - 23 working days per month.

Thus, the prevented damage from repeated use of resources compensates for the initial investment in the purchase of equipment and electricity for cleaning and regeneration in less than a year [12].

Considering the production as a whole and taking into account the need for the upcoming prospect of transition to a circular economy of a closed cycle (reusable), it is undoubtedly advisable to purchase the specified equipment for cleaning and regenerating resources, and will bring profit in an environmental and economic sense [13, 14].

5 CONCLUSIONS

The process of applying PVC has high environmental risks. Negative production factors in the application of coatings are due to highly toxic components that make up their composition. To protect the health of workers from suspensions of coatings and solvent vapors in PVC, painting booths with a water curtain equipped with hydrofilters are mainly used (70%).

Wastewater from hydrofilters of spray booths is characterized by a toxic and complex composition of pollutants, and therefore the discharge of wastewater from hydrofilters systems into the city sewer is unacceptable and is fraught with significant fines.

Even after complex treatment, the discharge of wastewater will lead to the fact that the necessary volume of water will be irretrievably removed from the technological cycle, which will need to be replenished. The toxic sludge released at the same time accumulates in storage tanks and is periodically removed for a fee by specialized companies for neutralization and disposal.

In order to avoid the loss of the resource necessary for the technological cycle of coating in spray booths with hydrofilters, it is necessary to design a drainless system for circulating water supply and sludge regeneration.

Due to the fact that wastewater contains heterogeneous pollutants, one part of which remains in suspension, while the other is subject to sedimentation, a combination of mechanical and physico-chemical treatment methods is necessary to neutralize them.

The most effective for this is thin-layer settling and electrocoagulation-flotation.

As for the regeneration of the sludge formed during the sedimentation of wastewater, when applying the proposed regeneration technology and obtaining a high-quality final product, it is necessary to take into account the compatibility of the applied coatings.

To do this, only compatible paintwork materials should be assigned to the spray booths and their sludge should not be mixed during regeneration.

When applying the proposed technologies for wastewater treatment and sludge regeneration, the loss of valuable waste due to their return to production cycles is excluded.

The costs and the initial decrease in the profitability of production associated with the purchase of the necessary equipment are compensated by a decrease in the cost of sludge disposal, water treatment and wastewater disposal over an average of 1 - 2 years.

It should be noted that the humanistic goals of ensuring the environmental safety of future generations are invaluable. Such measures for the restructuring of the Russian industry for low-waste and waste-free production are inevitable, since the transition to an economy of multiple use of resources has become the basis of the concept of sustainable development.

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