Ensuring environmental cleanliness and technosphere safety of electrochemical production

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Abstract. The article discusses the possibility of reducing the volume of wastewater from electrochemical shops that produce metal coating by electrolysis. Due to the complexity of wastewater treatment from an entire enterprise, the possibility of local return of valuable components to the very process in which they were lost is being considered. Possible ways of returning metal ions that have entered the wastewater back into the technological cycle are shown. The software for calculating the necessary equipment for the implementation of the most closed water circulation cycle is proposed. The author's software greatly simplifies the choice of the type of flushing and makes it possible to choose the best option for performing the necessary actions. It is possible to combine different types of washing baths and traps not only for environmental reasons, but also for economic reasons.

1. Introduction
The transfer of electrochemical production to an environmentally safe development path is a complex and extremely urgent task. This is due to the fact that at present this type of production is one of the largest pollutants of water resources [1-2]. Electrochemical production is an important branch of the national economy, dealing with the application of metal coatings to various products. As a result, the wastewater contains metal ions that pose a significant threat to the environment [3-7]. Most often, the treatment of effluents of such a production does not make it possible to completely extract all the contaminants, therefore, it is impossible to return water to the technological cycle. But it is possible to organize production in such a way as to minimize the volume of effluents or to organize a closed water circulation cycle.

Organization of drainless and low-waste production is a very difficult task. Here it is necessary to take into account the peculiarities of each technological section or line, to make numerous calculations to select the optimal solution. It is for these purposes that a software block was developed for calculating the parameters of the installed equipment for capturing valuable components and their subsequent return to production.

The aim of the study is to develop the idea of organizing low-waste and environmentally friendly production for the application of metal coatings.
2. Materials and methods
Most electrochemical enterprises involved in the application of metal coatings by electrolysis use so-called reagent cleaning as treatment systems. The essence of purification is to collect wastewater from all production lines and treat it with a cheap alkaline agent to convert existing metal ions into poorly soluble hydroxides or carbonates. Further, the formed sediment is filtered, dewatered and taken out of the enterprise, to landfills. Since a lot of dissolved salts and various inclusions remain in the filtered water, it cannot be used in the technological process either, and it is discharged to the city treatment facilities. Those. it is the most common, but not the most environmentally friendly, wastewater treatment method. Of course, there are other methods of purification and disposal of such effluents, up to pumping them under the ground, but each method has its own drawbacks, the main of which are the cost of treatment or its quality [8-10]. Complete modernization or replacement of treatment systems for electrochemical production is an extremely complex and costly process. Therefore, the main method of reducing the technosphere load on the environment will not be the choice of a treatment system, but the method of creating the most closed water circulation cycle. This will allow not only to reduce the volume of wastewater, but also to return metal salts to the technological process.

The essence of the technique comes down to the choice of the optimal number of traps for valuable components from effluents. The fact is that the electrochemical workshop consists of several technological lines for the application of various coatings with metals or alloys. This means that effluents of different composition are formed on each technological line. When such effluents are combined into a single stream, it is no longer economically feasible to separate individual metals from there. Therefore, it is necessary to consider each line separately and install a certain number of catchers. The main volume of wastewater is generated during parts washing operations. Washing is carried out in special tanks after each technological operation. For example, when applying chrome plating, the washes follow the operations of degreasing, etching, activation and the main operation - chrome plating. As a result, chromium ions and components of the process solution are carried away with the parts from the chrome plating operation, and during the washing operation they accumulate in the washing baths. In these baths, the concentration of chromium ions is measured and when a certain level of contamination is reached, they are drained. This is how metal ions enter the wastewater from other technological lines.

It is proposed to install additional baths for capturing electrolyte components and return electrolyte components to the technological chain. Naturally, the composition of the process solution carried away with the parts is not changed, and only its dilution takes place in the washing baths. Over time, the concentration of the process solution components in the washing baths increases. Such wash water simply cannot be thrown away, it must be returned to the technological cycle. After all, many coating operations are carried out while heating, which means there is active evaporation. It is precisely in such cases that the accumulated reserve from rinsing water can be used.

It is also possible to apply the method of changing the algorithm for moving parts along the technological line and, due to the same catchers and additional washing tanks, organize the most closed water circulation cycle. To do this, it is necessary to select such a number of traps to provide a drainless system in which valuable components of working solutions, thanks to the competent organization of the process, will return to the main technological operations of metal electrode position.

Of course, to solve this problem, it is necessary to make a huge number of calculations for the selection and analysis of the optimal equipment. For this purpose, special software was developed, taking into account the peculiarities of carrying out the washing processes on different technological lines.

3. Results
To implement a low-waste technology for applying a metal coating by electrode position, it is necessary to find out how many traps should be installed on a particular line. Using the developed program "Calculation of the concentration of substances in the collection bath", we are able to
calculate at what moment the solution will be so contaminated that it is time to change it. Typically, the collection bath is drained when half the concentration of the process charge is reached. Figure 1 shows the work of the program for calculating the time without draining in the case of the traditional algorithm for the movement of parts along the technological line.

**Figure 1.** Concentration calculation with the traditional motion algorithm of the auto operator.

It can be seen that at 2311 hours of operation, the chromium concentration in the bath reaches half the value and the solution must be replaced.

**Figure 2.** Calculation of concentration with a changed algorithm for the movement of the auto-operator.
Figure 2 shows data on the calculation of the same process, but the algorithm for moving parts along the line is changed. It is shown here that half the concentration is not reached even after the predetermined operating time of the electrolyte. Thus, shows the real possibility of prolonging the operation of the bath without draining.

Another case can be considered when several collection tanks are installed at once and control is carried out by the value of the limiting concentration. When the admissible concentration of metal ions is reached in the last installed trapping bath (Figure 3 shows that 3 trapping baths are used), the first trapping bath is drained into the collector or immediately added to the technological electrodeposition bath. Then from the second bath the solution is poured into the first, and from the third into the second. The third bath is filled with clean water. Thus, always the concentration of metal in waste water is below or equal to the maximum permissible concentration according to the required standards. If with three catchers, the drain is carried out at step 148, then when installing 5 catchers (Figure 4) already at step 900.

![Figure 3. Contamination level with three traps installed.](image-url)

In addition, by using software to select the flushing system and its parameters, it is also possible to significantly reduce the total volume of wastewater. After all, the use of, for example, cascade rinsing baths can also provide a fairly long-term operation without draining rinsing water. By combining rinsing and cascade baths with traps, continuous operation can be achieved in a drainless mode. When choosing the required combination, a number of factors must be taken into account, the main of which is the economic feasibility of a large number of equipment. In this case, the software makes it possible to analyze the best option, taking into account both ecology and economics.

4. Discussion

The performed calculations unambiguously show the possibility of organizing a drainless flushing system on technological lines. However, a number of restrictions on the use of such technology should also be taken into account. First, not all technological processes of metal coating by electrolysis are carried out with heating. Accordingly, evaporation from the surface of the process solution is minimal and the volume of water required for top-up will not be so large. Those the volume of accumulated water in the washing bath will exceed the required volume for adding to the process solution. In this case, the water will have to evaporate from the collector, but not all electrolytes can withstand heating.
without destruction. Secondly, on a number of technological lines, to ensure its drainlessness, it may be necessary to install more than five catchers, and in this case it is necessary to take into account the economic feasibility of installing a large number of equipment. Thirdly, the main emphasis is placed on rinsing after the electrodeposition operation, while wastewater is also formed during the etching, degreasing and activation operations. Here, the installation of traps is not always advisable due to the fact that, in addition to process solutions, contaminants formed as a result of these operations accumulate in the washing bath.

Nevertheless, the largest volume of effluents containing a high concentration of metal ions formed during electrodeposition can be minimized using the methods considered, and the proposed software will allow us to calculate all possible options and choose an appropriate solution.

Figure 4. Contamination level when installing five traps.

5. Conclusions
Thus, the proposed software according to the considered methods of reducing the volume of effluents in electrochemical production makes it possible to reduce the technospheric load and ensure the minimization of effluents and waste with metal ions.

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