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## ZINC RECOVERY FROM THE RAYON INDUSTRY WASTES BY COMBINING THE COLUMN ION-EXCHANGE METHOD WITH ELECTRODIALYSIS PROCESSES

A new technology allowing for a complete recovery of zinc and sulphuric acid from the acid wastes of rayon industry has been developed. The hot-dip bath overflow was concentrated in an electro dialysis process. Both dialyzate and rinse waters have been subjected to sorption process in a column ion-exchanger with the sulphopolystyrene-type resin bed. The concentrate, enriched with sulphuric acid during the electro dialytic process, has been used for the regeneration of the ion-exchanger. The design of an experimental arrangement including three ion-exchange columns and an optimized electro dialysis unit has been presented and the scale-up problems discussed.

### 1. INTRODUCTION

Viscose fibres take an important part in the total output of chemical fibres because of a relatively low costs of their production. The most important problem associated with the rayon industry is the production of large amounts of acid zinc wastes, with zinc sulphate concentrations varying depending upon technological phase. The whole problem is difficult since beside high toxicity of zinc compounds it involves economic losses resulting from zinc complexation in technological baths, as well as due to the costs of neutralization of zinc sulphate and sulphuric acid present in the wastes.

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Conventional techniques commonly used in wastes treatment are satisfactory as far as the neutralization of toxic components is concerned, but do not solve the problem of storage of useless waste sludge.

The methods of extraction, evaporation, electrolysis or sorption which allow for the reclamation of zinc — the most valuable component — are far from the economic optimum, because of large expenditures required by the methods used in reclamation of zinc and neutralization of acid wastes.

The above mentioned reasons have inclined the authors to search for a new solution. Their idea was to combine the column ion-exchange process (based on the cation-exchange-bed) with the membrane concentration (obtained in electro-dialytic process, by conventional system), in which cation- and anion-exchange membranes are applied alternately.

## 2. RESEARCH OBJECTIVE

Quality of zinc wastes obtained in production of rayon, is closely related to the applied technology hence, a description of its main stages seems to be necessary.

A successive alkalization and xanthation of wood cellulose, yields cellulose xanthate, which dissolved in diluted lye undergoes a ripening process. Spinning solution thus obtained is forced into a spinning bath containing water solutions of sulphuric acid, zinc sulphate, and sodium sulphate (cf. Tab. 1), where the regeneration of cellulose and that of lye is followed by the formation of the fibre. The concentration of spinning bath is changed due to the introduction of lay and water contained

Table 1

Characteristics of spinning solutions

Charakterystyka kąpieli technologicznych

Type of solution	H <sub>2</sub> SO <sub>4</sub> kg/m <sup>3</sup>	ZnSO <sub>4</sub> kg/m <sup>3</sup>	Na <sub>2</sub> SO <sub>4</sub> kg/m <sup>3</sup>	Temperature K
1 Rinse water	0.05–0.20	0.10–0.20	0.40–0.80	311
2 Hot-dip bath	40	16	20	363
3 Spinning bath	70	65	170	322

in viscose and partial evaporation of the solution; thus modification of its composition is necessary.

The next phase in the formation of fibre is hot-dip bath, which contains the same components as the spinning bath, but given in lower concentrations (cf. Tab. 1). The constant temperature 363 K is maintained by steam supplied to the solution. The volume of hot-dip bath is a continuously increasing and its excess periodically drained away to the waste stream. At the same time some amounts of the components taken by the fibre from the spinning bath slightly increase the content of zinc sulphate and partially compensate the loss in sulphuric acid.

The excess of mineral compounds and other impurities, brought out from the hot-dip bath, are removed by washing the fibre with softened water. This is the final operation in the production of fibre. The rinse water with its impurities (cf. Tab. 1) is drained into the waste stream.

### 3. THE METHOD OF NEUTRALIZATION OF ACID ZINC WASTES

a) So far chemical precipitation is the most commonly used method. It consists of neutralization of acid solutions to the pH values ranging from 7 to 11, and precipitation of hydroxide separated by filtration or decantation. The optimum pH of that process is 9–10, since at lower values no quantitative precipitation is obtained and a fine-grained structure of the precipitate makes the separation difficult; higher pH values promote the formation of soluble zincates.

Zinc sulphate may be reclaimed from hydroxide precipitate by acidification with  $H_2SO_4$ , however, simultaneous co-precipitation of calcium and ferric hydroxides and the presence of cellulose derivatives make its re-use difficult or even impossible.

b) Biological purification may also be applied but only in solutions with low zinc concentrations. The zinc reduction is incomplete and its efficiency decreases quickly with the increasing concentration of this element. The process needs an intense aeration and the addition of special biogenic nourishing substances. The concentrations exceeding toxicity threshold may poison the biological reactor.

The isolation of zinc from secondary waste sludges and its recovery create an additional and difficult problem.

c) Physical and chemical methods applied presently to various degrees are used out of necessity.

Zinc extraction requires a large amount of valuable organic solvents and their application is not justified by the achieved economical advantages.

Evaporation technique commonly used in rayon industry results in mere reduction of volume of wastes, and is not effective as far as the isolation of valuable components or the elimination of the accumulated organic impurities is concerned.

An attempt to adapt the electrolytic methods (widely applied in non-ferrous metallurgy) to zinc reclamation from rayon wastes failed because of unfavourable economic effects as well as due to the large amounts of the solutions used.

d) Ion sorption, (ion-exchange), being an efficient physical and chemical process, is from its very nature most suitable for the studied technology.

Convenient work under column bed conditions, the reversibility of sorption and desorption processes allowing to shift the equilibrium according to the required direction, the selectivity of ion separation and a sufficiently wide range of the sorbed agent concentrations have drawn the attention of many scientists dealing with this problem [1-3], [7-9], [12]. From the outlined technology of the rayon formation it follows that neutralization and reuse concern the overflow volume of hot-dip bath and the total volume of rinse waters, their ratio being equal to 1 : 50.

In the proposed arrangement both kinds of wastes have been mixed and the average mixture sorbed on column ion-exchange-bed.

Theoretically, the sorption of zinc may be performed on cation or anion-exchange-bed, in practice however only the cation-exchangers are applied.

The investigations of several types of cation-exchangers conducted with respect to polymer composition and to the acidity have proved that the most suitable sorbents are cation-exchangers of sulphopolystyrene type.

The main purpose of the reported research was to define the participation of zinc and sodium ions in total sorption, and to investigate the influence of the regeneration agent acidity on the course of the selective process of zinc desorption.

From economic point of view the choice of optimal solution for the cation-exchange-bed regeneration is the most important problem.

#### 4. THE COLUMN SORPTION OF RINSE WATERS COMBINED WITH THE ELECTRODIALYSIS [10]

Although column sorption is a technological progress, nevertheless it does not allow for an effective isolation of the valuable components and for simplification of the waste neutralization technique.

The problems of considerable losses of sulphuric acid and the necessity of its neutralization in local or central sewage treatment plants have remained unsolved.

The methods combining seemingly low amounts of hot-dip bath overflow with a fifty-times higher volume of rinse waters is contrary to generally accepted rules, bearing in mind that cumulative charge of zinc contained in hot-dip bath exceeds about four times the total amount of this ion in all rinse waters.

Thus, in column sorption about 80 % of zinc ions come from hot-dip bath waste, and the remaining 20 % — from rinse waters.

Under such conditions the inter-regeneration cycle of the ion -exchange bed is about five times shorter, and consequently, the units used for the total sorption of zinc wastes resulting from current production must be remarkably larger.

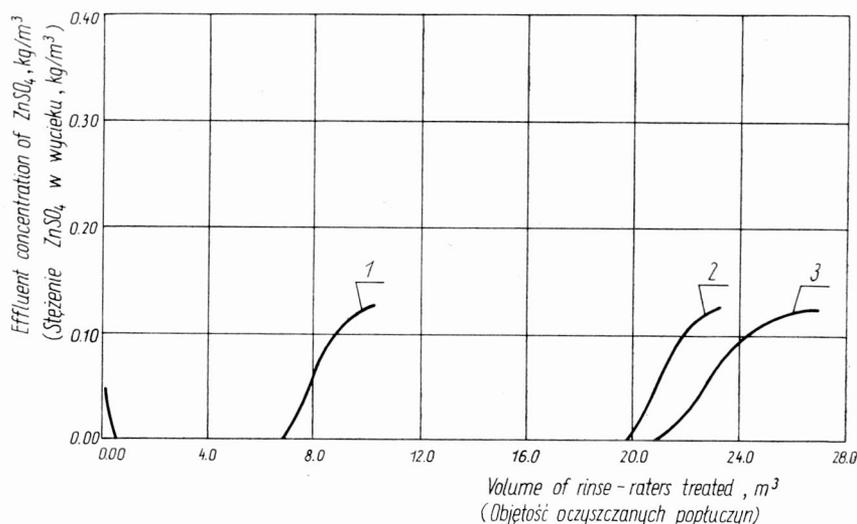


Fig. 1. Effluent concentration of zinc during process of sorption performed on different cation exchangers: 1 — MK-3, 2 — KPS, 3 — X-SD

Rys. 1. Zawartość cynku w wycieku w procesie sorpcji na różnych kationitach

The above analysis has inclined the authors to search for a new technology, in order to optimize the so far applied column ion-exchange process, both under sorption and desorption conditions.

It has been decided that the sorption of large volumes of rinse water with low concentrations of zinc sulphate will take place in a multi-column cation-exchange bed. The basic system consists of three identical inter-connected columns (Fig. 1). Column I does not work to the break-through point (as it does conventionally), but to a complete saturation point. The whole process runs as follows: starting with the break-through of the column I to a complete depletion of its ion-exchange capacity the remaining cation charge is captured by the buffer column II, connected in series with the column I. When the bed of the column I is fully saturated its function is performed by the column II, the buffer functions are taken by the regenerated column III, and the column I is regenerated. The sorption process shown in a three-column unit may be also realized in multi-column sets. They, however, are not a mere multiplication of the former system, being conditioned by the loading (coming from salts contained in rinse waters), dimensions of columns and the resin bed-solutions contact time. Under the above assumptions several variants are equally possible, e.g. a unit may consist of two parallel columns which perform the function of the column I and the buffering occurs in a single

Table 2

Sorption and desorption parameters of different cation-exchangers during regeneration with solution 1. Resin volume in H-form 0.032 m<sup>3</sup>. Column diameter 0.22 m. Linear flow velocity —  $2.78 \cdot 10^{-3}$  m/s

Zmienność parametrów sorpcji i desorpcji jonitów X-SD, KPS, MK-3 podczas regeneracji roztworem 1. Objętość jonitu spęcznionego w formie H 0,032 m<sup>3</sup>. Średnica kolumny — 0,22 m. Liniowa prędkość przepływu —  $2,78 \cdot 10^{-3}$  m/s

	Exchanger	Sorption ZnSO <sub>4</sub> kg	Recovered ZnSO <sub>4</sub> in the eluate kg	Recovered ZnSO <sub>4</sub> %	Eluate volume m <sup>3</sup>	Concen- tration in the eluate kg/m <sup>3</sup>	Capacity eq/dm <sup>3</sup>
1	X-SD	3.360	3.220	95	0.100	97.2	1.25
2	KPS	2.685	2.400	90	0.075	97.0	0.93
3	MK-3	1.341	0.998	74	0.120	73.3	0.39

column; it may also be a combination of other systems (connections in series and parallel), provided that the optimum sorption is achieved with the minimum investment cost.

Three highly acidous cation-exchange-resins with ionogenic sulphonic groups have been examined:

- 1) MK-3, based on p-phenolsulphonic acid, phenol and formaldehyde bead polycondensation;
- 2) Xenonit X-SD based on styrene-divinylbenzene copolymers;
- 3) Wofatit KPS, of the same polymeric components as the X-SD resin.

Rinse waters (composition shown in Tab. 1) have been passed through the column-beds of identical dimensions with a constant velocity. Sorption effects are presented in Tab. 2. The table includes also the total ion-exchange capacity values, and experimental data concerning practical ion-exchange capacity of the examined cation-exchangers, found for zinc ions under sorption conditions. The per cent of zinc sorption with respect to the total ion-exchange capacity of separate resins is also presented.

A comparative examination of three cation-exchangers has shown the best sorption properties of Xenonit X-SD. That is why this resin was used in a series of sorption and regeneration experiments. Results are listed in Tab. 3.

The decision that the rinse waters and hot-dip bath are not to be mixed for column sorption was based on successful experiments in which

Table 3

Change in sorption and desorption parameters of cation-exchanger X-SD during regeneration with solutions 1 and 2. Resin volume in H-form is 0.010 m<sup>3</sup>. Column diameter 0.22 m. Rate of flow 2.78·10 m/s

Zmienność parametrów sorpcji i desorpcji kationitu X-SD podczas regeneracji roztworem 1 i 2. Objętość jonitu spęcznionego w formie H 0,010 m<sup>3</sup>. Średnica kolumny 0,22 m. Liniowa prędkość przepływu 2,78·10 m/s

Type of solution	H <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub> sorption kg	ZnSO <sub>4</sub> recovery kg	ZnSO <sub>4</sub> recovery %
	concentration in the eluent, 4g/m <sup>3</sup>			concentration in the eluate, kg/m <sup>3</sup>					
1	70.2	65.2	169.0	66.2	98.1	131.0	1.065	0.955	90
2	98.0	42.0	115.0	90.7	64.6	90.0	1.030	0.960	93

zinc had been recovered from hot-dip bath in the process of electro-dialytic concentration. The above experiments, which will be described in chapter 5 of the present paper, have shown that the optimum of this process is attained at the concentration of zinc sulphate about three times higher than its concentration in hot-dip bath. The performed experiment has also allowed for determination of the amounts of sodium sulphate and sulphuric acid that pass to the concentrate.

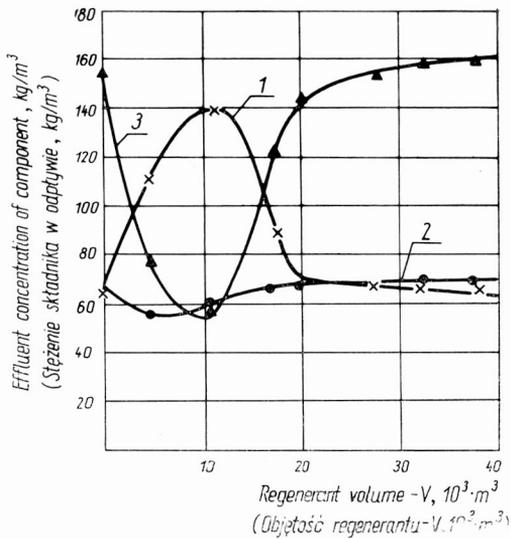


Fig. 2. Regeneration curves for solution 1:

1 — ZnSO<sub>4</sub>, 2 — H<sub>2</sub>SO<sub>4</sub>, 3 — Na<sub>2</sub>SO<sub>4</sub>

Rys. 2. Przebieg krzywych regeneracji podczas desorpcji roztworem 1

The aim of the combined process was, moreover, to utilize the acid solution of the concentrate from electro-dialysis, by applying it to the regeneration of the exhausted ion-exchangers. Because of the increased content of zinc sulphate in the solution the effluent is expected to contain this element in concentration higher than in spinning bath. This procedure would allow the post-regeneration solution to be returned to the technological circulation, after a possible modification in its composition.

Of several regeneration solutions described earlier by the authors, concerned with column-bed sorption, spinning bath seems to be the most advantageous one. For this reason in investigations of zinc desorption from the column-bed two regeneration methods have been compared,

namely spinning bath (solution 1) and model solution (in which the concentrations of separate components were more or less the same as in the concentrate from electro dialysis (solution 2).

The courses of curves obtained for the regeneration of X-SD exchanger by means of solution 1 (Fig. 2) and solution 2 (Fig. 3) indicate the

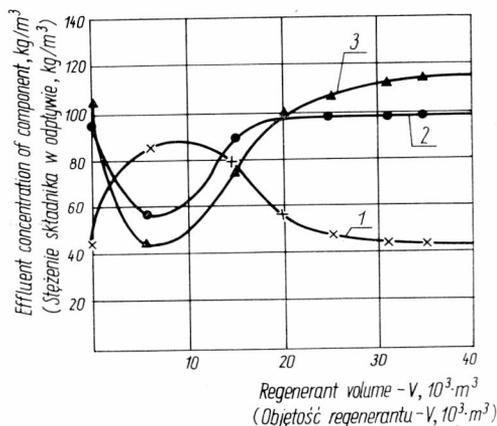


Fig. 3. Regeneration curves for solution 2:

1 -  $ZnSO_4$ , 2 -  $H_2SO_4$ , 3 -  $Na_2SO_4$

Rys. 3. Przebieg krzywych regeneracji podczas desorpcji roztworem 2

distribution of the concentrations of the sorbed components during the desorption. Hence, the effluent fraction which may be cut out for the re-circulation of the components may be determined.

## 5. ELECTRODIALYTIC CONCENTRATION OF HOT-DIP BATH COMBINED WITH COLUMN REGENERATION [4, 11]

The concentrations of salts in hot-dip bath, advantageous for electro dialysis, as well as relatively small volumes of this solution have inclined the authors to replace the dilution with rinse waters and hot-dip bath by membrane process. An additional, but important reason was the expected high mobility of sulphuric acid hydrogen ions. This means that their flow rate to the concentrate compartment would be much higher than that of zinc and sodium ions.

Table 4

## Characteristics of ion exchange membranes

## Charakterystyka membran jonowymiennych

Parameters	Neosepta Cl-2.5T	Neosepta AV-4T
Type of membrane	cationic	anionic
Active group	-SO <sub>3</sub> H	-N(CH <sub>3</sub> ) <sub>3</sub> OH
Polymeric matrix	polyvinyl	chloride
Thickness, mm	0.15-0.17	0.15-0.17
Mullen burst, N/cm <sup>2</sup>	300-400	400-500
Area resistance, Ω·cm <sup>2</sup>	2.7-3.2	2.5-3.0
Permselectivity*	0.98	0.98
Gel water, %	30-40	20-25
Ion-exchange capacity, meq/g	1.8-2.0	1.5-2.0

\* During electro dialysis of 0.5 NaCl,  $i = 10$  mA/cm<sup>2</sup>,  $t = 298$  K (25 °C).

Table 5

## Characteristics of the electro dialysers

## Charakterystyka elektrodializerów

Parameters	Laboratory unit type		Pilot unit typ	
	IME-50	IME-200	PME-640	PME-3800
Dimensions: length,	457	400	760	1500
width, mm	120	160	300	648
height,	200	330	515	400
weight, kg	3	10	50	400
Arrangement of membranes,	vertical			
Mode of the flow,	parallel or counter-flow			
Compartment thickness, mm	2 ; 4 ; 6 ; 8	4 ; 8	8	8
Active membranes area, cm <sup>2</sup>	50	200	640	3800
Total membrane area, cm <sup>2</sup>	240	528	1545	5000
Number of the membrane pairs	15	20	30	75
Electrodes	Pt	Pt	acid-resistant steel	
Output, m <sup>3</sup> /d	0.030	0.170	0.740	12.0
Cooling system	external			
Feeder-rectifier	BZA 60/10	BZA 60/10	BZA 240/10 2 × BZA BZA 240/25 24/240	

The maximum enrichment of the concentrate with hydrogen ions observed under regeneration conditions would, in turn, influence positively the shift in the ion-exchange equilibrium toward zinc desorption.

According to the assumptions, the electro-dialytic process was to be combined with column sorption not only by using the concentrate for regeneration but also by adding the dialyzate to rinse waters destined for column sorption. The addition of dialyzate to rinse water, considering its highly advanced deacidification, should increase the solute content in sorbed solution, but at the same time decreases relatively the acidity, and consequently, shifts the equilibrium of ion-exchange toward the direction desirable for sorption.

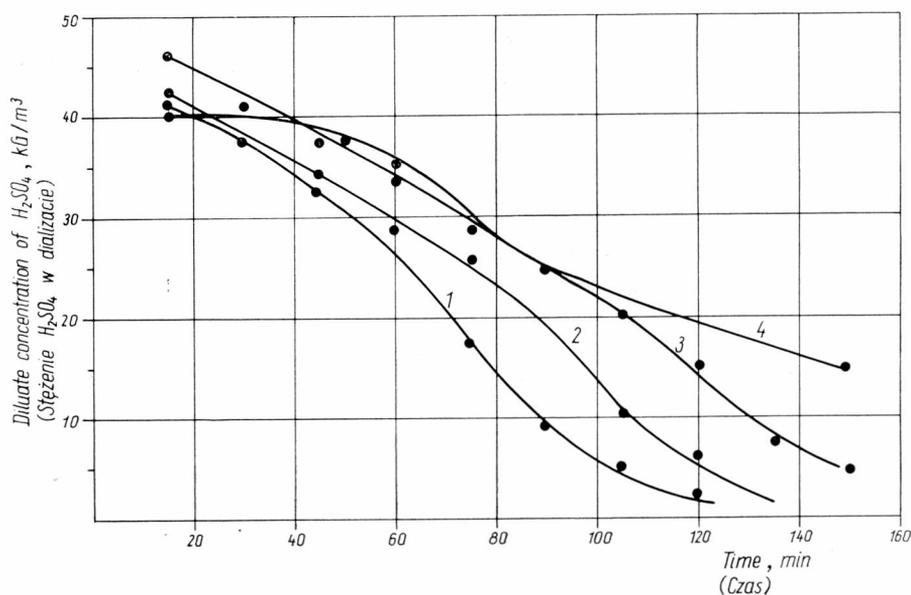


Fig. 4. Diluate concentration H<sub>2</sub>SO<sub>4</sub> versus time at different fluxes

1 - 100 cm/h, 2 - 250 cm/h, 3 - 500 cm/h, 4 - 750 cm/h

Rys. 4. Zależność stężenia H<sub>2</sub>SO<sub>4</sub> w dializacie od czasu przy różnych natężeniach przepływu

Electrodialytic process has been performed in the unit designed by the authors. Standard cation- and anion-exchange membranes (their characteristics are shown in Table 4) have been applied alternately.

The research has been carried out in four steps by increasing gradually the scale of production: starting with laboratory units up to a full-scale

industrial pilot-unit. The characteristics of electrolysing units used in the investigations are given in Table 5.

During the experiment flow velocity in compartments was changed in order to find out its effect on the changes in concentration of components, transferred to separate compartments.

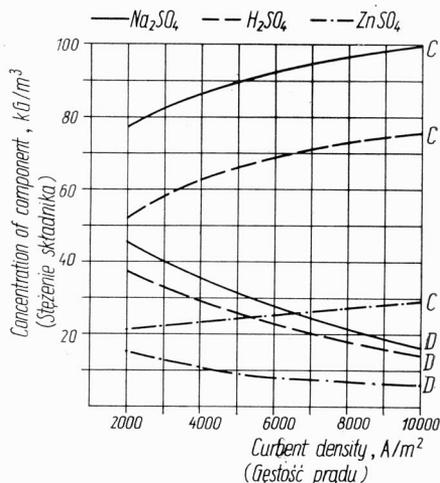


Fig. 5. Concentrate (C) and diluate (D) concentrations versus current density at time  $T = 30$  min.

Rys. 5. Zależność stężeń składników w dializacji (D) i koncentracji (C) od gęstości prądu przy czasie  $T = 30$  min.

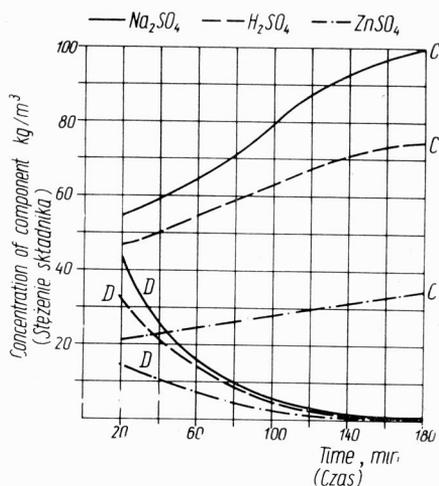


Fig. 6. Concentrate (C) and diluate (D) concentration versus time at current density  $i = 1000$  A/m<sup>2</sup>

Rys. 6. Zależność stężenia składników w dializacji (D) i koncentracji (C) od czasu przy gęstości prądu  $i = 1000$  A/m<sup>2</sup>

The change in current density resulted in an increased velocity of individual ion-transport. For laboratory experiments the above relationship is given in Fig. 5.

The transfer velocities of separate ions for the optimum current density found under laboratory conditions have been presented as the function of time (Fig. 6).

Results obtained in the whole (four-step) experiment are summarized in Table 6. The table includes the minimum and maximum values of the variable parameters. The columns of the Table should not be identified with particular experiments in column sorption.

It has been stated before that, as far as column sorption applied

Table 6

Parameters of the plasticizing bath treatment by electro dialysis used in experiments

Parametry doświadczalne stosowane przy oczyszczaniu kąpeli plastyfikacyjnej metodą elektrodializy

Item	IME-50		IME-200		PME-640		PME-3800	
	min	max	min	max	min	max	min	max
Number of cell pairs	1	10	1	10	1	20	1	75
Voltage, V	4	80	10	240	10	240	10	240
Current intensity, A	1	30	1	30	10	64	10	38
Current density, A/m <sup>2</sup>	200	6000	200	1500	200	1000	10	100
Experiment duration, h	1	6	1	6	1	6	1	6
Concentration of the concentrate								
Zn - g/dm <sup>3</sup>	—	12	—	10	—	10	—	8
H - g/dm <sup>3</sup>	—	3,5	—	2.4	—	2	—	3
Na - g/dm <sup>3</sup>	—	40	—	35	—	35	—	30
SO <sub>4</sub> - g/dm <sup>3</sup>	—	170	—	190	—	170	—	150
Concentration of the diluate								
Zn - g/dm <sup>3</sup>	1	—	2	—	3	—	3	—
H - g/dm <sup>3</sup>	0.09	—	0.1	—	0.1	—	0.1	—
Na - g/dm <sup>3</sup>	1	—	1.5	—	5	—	5	—
SO <sub>4</sub> - g/dm <sup>3</sup>	20	—	30	—	30	—	30	—

to full scale industry is concerned, the best effects are obtained by multiplying a 3-column module, which has been assumed to be a basic one. Similarly, a full-scale electro dialytic concentration is based on an optimal unit, but its multiplication is obtained by suitable connections, in series and in parallel arrangement.

The given system depends on the volume of wastes, the optimum flow velocity in a compartment and current density, as well as on the required concentration of the hot-dip bath concentrate.

The main difference between the two components of the combined process consists in the fact that column sorption scale increases linearly, while the dimensions of the electro dialyser unit are limited both by the standard size of the produced ion-exchanger membranes and by the optimum thickness of the set of membranes. Hence, the search for the most effective combination is fully justified.

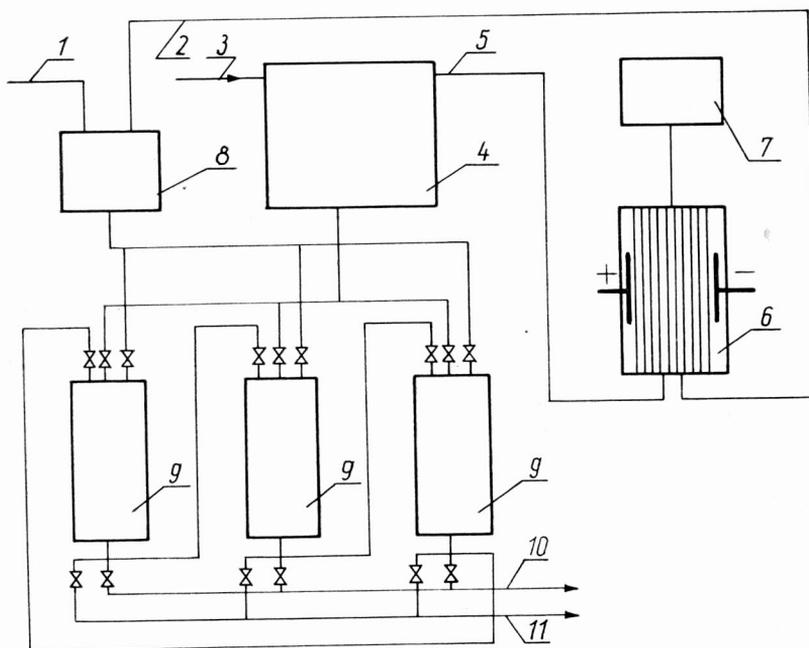


Fig. 7. Schematic representation of zinc recovery plant:  
 1 — adjusting of the solution composition, 2 — concentrate, 3 — rinse waters, 4 —  
 rinse water tank, 5 — dilute, 6 — electro-dialyzer, 7 — hot-dip bath tank, 8 — rege-  
 neration solution tank, 9 — ion-exchange column bed, 10 — eluat, 11 — treated  
 effluent

Rys. 7. Schemat instalacji odzysku cynku:  
 1 — korekta składu roztworu, 2 — koncentrat, 3 — wody płuczne, 4 — zbiornik  
 wód płucznych, 5 — dializat, 6 — elektrodializer, 7 — zbiornik kąpieli plastyfika-  
 cyjnej, 8 — zbiornik roztworu regenerującego, 9 — kolumny ze złożem jonitowym,  
 10 — eluat, 11 — ścieki oczyszczone

The simplest system, allowing to apply the combined process is shown  
 in Fig. 7.

## CONCLUSIONS

1. The ion-exchange methods, applied so far to sorption of zinc from  
 the rayon industry, though much more efficient when compared with  
 other methods, have precluded the full utilization of the optimum process  
 conditions.

2. Column sorption of the mixed solutions of rinse waters and dialyzate from the electro dialysis of hot-dip bath is very effective in recovery of zinc and creates favourable conditions for its desorption during regeneration.

3. The concentration of hot-dip bath during electro dialysis process allows the use of obtained concentrate, enriched with sulphuric acid, for regeneration of zinc-loaded column beds. The concentration of the effluent, after some modification of its composition, is high enough to be returned back to technical circulation.

4. The combined method presented in the paper may be applied to other types of wastes, provided, however, that the concentrations of the major components both in technological solutions, and in waste waters are comparable.

5. In separate applications the choice of optimum systems, both for column sorption and electro dialysis process is indispensable. In optimizing the size and number of columns their varying functions performed during the whole cycle have to be considered. The optimization of electro dialysis is confined to the choice of the most efficient scheme of connections of the optimum unit, which would guarantee the desired concentrations, obtained at the highest flow velocities, and at the lowest energy costs.

#### ODZYSK CYNKU ZE ŚCIEKÓW Z ZAKŁADÓW SZTUCZNEGO JEDWABIU SPRZEŻONĄ METODĄ JONITOWO-ELEKTRODIALITYCZNA

Opracowano technologię pełnego odzysku cynku i kwasu siarkowego z kwaśnych ścieków z produkcji włókien wiskozowych. Wody płuczne i dializat z elektrodialitycznego zateżania nadmiarów kąpieli plastyfikacyjnej poddawano procesowi sorpcji na kolumnowych złożach z kationitów sulfopolistyrenowych. Do regeneracji jonitów używano koncentratu elektrodialitycznego, w którym zwiększono zawartość kwasu siarkowego w wyniku procesu elektrodializy.

Zaproponowano układ modelowy złożony z trzech kolumn jonowymiennych i zoptymalizowanej jednostki elektrodializującej. Przedyskutowano możliwości i warunki zwiększenia skali urządzeń.

#### RÜCKGEWINNUNG VON ZINK AUS DEN ABWÄSSERN DER KUNSTSEIDENFABRIKEN MIT DEM GEKOPPELTEN VERFAHREN IONENAUSTAUSCH-ELEKTRODIALYSE

Es wurde eine Technologie bearbeitet zur vollen Rückgewinnung von Zink und Schwefelsäure aus sauren Abwässern der Viskosefaserproduktion, Spülwasser und Dialysat aus der elektrodialytischen Verdickung des Überschusses des Plastifizierbades

wurden der Sorption auf Kolonneuschichten von sulfopolystyrenen Kationenaustauschern unterworfen.

Zur Regenerierung der Ionenaustauscher verwendete man ein elektrodialytisches Konzentrat, in welchem der Schwefelsäuregehalt im Verlauf der Elektrodialyse erhöht wurde. Es wurde ein Modellsystem vorgeschlagen, welches aus drei Ionenaustauscherkolonnen und einer optimalisierten elektrodialysierenden Einheit besteht. Es wurden die Möglichkeiten und Bedingungen zur Vergrößerung der Ausmaße dieser Anlagen diskutiert.

#### РЕГЕНЕРАЦИЯ ЦИНКА ИЗ СТОЧНЫХ ВОД НА ЗАВОДАХ ИСКУССТВЕННОГО ШЕЛКА ИОНИТНО-ЭЛЕКТРОДИАЛИТИЧЕСКИМ МЕТОДОМ

Разработана технология полной регенерации цинка и серной кислоты из кислых сточных вод от производства вискозных волокон. Промывные воды и диализат от электродиалитического концентрирования избытков пластификационной ванны подвергались процессу сорбции на колонном слое из сульфополистироловых катионитов. Для регенерования ионитов употреблялся электродиалитический концентрат, в котором содержание серной кислоты было повышено в результате процесса электродиализа. Предложена модельная система, составленная из трех ионообменных колонн и оптимизированной электродиализирующей единицы. Обсуждены возможности и условия увеличения масштабов оборудования.

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