Proceedings of ECOpole
DOI: 10.2429/proc.2015.9(1)016 2015;9(1)

Izabela PŁONKA[1], Barbara PIECZYKOLAN[1] and Magdalena KOSEL[1]

DEWATERING OF SLUDGE FROM ELECTROPLATING WASTEWATER TREATMENT

ODWADNIALNOŚĆ OSADÓW POCHODZĄCYCH Z OCZYSZCZANIA ŚCIEKÓW GALWANICZNYCH

Abstract: Electroplating coating of products more sustainable coatings is their protection or decoration. As a result of these technological processes generated waste water, which are treatment. During the treatment of waste water produced sludge that were the subject of research. Sludge were from wastewater treatment plants located at the manufacturing plant which produces car parts. They were taken from the sludge tank, preceded by sedimentation in the lamella. In order to determine their sensitivity to dewatering the first step was selected the type and dose of reagent. In the second stage of the study conditioned sludge were tested mechanical dewatering centrifuge and belt press simulator. The results obtained showed that the most effective effect was observed when using anionic polyelectrolytes Praestol 2505 and Superfloc A 110 and A 130. Were used in a dose of 2.1 mg/g TS to 3.4 mg/g TS, and from 8.2 mg/g TS to 15.4 mg/g TS. The use of too low a dose of reagent and overdose resulted in unsatisfactory conditioning effects. The excess polyelectrolyte increased viscosity of the liquid sludge, which gave slower water contained therein. Conditioned selected polyelectrolytes sludge were subjected to a mechanical dewatering. The sludge obtained after centrifugation is characterized by a total solids a maximum of 12.7%. The centrifugation process efficiency was influenced by the spin speed and the duration of the process. The best results were obtained for a duration of 10 min and a speed of 3000 turns/min. A higher degree of dewatering of 29.5% TS obtained using the simulator of belt press.

Keywords: sludge from industrial, mechanical dewatering, the choice of polyelectrolyte

Introduction

Electroplating process is used to layer products with fewer precious materials with more durable layers. In connection with this operation surface of the unit achieves better corrosion and heat-resistant properties. In addition, galvanic coating of the products can be carried out for the improvement of surface protective and decorative purposes and to give the required characteristics of the profiled elements, mainly hardness and wear resistance (technical coating) [1-4]. Electroplating process consists of several stages. First, the devices are mechanically cleaned, degreased and acidified. The aim of the acidification is to remove oxides from the surface of objects created in the degreasing and etching of the surface cloudy. After preparatory operations galvanic coating process takes place. Electroplating is performed under the effect of direct electric current. The bath composition obviously depends on the kind of the cover. This may be a process of coating with nickel, chromium, copper, zinc plating, oxidation, blackening, cadmium, lead, etc. The final stage of treatment is aimed at upgrading and consolidating imposed electroplated coatings. For this purpose, the most commonly used is passivation, coloring, polishing and varnishing [1, 5, 6]. After completion of the electroplating bath items are subjected to washing. Flushing is normally carried out in tanks with a continuous flow of fresh water, rarely used rinse spray [7]. As a result wastewater is produced, *ie* backwash water and spent baths. In

[1] Faculty of Energy and Environmental Engineering, Silesian University of Technology, ul. Konarskiego 18A, 44-100 Gliwice, Poland, phone +48 32 237 16 98, fax +48 32 237 10 47, email: izabela.plonka@polsl.pl
[*] Contribution was presented during ECOpole'14 Conference, Jarnoltowek, 15-17.10.2014

the diluted wastewater washing water generated in the process of chemical or electrochemical treatment of objects are present. Backwash water pollution are main components of the bath [1, 5, 6]. On the other hand, taking into account the type of impurities from the electroplating industry wastewater, wastewater from cleaning and degreasing, waste of digestion, waste chromium (water washing after the electrochemical plating and chromate passivation) and cyanide wastewater can be distinguished. This wastewater is treated and as a result of the process sludge is produced [1, 4-6, 8].

Subject and methodology of research

The aim of the subject was sludge from industrial wastewater treatment plant taking place next to the automotive manufacturing. System of technological wastewater treatment consists of: reduction of chromium(VI) using a sodium bisulfate (waste chrome), coagulation process with the use of Flokor 1A (for the waste water mixed, precipitation of by the addition of milk of lime solution. Then sedimentation process in lamella tank where separation of the treated sewage sludge. Sedimentation process is enhanced with polyelectrolyte conditioning. The separated sludge is periodically pumped into the sludge tank. Then adjustment of the pH by the use of H_2SO_4 or NaOH to obtain pH of fulfilling the requirements for wastewater that can be discharged into the drains. The final stage of wastewater treatment process is filtration through sand filter. This filter removes from wastewater remains of insoluble's.

The tests were performed for sludge taken from the tank. The tests were carried out in three stages. In the first stage of the analysis examined the sludge properties. The extent of the research included the like: total solids (TS), volatile solids (VS), specific resistance, capillary suction time (CST), pH, odor. All analyzes were conducted in accordance with the applicable standards [9-13]. In the second stage the type and dose of polyelectrolyte was select based on the flocculation tests, strength, CST. Conditioning with polyelectrolyte enables to change the structure of the sludge and the surface of the dispersed solid phase particles, which leads to reduction of the interface and reduce the force of binding water from the surface of sludge flocs. Cationic and anionic polyelectrolytes were used in conditioning process. They are presented in Table 1.

Table 1

Type of tested polyelectrolyte

An ordinal number	Polyelectrolyte	Ionic character
1	Praestol 644	weak cationic
2	Praestol 611	weak anionic
3	Praestol 2505	anionic
4	Zetag 63	cationic
5	Zetag 47	cationic
6	Magnafloc 155	anionic
7	Zetag 8846	cationic
8	Praestol 2640	average anionic
9	Praestol 2540	average anionic
10	Superfloc A 110	anionic
11	Superfloc A 150	anionic
12	Superfloc A 130	anionic

Flocculation test was based on visual assessment of the size and structure of the flocs after the introduction of the sludge and mixing. Then, based on the strength test flocs strength was evaluated. That flocs structure should be robust, due to the centrifuge action of the centrifugal force and the shearing forces occurring in the belt press. For this purpose, from the depth of 10 cm five times the sludge was poured from the beaker to beaker. Sieving test was carried out using Buchner funnel lined with filter belt. Filter belt was made of the same material as the belt filter used for mechanical dewatering. The flocculated sludge was placed on the belt and the filtrate was collected.

The dewatering tests sludge were carried out on the simulator belt press and in a centrifuge nn the last stage. In the study a laboratory centrifuge Centrifuge company MPW - type 340 with a maximum speed 4000 rev./min and time centrifugation of the 1 to 60 min were used. The sludge was conditioned by selected doses and type of polyelectrolyte. It was centrifuged for a period of 5 and 10 minute, whit velocity 1500 and 3000 rev./min. After centrifugation total solids were analyzed.

In turn, as the belt filter press simulator Büchner funnel lined with filter belt was used. It was made of the same material as the belt filter press used for mechanical dewatering, and piston pressure. In the initial stage of the dewatering gravity filtration takes place, wherein water is removed during the conditioning process. Then, the clarity and quantity filtrate obtained in 5 minutes were measured. During filtration it was checked whether cake sludge produced on the belt does not block the mesh. Then, shaking the funnel in horizontal position it was determined whether the sludge cake was broken and whether it was susceptible to create a sludge roller. Then, the sample of mechanical dewatering of sludge cake by means of the pressure piston was made. After dewatering total solids were measured.

Results and analysis

The results of physico-chemical sludge derived from the treatment of wastewater from the electroplating industry showed that the precipitate was characterized by a slightly alkaline pH equal to 8.63, and also had a characteristic smell and intense and characteristic grey - green color. The test sludge showed high hydration amounting to 98.6%, a low total solids (TS) 1.4% and volatile solids (VS) 15.7% TS. Low content of volatile solids indicates that it is a mineral sludge derived from the treatment of industrial waste water. Furthermore, the sludge tested showed good filtration properties, as evidenced by the short period of capillary suction time (CST) equal to 68 seconds and a low value of the specific resistance equal to $9.9559 \cdot 10^{11}$ m/kg. Low values of the parameters determining the filtration properties are also characteristic of the sludge from the treatment of industrial wastewater.

Because of relatively high hydration sludge the studies were undertaken to determine the susceptibility of this type of sludge to mechanical dewatering. Sludge prior to dewatering process should be subjected to appropriate treatment. This process can change the structure of the sludge and reduce the forces bonding water with surface of sludge flocs.

Therefore, the studies were performed using conditioning of sludge with polyelectrolytes of various ionic character whit dose of 2.1 mg/g TS. The results of tests carried out (Table 2) showed that the best results were obtained when conditioning anionic polyelectrolytes Praestol 2505, Superfloc A 110 and A 130 Superfloc. With their use, large flocs with robust structure and good sedimentation properties were formed.

Table 2

The results of selection of polyelectrolyte type

Type of polyelectrolyte	Dose [mg/g TS]	Results
Praestol 644	2.1	small flocs, undergoing defragmentation, low sediment properties
Praestol 611	2.1	small flocs, undergoing partial defragmentation, low sediment properties
Praestol 2505	2.1	large flocs, non-undergoing defragmentation, well sediment properties
Zetag 63	2.1	small flocs, undergoing defragmentation, low sediment properties
Zetag 47	2.1	small flocs, undergoing defragmentation, low sediment properties
Magnaflock 155	2.1	small flocs, undergoing defragmentation, low sediment properties
Zetag 8846	2.1	small flocs, undergoing defragmentation, low sediment properties
Praestol 2640	2.1	average flocs, undergoing partial defragmentation, low sediment properties
Praestol 2540	2.1	average flocs, undergoing partial defragmentation, low sediment properties
Superfloc A 110	2.1	large flocs, non-undergoing defragmentation, well sediment properties
Superfloc A 150	2.1	average flocs, undergoing partial defragmentation, low sediment properties
Superfloc A 130	2.1	large flocs, non-undergoing defragmentation, well sediment properties

Table 3

The results of selection of polyelectrolyte dose

Type of polyelectrolyte	Dose [mg/g TS]	Results
Praestol 2505	2.1	large flocs, undergoing partial defragmentation, well sediment properties, partially passing through the belt
	3.4	large flocs, non-undergoing defragmentation, well sediment properties, partly passing through the belt
	8.2	large flocs, partial undergoing defragmentation, very quickly sediment properties, does not passing the belt
	15.4	very large flocs, non-undergoing defragmentation, well sediment properties, does not passing the belt
Superfloc A 110	2.1	large flocs, partial undergoing defragmentation,well sediment properties, partially passing through the belt
	3.4	large flocs, partial undergoing defragmentation, well sediment properties, partially passing through the belt
	8.2	large flocs, partial undergoing defragmentation, well sediment properties, does not passing the belt
	15.4	very large flocs, non-undergoing defragmentation, well sedimenting, does not passing the belt
Superfloc A 130	2.1	large flocs, partial undergoing defragmentation, well sediment properties, passing through the belt
	3.4	large flocs, non-undergoing defragmentation, well sediment properties, partially passing through the belt
	8.2	large flocs, partial undergoing defragmentation, well sediment properties, partially passing through the belt
	15.4	very large flocs, non-undergoing defragmentation, well sediment properties, does not passing the belt

In the next stage the most effective polyelectrolytes for the selection of the optimum dose of the reagent in the range of 2.1-15.4 mg/g TS were carried out flocculation tests, the strength test and the sieve test. The results of these tests are presented in Table 3. Analyzing the results of the tests it can be concluded that for lower doses of polyelectrolyte the results were unsatisfactory. The obtained in the test sieve filtrates were turbid and flocs structure was unstable and most of them passed through the belt. The best results in the form of large and robust flocs and a clear filtrate was obtained for doses 8.1 and 15.4 mg/g TS.

In addition, filtration properties of sludge during conditioning polyelectrolytes improved. It was confirmed by shortened capillary suction time. The results of CST varied in the range of 18 to 33 seconds (Fig. 1). It should be noted that an overdose of the reagent adversely affected the filtration properties of the sludge, as indicated by prolonged capillary suction time at the dose of 15.4 mg/g TS. The excess polyelectrolyte increased the viscosity of the liquid sludge, so sludge slowly removed water contained therein. For this reason, the selection of the optimal dose of the reagent both the value CST and structure of flocs should be taken into account. Sludge conditioned by selected polyelectrolyte at a dose 8.2 and 15.4 mg/g TS were tested by mechanical dewatering. In this regard, lab centrifuge and belt filter simulator were applied. As a result of dewatering in the centrifuge a relatively small decrease in the total solids was noted (Fig. 2). The effect dewatering depended on the type of a polyelectrolyte used in conditioning. In case of Praestol 2550 dewatered sludge was characterized by a total solids content of 7.8 and 8.2%. More effective was Superfloc A 130, with the total solids content in the sludge after dewatering at 10.4 and 12.7% respectively, for a dose of 8.2 and 15.4 mg/g TS. Increasing dose of polyelectrolyte did not significantly affect the efficiency of the process.

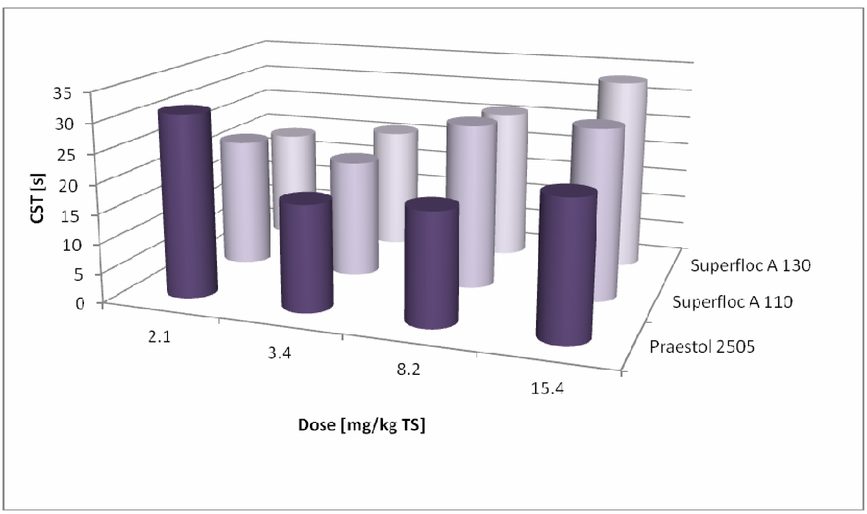

Fig. 1. Changes in CST depending on dose and type of polyelectrolyte

Taking into consideration the results it can be concluded that the use of centrifuges in the process of mechanical dewatering of this type of sludge is inefficient. Significantly better results were obtained when dewatering belt filter simulator was used (Fig. 3). Then dewatered sludge was characterized by a total solids content ranging from 17.7% for the polyelectrolyte Superfloc A 110 and dose 15.4 mg/g TS to 29.5% for polyelectrolytes Superfloc A 110 and Praestol 2550 and the dose 8.2 mg/g TS. In this case, increasing dose of polyelectrolyte resulted in worsening the effects of dewatering.

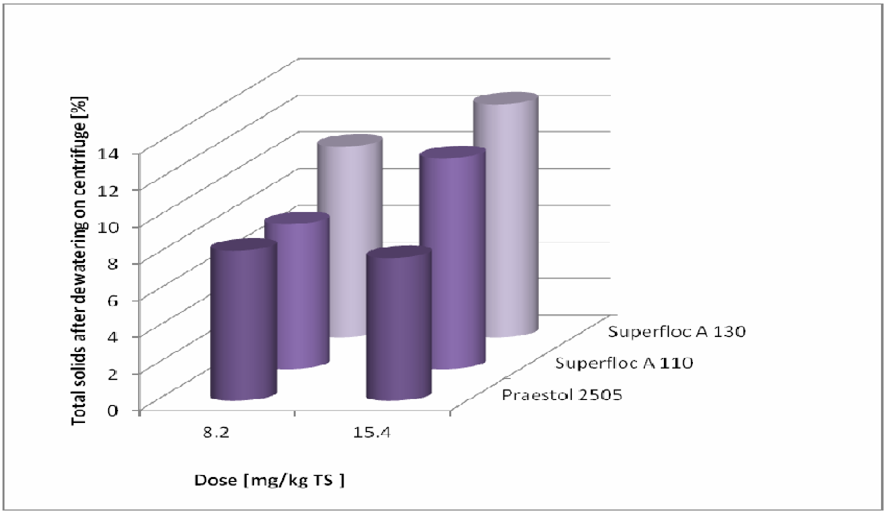

Fig. 2. Changes in total solids after dewatering on centrifuge depending on dose and type of polyelectrolyte

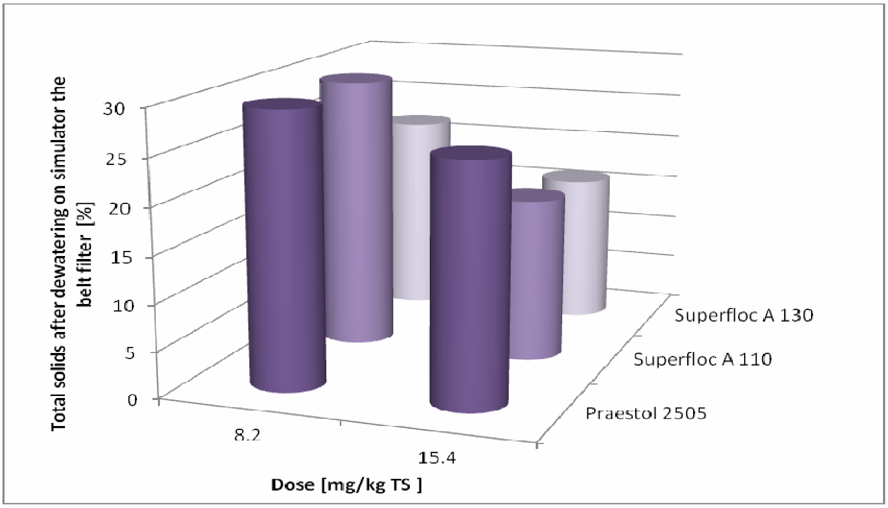

Fig. 3. Changes in total solids after dewatering on belt filter depending on dose and type of polyelectrolyte

Summary and conclusions

Treatment of sewage sludge is an important element of water - sewage management. This is due to the need to remove sludge from sewage treatment plants and its disposal in such a way to reduce their negative impact on the environment. In case of sludge derived from treatment of wastewater from the electroplating industry its disposal is important, because the sludge is characterized by high toxicity caused by inorganic compounds present in wastewater after plating processes. It is important to apply processes to reduce them, which can be implemented in the process of mechanical dewatering. Therefore, the studies were made in order to assess the susceptibility of sludge from the industrial treatment of wastewater to mechanical dewatering.

The sludge prior to dewatering should be subjected to conditioning process. This process improves the structure of the sludge and increases the amount of free water. Process conditioning was conducted based on different types of ion-polyelectrolytes for the equal dose of 2.1 mg/g TS. Test results have shown that the best effective was obtained when the anionic polyelectrolyte were used (Praestol 2505 and Superfloc A 110 and A 130). In the case of these polyelectrolytes prior to the test of mechanical dewatering the optimal dose from 2.1 to 15.4 mg/g TS was determined. Properly selected type of polyelectrolyte and the dose for improvements in the filter characteristics of sludge, increased its susceptibility to dewatering. Sludge conditioned with polyelectrolytes was mechanically dewatered in a centrifuge and in a belt filter simulator. The centrifuged sludge characterized by a relatively low concentration total solid content of 7.8-12.7%. The efficiency of dewatering process was affected by the spin speed and duration of the process. The best results were obtained after 10 min at a speed of 3000 rev./min. Definitely better effect of dewatering occurred when using the belt filter simulator. The dewatered sludge possessed concentration total solids content 17.7-29.5%. The highest degree of dewatering has been achieved with doses of 8.2 mg/g TS of Praestol 2550 and Superfloc A 110. It is worth noting that increasing dose of polyelectrolyte resulted in the worse efficiency of mechanical dewatering. Comparing the results of the mechanical dewatering it was stated that the belt filter is more efficient as indicated by the high degree of dewatering. Definitely worse effect was obtained with the centrifuge, where the centrifugal force is the crucial factor. Satisfactory results dewatering may be obtained with a filter press in which pressure is generated under the influence of the two belts.

Industrial sludge from treatment of electroplating process wastewater can be subjected to mechanical dewatering. However, in order to achieve the expected results the proper preparation of sludge before dewatering, as well as the selection of the appropriate device is necessary.

References

[1] Bartkiewicz B, Umiejewska K. Oczyszczanie ścieków przemysłowych (Treatment of industrial wastewater). Warszawa: Wyd Nauk PWN; 2010.

[2] Przybyłowicz K. Metaloznawstwo (Metallurgy). Warszawa: Wyd Nauk-Tech; 2003.

[3] Dylewski R, Gnot W, Gonet M. Elektrochemia przemysłowa - wybrane procesy i zagadnienia (Industrial electrochemistry - selected processes and issues). Gliwice: Wyd Politechniki Śląskiej; 1999.

[4] Velazquez-Peña S, Barrera-Díaz C, Linares-Hernández I, Bilyeu B, Martínez-Delgadillo SA. An effective electrochemical Cr(VI) removal contained in electroplating industry wastewater and the chemical

characterization of the sludge produced. Ind Eng Chem Res. 2012;51(17):5905-5910. DOI: 10.1021/ie200968s.
[5] Koziorowski B, Kucharski J. Ścieki przemysłowe (Industrial wastewater). Warszawa: Wyd Nauk-Tech; 1964.
[6] Abbott A, Griffith J, Nandhra S, O'Connor C, Postlethwaite S, Ryder K, et al. Sustained electroless deposition of metallic silver from a choline chloride-based ionic liquid. Surface and Coatings Technol. 2008;202(1):2033-2039. DOI: 10.1016/j.surfcoat.2007.08.055.
[7] Meinck F, Stooff H, Kohlschutter H. Ścieki przemysłowe (Industrial wastewater). Warszawa: Arkady; 1975.
[8] Bogdach S, Biestek T, Socha J. Poradnik galwanotechnika (Guide electroplating). Warszawa: Wyd Nauk-Tech; 2002.
[9] Polski Komitet Normalizacyjny: Characterization of sludges - Determination of dry matter and content on a mass basis. PN-EN 12880, September; 2004.
[10] Polski Komitet Normalizacyjny: Characterization of sludges - Determination of the loss on ignition of dry mass, PN-EN 12879, September 2004.
[11] Polski Komitet Normalizacyjny: Characterization of sludges - Determination of the pH, PN-EN 12176, Warszawa 2004.
[12] Polski Komitet Normalizacyjny: Characterization of sludges - Filtration properties. Part 2. Determination of the specific resistance to filtration, PE-EN ISO 14701-2, May; 2007.
[13] Polski Komitet Normalizacyjny: Characterization of sludges - Filtration properties. Part 1. Capillary suction time (CST), PE-EN ISO 14701-1, May; 2007.

ODWADNIALNOŚĆ OSADÓW POCHODZĄCYCH Z OCZYSZCZANIA ŚCIEKÓW GALWANICZNYCH

Wydział Inżynierii Środowiska i Energetyki, Politechnika Śląska, Gliwice

Abstrakt: Galwaniczne pokrywanie wyrobów trwalszymi powłokami stanowi ich ochronę lub dekorację. W wyniku tych procesów powstają ścieki technologiczne, które są oczyszczane. Podczas oczyszczania ścieków powstają osady, które stanowiły przedmiot badań. Osady pochodziły z oczyszczalni ścieków znajdującej się przy zakładzie produkującym części samochodowe. Zostały pobrane ze zbiornika szlamowego, poprzedzonego sedymentacją w osadniku lamelowym. W celu określenia ich podatności na odwadnianie w pierwszym etapie dokonano doboru rodzaju i dawki polieletrolitu. W drugim etapie badań kondycjonowane osady poddano próbom mechanicznego odwadniania w wirówce oraz symulatorze prasy taśmowej. Uzyskane wyniki badań wykazały, że najskuteczniejszy wpływ zaobserwowano w przypadku zastosowania polielektrolitów anionowych Praestol 2505 oraz Superfloc A 110 i A 130. W badaniach zastosowano dawki od 2,1 do 3,4 mg/g s.m. oraz od 8,2 do 15,4 mg/g s.m. Zastosowanie zarówno zbyt małej dawki reagenta, jak i przedawkowanie doprowadziło do uzyskania niezadowalających efektów kondycjonowania. Nadmiar polielektrolitu zwiększył lepkość cieczy osadowej, przez co osad wolniej oddawał zawartą w nim wodę. Kondycjonowane wybranymi polielektrolitami osady zostały poddane procesowi mechanicznego odwadniania. W wyniku wirowania otrzymano osad charakteryzujący się zawartością suchej masy maksymalnie 12,7%. Na efektywność procesu odwirowania miała wpływ prędkość wirowania oraz czas trwania procesu. Najlepsze efekty uzyskano dla czasu wynoszącego 10 min oraz prędkości 3000 obr/min. Wyższy stopień odwodnienia wynoszący 29,5% s.m. uzyskano przy zastosowaniu symulatora pracy taśmowej.

Słowa kluczowe: osady ściekowe z przemysłu, odwadnianie mechaniczne, dobór polielektrolitu