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# Decrease in chromium losses due to the effective dehydration of sludge generated during the production of chromium pellets

Tusbayev B.N., Akimzhanov Z.A., Kolesnichenko V.Y., Stogov A.V.

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**Abstract.** The study was aimed at reducing losses of chromium due to the effective dehydration of sludge generated during the production of chromium pellets. The results of studies on thickening and filtering sludge are presented. The study showed that Flopam AN926 is an effective flocculant for thickening sludge, while the solid content in the thickened sludge increases from 1-2% to 50-55% with a specific thickening operation of 0.02 t/(m<sup>2</sup>\*h) and a clean top discharge 150 mg/l. In the process of press filtration, the moisture content of the sludge is reduced to 13.4% with a specific productivity of 0.1 t/(m<sup>2</sup>\*h). Dehydrated sludge can be used for the production of chrome pellets or for the smelting of ferroalloys.

**Keywords:** Sludges of chrome production, thickening, flocculant, press filtration.

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## Introduction

This study presents the results of a study that was aimed at the decrease in chromium losses with sludge generated during the production of chromium pellets. As a result of the study, the technological parameters of the sludge thickening process were determined from a solid content in the pulp of 1-2% to 50-55% (type and dosage of flocculant, specific productivity of the thickening operation, solid content in recycled water), and the technological conditions of the press filtration process of condensed sludge were determined. Dehydrated sludge can be used to produce chrome pellets or smelt ferroalloys.

## Experimental part

During the production of chromium pellets [1], sludge is formed which are:

- sludges obtained from scrubbers of the wet dust collection system of the roasting machine;
- underwashing of way dirt of the burden constituent, raw pellets and fired product from the territory of the pellet production site.

The properties of the sludge formed during the production of chromium pellets are as follows: the Cr<sub>2</sub>O<sub>3</sub> content is 48-52%, the solid phase density is 3.47-3.66 t/m<sup>3</sup>, and the solid content in the pulp is 1-2%. Under current production conditions, sludge is

directed to the existing clarifier, while the solid content in the clarifier feed is 1-2%, and the solid content in the condensed product is not higher than 5%. To study the process of sludge dehydration, together with Outotec, thickening and filtration studies were carried out to obtain a mass fraction of

moisture in dehydrated sludge at the level of 8%. The granulometric composition of the sludge is shown in Figure 1, which shows that the amount of class -20  $\mu\text{m}$  is 15%, the amount of class -70  $\mu\text{m}$  is 80% and 100% of the size of the sludge is less than 0.3 mm.

Лазерный анализатор частиц

ВА Инсталт

**M i c r o S i z e r 2 0 1**

Санкт-Петербург

Россия

Оператор:

Комментарий:

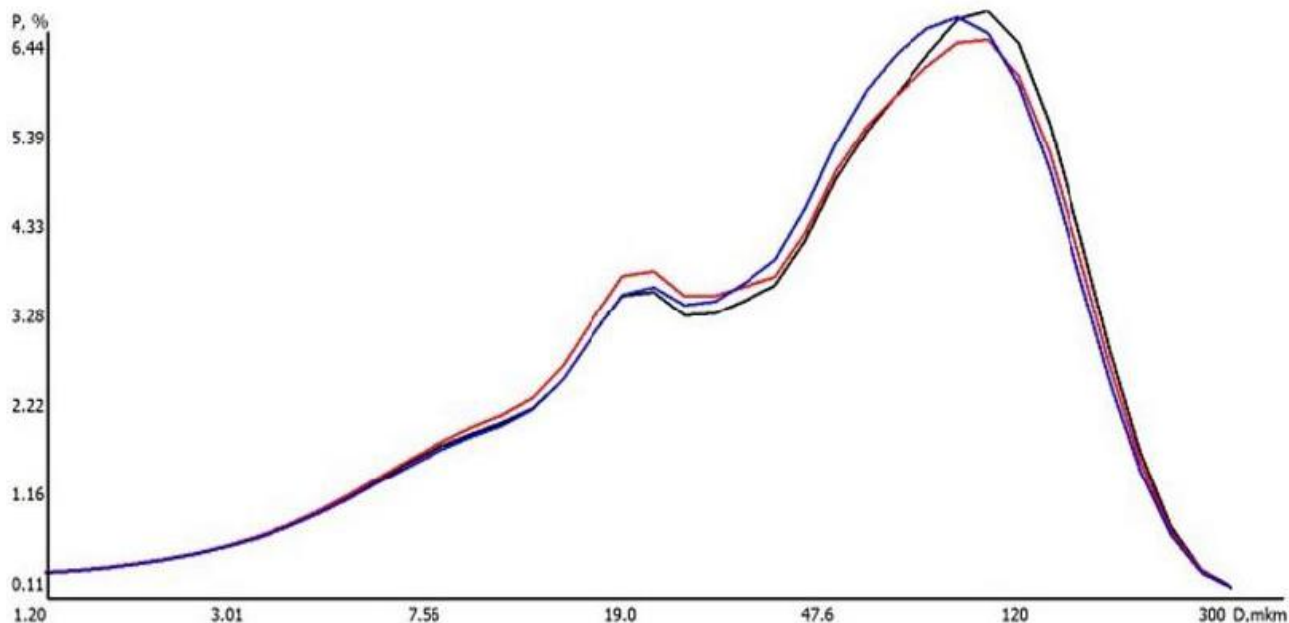


Таблица соответствия размеров частиц (D, мкм) заданным значениям весовых долей

УПО-2(кек)-1	7.76	15.1	23.3	35.8	50.0	64.9	81.6	101	129	300
УПО-2(кек)-2	7.73	14.8	22.1	33.4	47.3	61.8	78.5	98.3	127	300
УПО-2(кек)-3	7.95	15.4	23.6	35.5	48.5	62.0	77.5	96.6	125	300
Среднее значение	7.81	15.1	23.0	34.9	48.6	62.9	79.2	98.7	127	300
P, %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100

Таблица весовых долей частиц (P, %), соответствующих заданным значениям размеров частиц

УПО-2(кек)-1	0.00	0.20	0.60	1.20	1.90	2.90	4.10	5.70	7.80	10.5	13.3	13.6	16.9	21.3	26.5	26.8	32.1	35.8	37.5	42.9
УПО-2(кек)-2	0.00	0.20	0.60	1.20	1.90	2.90	4.10	5.70	7.90	10.5	0.00	0.20	0.60	1.20	1.90	2.90	4.10	5.70	7.90	10.5
УПО-2(кек)-3	0.00	0.20	0.60	1.20	1.90	2.80	4.00	5.60	7.60	10.2	12.9	13.2	16.6	20.9	26.1	26.5	31.9	35.7	37.6	43.4
Среднее значение	0.00	0.20	0.60	1.20	1.90	2.87	4.07	5.67	7.77	10.4	8.73	9.00	11.4	14.5	18.2	18.7	22.7	25.7	27.7	32.3
D, мкм	1.01	1.27	1.60	2.02	2.54	3.20	4.03	5.08	6.40	8.06	10.0	10.2	12.8	16.1	20.0	20.3	25.6	30.0	32.3	40.0

УПО-2(кек)-1	43.3	50.0	50.9	56.9	59.8	69.9	80.4	90.0	94.4	96.2
УПО-2(кек)-2	45.1	51.9	52.8	58.9	61.8	71.6	81.6	90.6	94.8	96.5
УПО-2(кек)-3	43.9	51.2	52.1	58.6	61.8	72.3	82.5	91.2	95.1	96.7
Среднее значение	44.1	51.0	51.9	58.1	61.1	71.3	81.5	90.6	94.8	96.5
D, мкм	40.6	50.0	51.2	60.0	64.5	81.3	102	129	150	163

Figure 1 Granulometric composition of sludge

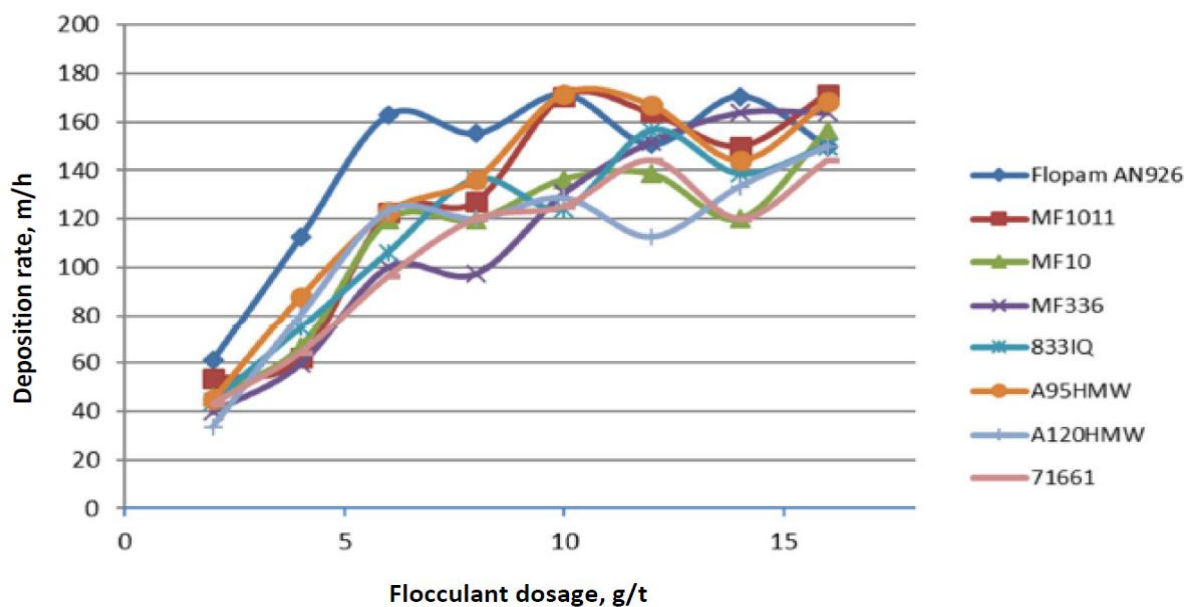
The thickening study was carried out to determine main technological parameters:

- type of flocculant and its flow rate;
- purity degree of the drain after thickening;
- solid content in the condensed product and its physical properties.

To determine the effective flocculant for sedimentation of sludge, the following flocculants of the companies were tested:

- BASF-Magnafloc 10, 336, 1011;
- Nalko - 71661, 833IQ;
- Kemira - A120HMMW, A95HMMW;
- SNF Floerger - Flopam AN926.

The results of experiments to determine the deposition rate depending on the flow rate of the flocculant are shown in Figure 2.



**Figure 2** Sludge sedimentation rate depending on the type and the flow rate of the flocculant

According to Figure 2, it is clear that the Flopam AN926 flocculant sediments sludge most effectively, so when increasing flocculant flow rate from 5 to 15 g/t, the sludge sedimentation rate rises from 120 to 165 m/h. According to the Outotec methodology, it was found that the optimum concentration for solidification is the solid content in the feed supply of the thickening operation at the level of 34.7%.

The determination of sludge thickening in dynamic mode was carried out on a laboratory thickener, shown in Figure 3.

At different pH values of the source sludge (regulated by the addition of lime) were tested in a dynamic mode.

In each test, the initial sludge was supplied by a peristaltic pump from the agitation tank to the feeding well of the thickener. At the same time, a flocculant with a concentration of 0.5% was supplied to the supply well by another pump at a given flow rate. The laboratory thickener is equipped with rakes that help to dehydrate the material, rotating at a speed of about 2 rpm.

To thicken the sludge, a rake configuration with three static and two dynamic peaks was used. When



**Figure 3** Outotec laboratory thickener 99 mm in diameter

thickening the sludge, overflow samples were taken at a bedding height of the thickened sludge of 160 mm at the discharge level of the supply well. Thickened sludge samples were also taken using a peristaltic pump.

The first dynamic test was carried out with a solid content of 1% in the laboratory thickener feed and a

load of  $0.02 \text{ t}/(\text{m}^2 \cdot \text{h})$ . The Flopam AN926 flocculant consumption was  $8 \text{ g}/\text{t}$ , the pH value of the medium in the thickener was 8-9. As a result, a thickened sludge with a density of 56.7% was obtained; the solid content in the overflow of the thickener was  $150 \text{ mg}/\text{l}$ .

The second dynamic test was also carried out with a solid content of 1% in the laboratory thickener feed and a load of  $0.02 \text{ t}/(\text{m}^2 \cdot \text{h})$ . The Flopam AN926 flocculant consumption was  $8 \text{ g}/\text{t}$ , the pH value of the medium in the thickener was increased to 11-12. The thickened sludge with a density of 46% was received, the solid content in the overflow of the thickener was  $150 \text{ mg}/\text{l}$ .

The rheological properties of the thickened sludge (shear stress) were determined using a Haake thermo VT550 rotational electronic viscosimeter and an ok600 4-bladed nozzle, shown in Figure 4.



**Figure 4** Haake thermo VT550 viscosimeter

It was determined that when increasing the solid content in the thickened sludge, the shear stress increases - for example, up to  $33 \text{ Pa}$  at a density of 46%, up to  $94 \text{ Pa}$  at 56%. According to these data, the main mechanisms of the thickener are calculated (hydrostation, geared system, rake) further at the design stage.

The spreadability of thickened sludge according to the Warman Ring test is equal to 3-4 ring at a density of 46% and 2-3 ring at 56% (shown in Figure 5). These data together with other ones are used to calculate and select sludge pumps for thickened product pumping. According to the results of the study, it was found that the chromium-containing sludge generated during the production of pellets can be thickened at a specific productivity of  $0.02 \text{ t}/(\text{m}^2 \cdot \text{h})$  from a solid content of 1-2% to 50-55% at



**Figure 5** Spreadability of sludge thickened to a 56% density according to the Warman Ring test

a pH medium of 8-9 and Flopam AN926 flocculant flow rate at the level of  $8 \text{ g}/\text{t}$ . In this case, the shear stress of the thickened sludge is at the level of  $90\text{-}100 \text{ Pa}$  and the spreadability according to the Warman Ring test is 2-3 ring.

According to the classification given in [2], the thickening of chrome sludge proceeds according to the light thickening mode, which is characterized by a specific productivity of  $0.01\text{-}0.05 \text{ t}/(\text{m}^2 \cdot \text{h})$ .

A study on the filtration of thickened chromium-containing sludge was carried out on an Outotec pilot filter press, which is shown in Figure 6.



**Figure 6** Outotec pilot filter press with  $0.27 \text{ m}^2$  filtration area.

The pilot filter implements filtration, pressing and blowing-out of the cake layer during dehydration. The filtration operation is carried out

when the filtration press chamber is filled with sludge under a pressure of 6 bar. The membrane pressing of the sludge is carried out at a pressure of 12-16 bar, due to which excess moisture is removed through the filter cloth from both sides of the filtration chamber. The cake blowing-out is carried out at a pressure of 6 bar during up to 4 minutes, when moisture is replaced by air in the material layer. After the filter opening, the cake is unloaded onto the pallet. In the study, ASKO T50 filter cloth was used, the depth of the chamber was 50 mm.



**Figure 7** Photograph of a chromium-containing sludge cake from a pilot filter press

In the tests, cake with a moisture content of 13.4 to 14.8% was obtained, depending on the duration of filtration, pressing and blowing-out. The specific productivity in the tests ranged from 99.8 to 126.2 kg/(m<sup>2</sup>\*h). A decrease in humidity up to 13.4% was achieved by increasing the duration of membrane pressing and blowing-out, while the productivity of

the press filtration process achieved during the study is comparable to the data of [3, 4] on the press filtration of concentrates with a fine particle size distribution - class content - 45 μm more than 80%.

### The discussion of the results

Initially, it was assumed that in the course of thickening and subsequent press filtering, a cake with a moisture content of 8% would be obtained,

however, it was not possible to obtain a cake below 13.4%, while the cake was loose, transportable and did not adhere to the filter cloth. The inability to obtain cake moisture below 13.4% is due to the properties of the sludge that is formed during the production of chrome pellets, namely the presence of bentonite in an amount of up to 1% inside the particles of the sludge.

### Conclusions

Thus, when studying the dehydration of chromium-containing sludge formed in the production of chromium pellets, it was found that:

- sludges can be thickened from a solid content of 1-2% to 50-55% at a pH medium of 8-9 and a Flopam AN926 flocculant flow rate of 8 g/t, while the specific productivity of the thickening operation is 0.02 t/(m<sup>2</sup>\*h);

- in the process of filtering sludge, cake is formed with a mass fraction of moisture of 13.4% depending on the time of filtration, pressing and blowing-out, while the specific productivity of the filtration was 99.8 kg/(m<sup>2</sup>\*h).

Based on the results of the study, Outotec proposed measures to modernize clarifiers into high-performance thickeners and a filter press for effective dehydration of chromium-containing sludges.

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## Хром түйіршіктерін өндіру кезінде пайда болатын шламды тиімді сусыздандыруға байланысты хром шығынын азайту

Тусбаев Б.Н., Акимжанов Ж.А., Колесниченко В.Е., Стогов А.В.

**Түйіндеме.** Зерттеу хром түйіршіктерін өндіру кезінде пайда болған шламды тиімді сусыздандыруға байланысты хромның шығынын азайтуға бағытталған. Шламды қоюлау және сүзгілеу бойынша зерттеулердің нәтижелері келтірілген. Зерттеу көрсеткендей, Flopam AN926 шламды қоюландыруға тиімді флокулянт болып табылады, ал қоюландырылған шламдағы қатты құрам 1-2% -дан 50-55% -ға дейін артады, қоюландыру операциясының нақты

өнімділігі 0,02 т/(м<sup>2</sup>\*сағ), жоғарғы ағызу тазалығы 150 мг/л. Прессті сүзу процесінде шламның ылғалдылығы 13,4% дейін жеткізілді, нақты өнімділігі 0,1 т/(м<sup>2</sup>\*сағ). Сусыздандырылған шламды хром түйіршіктерін өндіру немесе феррокорытпаларды балқыту үшін пайдалануға болады.

**Түйінді сөздер:** Хром өндірісінің шламдары, қоюландыру, флокулянт, прессті сүзу.

## Снижение потерь хрома за счет эффективного обезвоживания шламов, образующихся при производстве хромовых окатышей

Тусбаев Б.Н., Акимжанов Ж.А., Колесниченко В.Е., Стогов А.В.

**Аннотация.** Исследование было направлено на снижение потерь хрома за счет эффективного обезвоживания шламов, образующихся в процессе производства хромовых окатышей. Приведены результаты исследования по сгущению и фильтрации шламов. Исследованием показано, что эффективным флокулянт для сгущения шламов является Floрам AN926, при этом содержание твердого в сгущенном шламе повышается с 1-2% до 50-55% с удельной производительностью операции сгущения 0,02 т/(м<sup>2</sup>\*ч) и чистоте верхнего слива 150 мг/л. В процессе пресс-фильтрации влажность шлама снижается до 13,4% при удельной производительности 0,1 т/(м<sup>2</sup>\*ч). Обезвоженные шламы могут быть использованы для производства хромовых окатышей или для выплавки ферросплавов.

**Ключевые слова:** Шламы хромового производства, сгущение, флокулянт, пресс-фильтрация.

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