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USE OF FLOTATION TAILINGS FROM A ZINC-LEAD ORE IN STABILIZED BACKFILL

Summary. The paper presents results of research program and design of hydraulic backfill technology for an underground zinc-lead ore mine. A requirement of the mine operator was to use flotation tailing from the own ore processing plant as the only main component of the backfill slurry. A range of binders and mixture compositions has been examined in aim to find slurries of such properties, which are able to meet the requirements of pipeline transport and required mechanical properties of stabilized fill material in underground voids. In the next phase the construction of mixture preparation plant has been taken under consideration. To avoid the need for excessive high pressure pumping systems, an idea of mobile mixture preparation plant has been developed. In final design option the whole plant consists of two containers and a tank for the binder, which can be easily transported between shafts and inclines of the mine. Pump, situated in one of the containers, serves mainly to deliver fill mixture from the plant to the inlet of vertical shaft pipeline. Gravitational flow allows delivering the mixture down to places of mining operations (extracted rooms).

WYKORZYSTANIE ODPADÓW FLOTACJI RUDY ZN-PB DO PODSADZKI ZESTALANEJ

Streszczenie. W artykule przedstawiono wyniki programu badawczego poświęconego opracowaniu technologii podsadzki hydraulicznej dla podziemnej kopalni rud cynku i ołowiu. Podstawowy wymóg stanowiło wykorzystanie własnych odpadów flotacyjnych kopalni jako jedynego podstawowego składnika mieszaniny podsadzkowej. Przeanalizowano szeroki zakres środków wiążących oraz receptur mieszaniny podsadzkowej w celu uzyskania mieszaniny spełniającej zarówno kryteria transportu rurociągowego, jak i wymagania dotyczące własności fizycznych zestalonego materiału w pustkach podziemnych. W drugiej części pracy opracowano projekt stacji wytwarzania mieszaniny podsadzkowej. Jako alternatywę dla kosztownego systemu pomp wysokociśnieniowych opracowano koncepcję mobilnej stacji wytwarzania mieszaniny. W swej ostatecznej formie składa się ona z dwóch kontenerów oraz zbiornika na środek wiążący, które mogą być łatwo przemieszczane w rejony poszczególnych szybów i upadowych kopalni. Pompa umieszczona w jednym z kontenerów służy do dostarczenia mieszaniny do początku rurociągu podsadzkowego w szybie, skąd dalszy transport mieszaniny do miejsc prowadzenia robót górniczych odbywa się grawitacyjnie.

1. Introduction

Zinc and lead ore mining has a few hundred years history. Most of the resources are located in southern Poland and are divided into four main mining areas: Olkusz, Chrzanów, Zawiercie and Bytom. Currently, two mines are in operation, one is located in Olkusz area and other one in Chrzanów area.

"Trzebionka" Mine S.A. is the only operating mine in Chrzanów area which extracts lead and zinc ores. Low grade ore (ca. 3.3% zinc and ca. 1.2% lead) is mined underground at the depth of 200 m Mined ore is hoisted to the surface and beneficiated with the use of flotation method in mineral processing plant. Final products are lead and zinc concentrates. Yearly production of flotation blend (60% of Zn) is approximately 100 th. Mg. while the production of flotation galena (73-79% of Pb) is approximately 40 th. Mg.

Inseparable part of an ore mine is a post flotation tailings tank located on the mining area. Ore tailings dumped to the pond consist of finely grained dolomite with ore minerals which are transported there in pipes as a water slurry. Limited sink capacity has a significant impact on the life of the mine. Lack of a place for waste dumping might shorten mining operation at the site in spite of existing reserves. Due to that fact "Trzebionka" Mine S.A. decided to start research on the technology of using flotation tailings from a current production for filling of underground workings. The paper presents results of research and implementation work.

2. Self-solidifying backfill technology

Base on the experience of managing with flotation tailings disposal the most realistic perspective to manage large amount of lead and zinc tailings is its use as a component of self-solidifying backfill. The main idea of the technology is to prepare a hydro mixture that has binding properties and later to transport and fill a fenced working (Fig. 1). The use of a self-solidifying has following advantages:

- Supports roof and provides further safe extraction,
- Reduces rock mass and surface deformations,
- Improves rock mass stability,
- Is an alternative of surface waste storage,
- Improves ventilation in a mine.

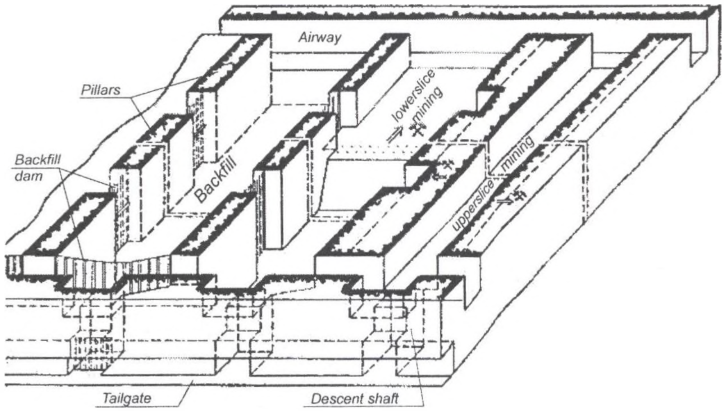

Fig. 1. Example of a room and pillar Zn-Pb ore mining system with backfill
Rys. 1. Przykład systemu filarowo-komorowego z podsadzką hydrauliczną stosowanego w górnictwie rud Zn-Pb

3. Backfill slurry selection – laboratory research

Use of flotation tailings for self-solidifying backfill in "Trzebionka" Mine S.A. is a first industrial scale technology of underground waste disposal in polish lead-zinc ore mines. Waste for the technology comes from a current production.

Flow of slurry defines its transport and fill properties and can be determined by spread test. Slurries with a spread larger than 160 mm have good flow and migration properties. Thus, such slurries can be used in gravitational transport installations. Slurries with a spread smaller than 160 mm are characterized by a denser consistence and its transport in gravitational installations is far more difficult and rarely used. Fig. 2 presents spread and Fig. 3 density of a wasted dependant on solid and water fraction as well as dry waste.

Due to the fact that flotation tailings do not have binding properties it is necessary to add binder to the backfill slurry. On the basis of research results of various mixtures with different density and binder ratios four types of slurries with additive of 3, 4, 5 and 8% of HSS binder were selected. Density of mixture at the outlet of a hydrocyclone should be 1935 g/dm^3. Basic physical and mechanical properties of selected mixtures are shown in table 1.

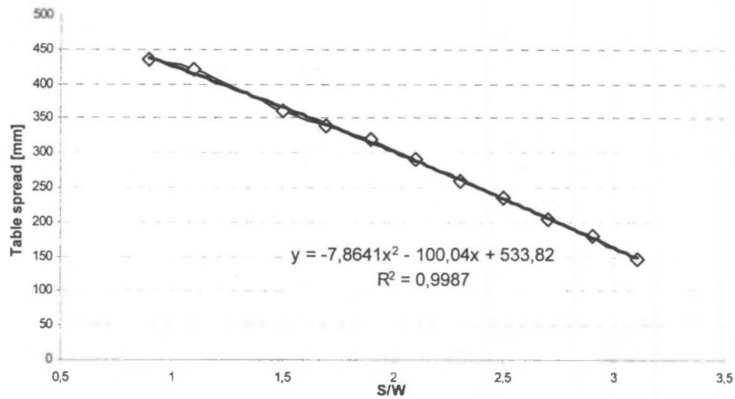

Fig. 2. Table spread of a slurry in the function of solid and mass fraction (S/W)
Rys. 2. Rozlewność mieszaniny jako funkcja proporcji części stałych do wody (S/W)

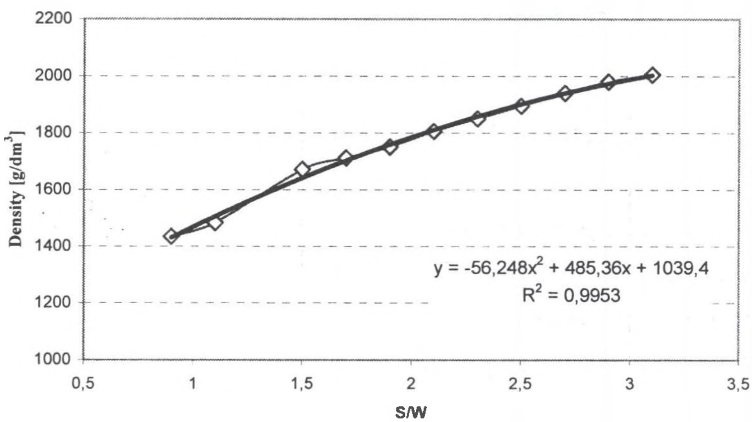

Fig. 3. Density of a slurry in the function of solid and mass fraction (S/W)
Rys. 3. Gęstość mieszaniny jako funkcja proporcji części stałych do wody (S/W)

Table 1

Physical and mechanical properties of selected binding mixtures

Mixture content (mass fraction)		Density [g/dm^3]	Table spread [mm]	Excessive water [%/dm^3]	Load capacity 0,5MPa [days]	Binding time [days]	Rc after 28 days [MPa]	Soak resistance „k" [%]
Flotation tailings	HSS binder							
96%	4%	1951	195	1,19	2	4	0,58	53
95%	5%	1955	180	0,85	1,8	3	0,88	48
94%	6%	1959	172	0,72	1,6	3	1,25	29
92%	8%	1967	167	0,58	1,3	2	2,24	21

Selected mixtures have very good binding properties. Load capacity standard of 0.5 MPa is met after two days of curing in climatic chamber. Mixtures of watered flotation tailing with

HSS binder in the amount of 4 to 8% are characterized by high compressive strength. After 28 days of curing in climatic chamber uniaxial compressive strength is between 0,58 to 2,24 MPa. Experienced gained in previous similar experiments shows that increase in uniaxial compressive strength in the longer curing time period should be expected.

Water moistening of mixtures results in decrease of compressive strength in comparison to mixtures without water moistening by 21 to 53% Excessive water observed in mixtures was insignificant amounting from 0,58 to 1,19%. Amount of excessive water is strictly connected with the amount of HSS binder and decreases with the addition of a binder in a mixtures. Worth attention is a fact that 1% of excessive water is almost a trace amount and its influence on environment is negligible. Leaching of noxious substances from a flotation tailing mixture of "Trzebionka" Mine with HSS binder in the amount of 4-8% does not violate polish standards. Reaction of a water extract is close to the upper limit (table 2).

Table 2

Water extract (1:10) from solidified backfill mixtures

Tested indicator		Wart. max PN-G-11011:93	HSS fraction, %			
			4%	5%	6%	8%
		Code	426	427	428	429
pH	-	6÷12	11,6	11,9	11,7	12,0
COD	mgO_2/l	150	39,8	11,4	16,4	14,6
sulphide	mg S/l	0,2	0,22	0,16	0,14	0,16
chloride	mg Cl/l	1000	<5,0	<5,0	<5,0	<5,0
Sulphates	$mg SO_2/l$	500	42,1	12,4	52,3	8,9
Cyanides	mg CN/l	0,1	<0,002	<0,002	<0,002	<0,002
Chromium +3	mg Cr/l	0,5	<0,01	<0,01	<0,01	<0,01
Chromium +6	mg Cr/l	0,2	<0,01	<0,01	<0,01	<0,01
Arsenic	mg As/l	0,2	0,00155	0,00070	0,00145	0,00033
Mercury	mg Hg/l	0,02	0,00109	0,00090	0,00111	0,00134
Copper	mg Cu/l	0,5	0,0072	0,0056	0,0072	0,0056
Cadmium	mg Cd/l	0,1	<0,001	<0,001	<0,001	<0,001
Lead	mg Pb/l	0,5	0,057	0,155	0,053	0,106

4. Backfill slurry preparation technology

Precise dosing and preparation of mixture is the main condition to obtain expected parameters. Scheme of a backfill slurry preparation plant is presented in Fig. 4.

Flotation tailing from a current production is transported through a pipeline from a mineral processing plant. After thickening in a hydro cyclone (Fig. 5) tailing are directed into a mixer a tank where it mixed with a proper amount of a binding agent. Ready made mixture is directed into a tank where it is pumped into a backfill pipeline and to underground workings.

Backfill pipeline which connects backfill preparation plant with underground workings has a diameter of 185 mm. Pipeline is located in a dip-heading haulage gallery and is connected with an existing backfill pipeline at the III ore level. Outlet of a backfill pipeline is shown in Fig. 6.

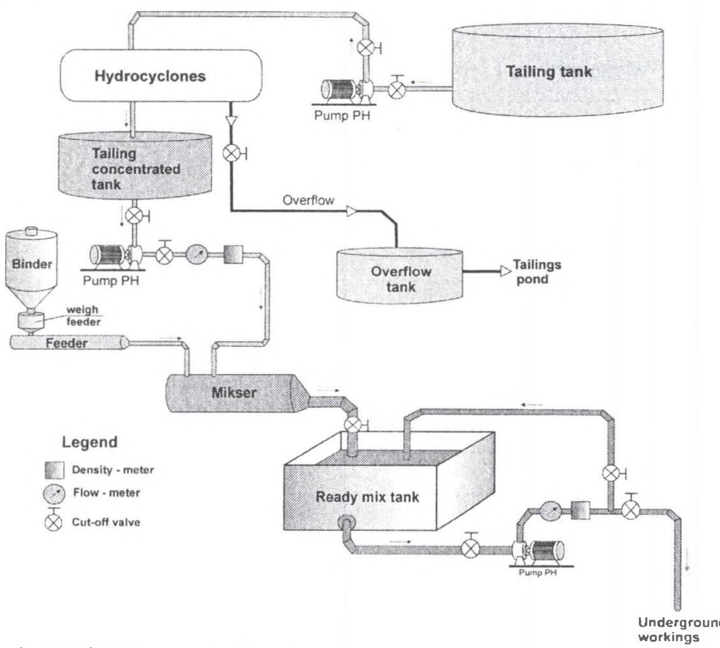

Fig. 4. Scheme of a backfill slurry preparation system
Rys. 4. Schemat układu wytwarzania mieszaniny podsadzkowej

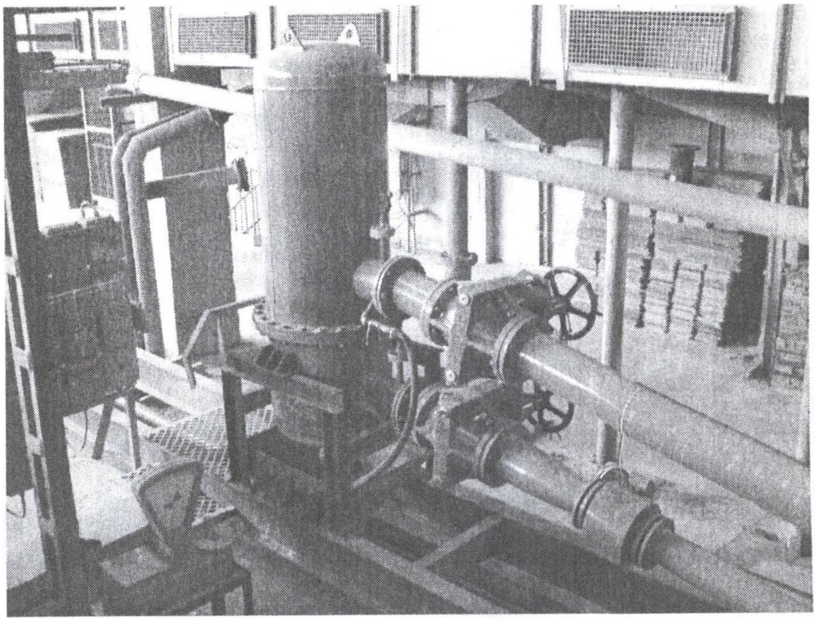

Fig. 5. View of a HLS hydro cyclone
Rys. 5. Widok hydrocyklonu HLS

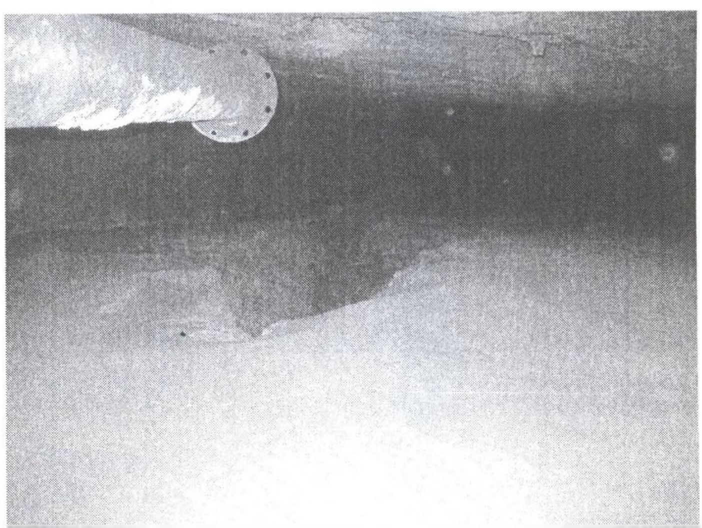

Fig. 6. View of a filled room with the pipeline outlet
Rys. 6. Widok podsadzonej komory wraz z wylotem rurociągu

5. Backfill slurry preparation system

Backfill slurry preparation system is located in the incline leading to underground workings where backfill pipeline is (Fig. 7).

Dosing device (Fig. 8), mixer with a control and monitoring system is located in the technical container (Fig. 9). Pipelines with concentrated slurry and carrying out readymade slurry into a backfill pipeline (Fig. 10) and media (compressed air, water and electricity) are passing through a container. System has an efficiency of 200 m^3 per hour. Monitoring system enables for a fully automatic functioning of a system. In case of an automatic system failure manual operation of a slurry preparation process is available.

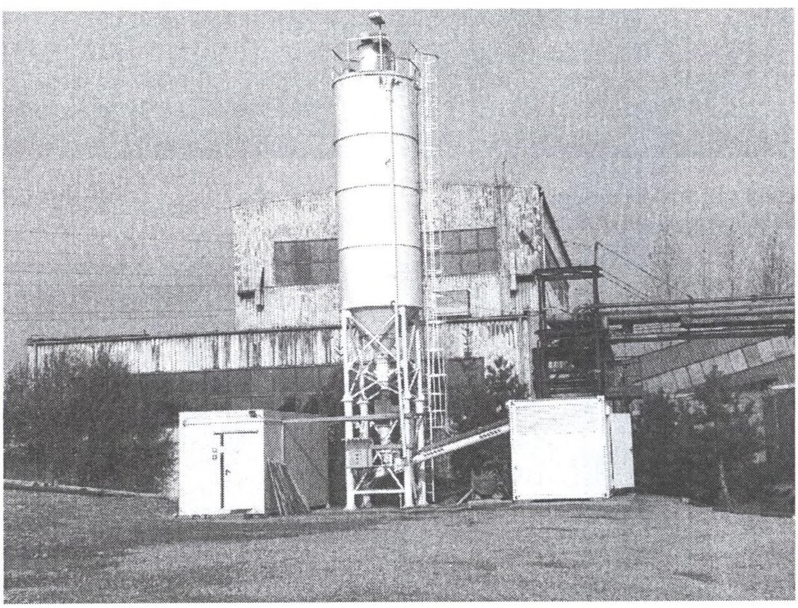

Fig. 7. View of a backfill slurry preparation plant
Rys. 7. Widok stacji wytwarzania mieszaniny podsadzkowej

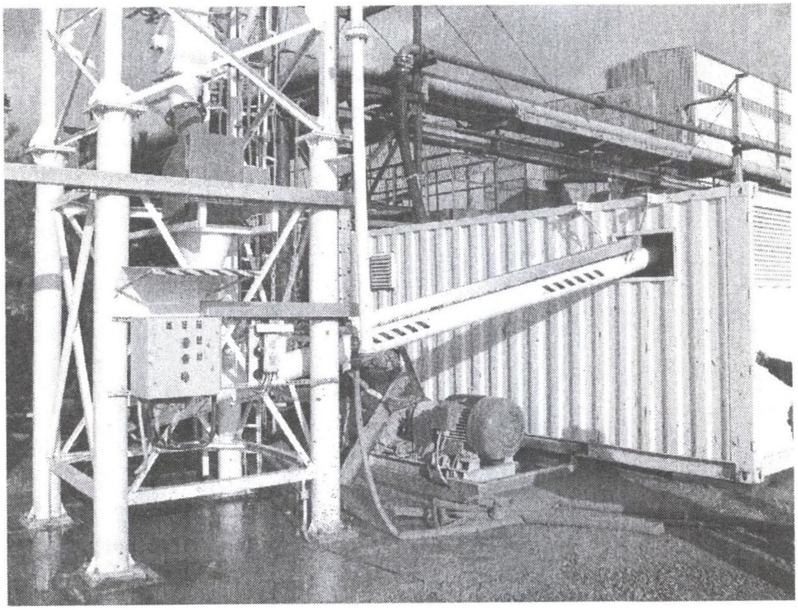

Fig. 8. Dosing station of HSS binder with container
Rys. 8. Dozownik spoiwa HSS oraz kontener mieszalnika

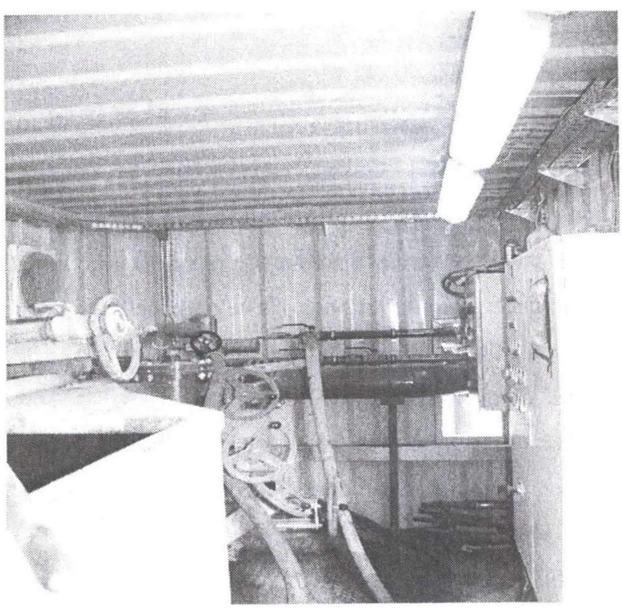

Fig. 9. Dosing container interior
Rys. 9. Wnętrze kontenera mieszalnika

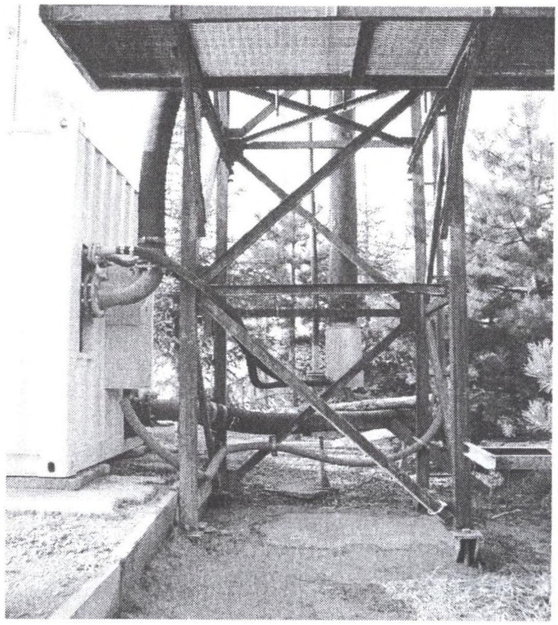

Fig. 10. Electricity, water and pipeline systems
Rys. 10. Podłączenia wody, elektryczności i rurociągu podsadzkowego

6. Summary

Environmental protection and limited capacity of a flotation tailing pond in a "Trzebionka" mine convinced to a new technology search for reducing the amount of waste dumped into a pond. Conducted research shown the possibility of using flotation tailings in backfill technology of underground workings. Developed self-solidifying which consist of HSS binder and flotation tailings has very good parameters from an environmental and technical point the point of a view.

Choice of the HSS binding agent was done after extended laboratory research. Results of research show that for the purpose of compliance with a PN-G-11011-98 standard and a maximum density received, i.e. 1935 g/dm^3 it is necessary to add minimum 4% of a binder.

Developed backfill preparation system and hydrotransport system allows to dispose 1000 m^3 of waste underground daily.

Self-solidifying mixtures presented in the paper can be used for backfilling of underground workings in other lead-zinc mines (in Poland and worldwide). This method is getting more and more popular in Europe. It is estimated that in European non-ferrous metal ore mining 16-52% of waste is used in various backfill methods

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