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POSSIBILITIES OF RECYCLING OF FINE-GRAINED METALLURGICAL WASTES FROM OLD WASTE DEPOTS

MOŽNOSTI RECYKLACE JEMNOZRNNÝCH HUTNÍCKÝCH ODPADŮ ZE STARÝCH ZÁTĚŽÍ

Abstract

Fine top gas mud from washing the blast-furnace gas was deposited to the waste disposal sites in the past, because its further processing was not possible because of heavy metal content – particularly lead and zinc – higher than what is allowed by the relevant regulations [6]. The goal of the project is to monitor the waste disposal sites with top gas mud in the Ostrava region, taking and analysing the samples and following laboratory verification of the technology for physical or possibly chemical removal of zinc and lead. Such decontaminated old ecological burdens could be used as a sinter charge of agglomeration together with other raw materials - by that the waste would be used and the occupation of the land would be reduced. At the same time the cost of depositing and disposal of top gas mud from the production would be decreased.

Abstrakt

Jemné kaly z mokrého vypírání vysokopecního plynu byly v minulosti ukládány na skládky, neboť nebylo možné jejich zpracování z důvodů vyššího obsahu těžkých kovů, hlavně olova a zinku, než povolují příslušné předpisy [6]. V rámci projektu byl proveden monitoring skládek vysokopecních kalů v ostravském regionu, odebrány a analyzovány vzorky, a posléze provedeny laboratorní ověření technologie odstranění zinku a olova fyzikální, případně chemickou cestou. Takto dekontaminované staré ekologické zátěže by mohly být využity jako vsázka do aglomerace spolu s ostatními surovinami. Došlo by tak k využití odpadu a odlehčení záboru půdy. Zároveň by byly sníženy náklady na ukládání a zneškodňování vysokopecních kalů z výroby.

Key words: blast furnace mud, sludge bed, hydrocyclone, non-iron metals.

Introduction

Selection of locations and drilling survey

The goal for the first phase of the project was the localization of the waste disposal sites for fine-grained metallurgical wastes – JHO (top gas mud and steel work sludge), and determination of the deposited amount of the mud and sludge in it. There are three such locations in the area of the city of Ostrava – see Figure No. 1 the partial map of Ostrava region (Ostravsko), publication KČT 61-62 2, issued in 2000. The waste disposal sites of Vítkovice, a.s. and Nová huť (NH), a.s. are there marked by circles.

The waste bank of Vítkovice, a.s. – which is at the west part of the partial map - where JHO was deposited into the space created by the mining of slag at the north side of the waste bank in the area of Hrabůvka city district on the left bank of the Ostravice river. The waste disposal site of JHO or also of the metal-bearing mud was established at the beginning of the 70s on the top of the nowadays reduced waste disposal site (waste bank) of Vítkovice, a.s.

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Nová huť, a.s., which celebrated its 50th anniversary of blast furnace operation in 2001, deposited the mud from the production to two main locations. Mainly top gas mud was deposited at the Rudná location in the area of the Kunčičky city district and also at the common sludge bed in the area of Bartovice, where fly ash (P), top gas mud (VPK) and steel work sludge (OK) were deposited. These locations are also marked on the partial map. We were detecting an amount of deposited JHO both through planar dimensions and average depth of the drills and from consultations with responsible employees of individual companies.

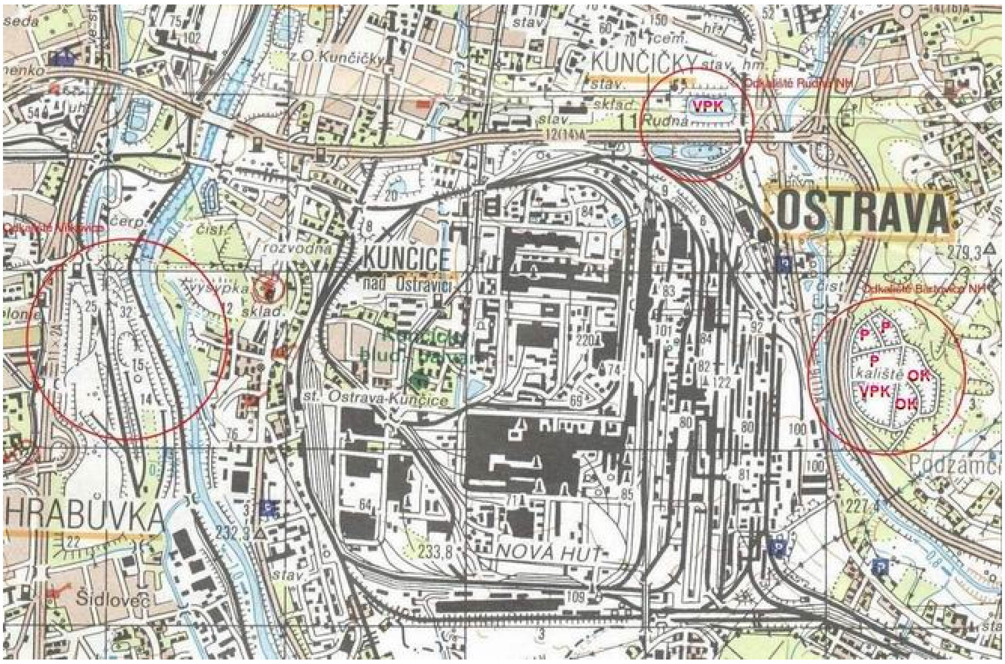

Fig. 1: Partial map with the sludge beds of Vítkovice, a.s. and Nová huť, a.s.

Obr. 1: Výřez mapy s odkališti Vítkovic, a.s. a NH, a.s.

Fig. 2: MVS drilling set in action

Obr. 2: Vrtná souprava MVS v akci

Drills were done by an MVS portable drilling set, Figure No. 2, which is able to drill down to a depth of 15 m. The diameter of the drill by spiral bar was 80 mm. The drilling set was developed in cooperation with VŠB – Technical University of Ostrava, the Institute of Geological Engineering and the company Mineco, s.r.o. and it is determined for taking samples of soil, concrete, masonry and solid rocks by drilling by a spiral bar or by bars with the boring bit for the core with the water flush. The set is fully hydraulic. The hydraulic aggregate is driven by the internal combustion engine.

In the case of the Rudná I sludge bed, drillings up to a depth of 17 m were made, because it was drilled in a relatively shallow environment. For technical reasons it was not possible to drill to a bigger depth.

According to the oral statement, the thickness of the mud/sludge in this sludge bed should be about 18 m. The height of the dam is 22 m. The Rudná I sludge bed is located north of the area of NH, a.s. over the Rudná 1st class road, left in the direction of Havířov. It is of a rectangular shape with the longer side in the east-west direction. This sludge bed does not use the natural dip of the terrain but is built by the slag dam around the whole sludge bed. In the east part it is partially extracted and about half of it is covered by sparse self-seeding woods. Drills and surface samplings were provided diagonally at the west part of the sludge bed, where the surface is not covered by the woods.

Bartovice's sludge bed, which is at the east side of the NH, a.s. area and in the area of the Bartovice city district, is partly using the terrain unevenness and partly the slag dam. This sludge bed is divided into several segments: in three of which - light ash (**P**) is deposited, in the biggest western part - top gas mud (**VPK**) is deposited and in two of the eastern segments below the hill - steel work sludge (**OK**) is deposited – see Figure No. 1. Several testing drills were also done here. Drillings were made down to the bedrock at this location. The biggest drilled depth in the steel work sludge section was 12 m – there was steel work sludge down to a depth of 11.7 m and the rest was clay.

The cubage of Bartovice's sludge beds is also calculated from the average depth and area. Particularly for the OK it is a rough estimation only, because the steel work sludge is deposited in the hill and a detailed drilling survey could not be done for financial reasons. VPK Bartovice - 270 000 m^3 which corresponds to 404 000 tons of dry mud. Steel work sludge deposited in the north segment is at a volume of approximately 324 000 m^3 which at the volume mass of 2 600 kg.m^{-3} corresponds with 635 440 tons of dry matter. Steel work sludge contents in average 60 % of Fe.

According to previous work done at our and other workplaces an option of VPK recycling by physical separation on hydrocyclones can already be assumed. The content of Zn and Pb in component of interest including Fe, can be lowered several times by this technology. The iron yield is at this procedure is over 80 %.

If we would consider only the Rudná I and Bartovice sludge bed with VPK, where the total estimated weight is 854 000 tons in dry matter with a mean moisture of 35 % and Fe content of 50 %, then we could obtain 341 600 tons of Fe.

In the case of the sludge beds, where steel work sludge is deposited, the situation is somewhat complicated, even when the Fe content is here higher then at VPK. OK are usually a lot finer and recycling by physical method must be subjected to further research. Pyrometallurgical processes, by which Fe could be obtained from this sludge, are very high cost at the primary investments and also at the process [7,9,10].

Experimental

Physical methods of decontamination

In the following phase of the project technological tests on laboratory hydrocyclone were done at different parameters of the jets, angles of the conical part and pressures. The goal was to obtain a product with the highest content of iron together with the lowest content of zinc and lead. From the previous tests it was obvious that the decontamination of steel work sludge will need to be done by the chemical methods.

In 2002 a number of technological tests were done, on laboratory hydrocyclone with a 60 mm diameter of the cylindrical part and with the interchangeable input, outlet and overflow jets. Also the cone part of the hydrocyclone was interchangeable. Several angles of the outlet part of the hydrocyclone were used here. Tests were also done with variable input pressure of inflowing suspension. The pressure was regulated by the fixtures on the inlet piping – from the pump to hydrocyclone. A diagram of the hydrocyclone work is on Figure No. 3

and the photograph of the HC station with the vessel for the preparation of suspension and testing hydrocyclone is on Figures No. 4 and 5.

The experiments done with the samples of top gas mud and steel work sludge confirmed in the principles the assumption - of transition of non-iron metals to the overflow of the hydrocyclone, and of the iron concentration in rough product. By comparing of achieved results at different settings of the hydrocyclone it is obvious (yield of Zn 30-80 %, Pb 10-70 %) that to reach the required goal – the hydrocyclones with bigger crown angles (30, 60^{o}) are better for the case of top gas mud.

At the processing of steel work sludge, the results of separation on hydrocyclones are less favourable than at the processing of top gas mud. The yield of non-iron metals at the enriched product (overflow of hydrocyclone) fluctuates in a wide range from 40 to 90 %. But the higher values of this index are caused particularly by the high mass return of finer product, which eliminates the effect of enriching the overflow of pursued metals. From the content values of Zn and Pb in individual products of the separation it is clear that some enriching of the overflow is occurring according to the outlet of hydrocyclone. The ratio of the metallic content of outlet and inlet fluctuates in the range from 1.2 to 3.5. But the concentration level (the ration of metallic content of overflow and inlet) reaches very low values, which in the case of zinc and lead fluctuates around the value *k=1,2.* The iron is distributed into both products approximately evenly. Based on experimental work and achieved results, and due to desired higher outputs, the hydrocyclone of the 90 mm diameter, with the conical part of the crown at an angle of 60^{o}, was designed by the theoretical recount for the processing of pursued materials. After the successful semi-operation testing, this hydrocyclone has all conditions for possible use in the form of a hydrocyclone battery (in the connection with relevant pumps) [1,2,3,4,10,11,12].

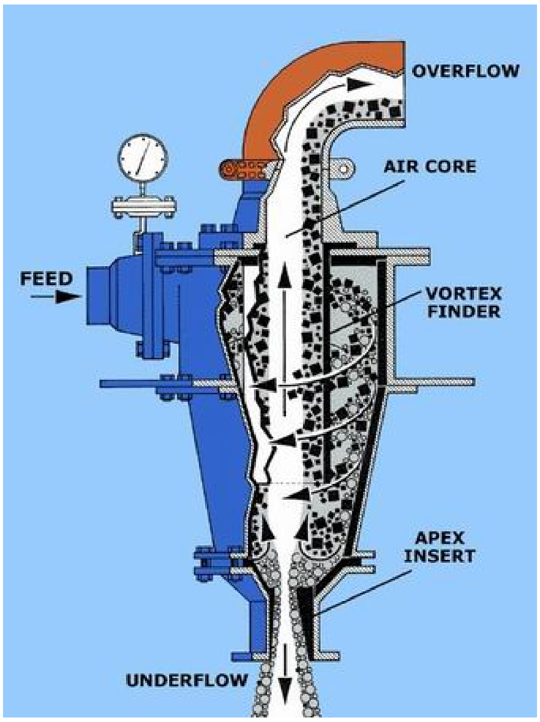

Fig. 3: Schematic diagram of the hydrocyclone

Obr. 3: Schematické znázornění hydrocyklonu

Fig. 4: Hydrocyclone station

Obr. 4: Hydrocyklonová stanice

Fig. 5: Hydrocyclone with a 60° angle conical part

Obr. 5: Hydrocyklon s konusovou části o úhlu 60 °

References

[1] Botula, J., Řepka, V.: Možnosti recyklace jemnozrnných hutních odpadů ze starých zátěží. In: *CD ROM symp. Metal 2002, E č.17, 14. – 16. 5. 2002, Hradec nad Moravicí, Tanger spol. s r. o., Ostrava, ISBN 80-85988-73-9.*

[2] Botula, J., Řepka, V., Kret, J.: Recyklace jemnozrnných hutních odpadů. *Acta Metallurgica Slovaca, 7, 2001, ISSN 1335-1532, p. 171-177.*

[3] Botula, J., Řepka, V.: Verifikace dělení zinku a olova ve vysokopecních kalech. *Výzkumná zpráva HČ 580443/98, VŠB Ostrava, 1998, 8 p.*

[4] Botula, J., Řepka, V.: ověření možnosti separace zinku a olova z vysokopecních kalů pomocí hydrocyklonů. *Výzkumná zpráva HČ, VŠB Ostrava, 1998, 6 p.*

[5] Kursa, M., Botula, J., Krištofová, D., Kret, J., Leško, J., Řepka, V.: Komplexní výzkum jemnozrnných hutních odpadů. *Závěrečná zpráva MPO č. PZ 01/30/97, Ostrava, 2000, 98 p.*

[6] Růžičková, Z., Srb, J., Vidlář, J.: Druhotné suroviny kovů. *SNTL, Praha, 1989, 193 p.*

[7] Řepka, V.: Staré zátěže jemnozrnných hutních odpadů z NH a.s. In: *Odpadové fórum, 2002, č. 3, ISSN 1212-7779, p. 20-21.*

[8] Řepka, V., Botula, J.: Recyklace vysokopecních kalů. In: *Odpadové fórum, 11/2000, ISSN 1212-7779, p. 13.*

[9] Řepka, V., Botula, J., Bajger, Z.: Complex Research of fine-grained metallurgical wastes. In: *Sborník přednášek kongresu II Encuentro minero del cono sur de America, VII Encuentro minero de Tarapaca. Iquique – Chile agosto, 2001, ISBN 956-7379-19-X, p. II-17 - II-23 (7 p.).*

[10] Řepka, V., Botula, J., Kursa, M., Kret, J., Krištofová, D., Leško, J., Vidlář, J.: *Závěrečná výzkumná zpráva projektu GAČR 106/01/0122 Recyklace hutnických odpadů ze starých zátěží. VŠB – TU Ostrava, 2003, 46 p.*

[11] Řepka, V., Vidlář, J., Homzová, M., Rezek, K., Fečko, P., Botula, J., Kociánová, H,: Výzkum recyklace vysokopecních kalů TŽ Třinec. *Výzkumná zpráva HČ 207/90, Ostrava, 1990, 40 p.*

[12] Vidlář, J., Řepka, V., Fečko, P., Malysiak, V.: Výzkum odstraňování Zn and Pb z vysokopecních kalů TŽ VŘSR Třinec. *Výzkumná zpráva HČ 588/89, Ostrava, 1989, 55 p.*

Resumé

Experimenty prováděné se vzorky vysokopecních a ocelárenských kalů v zásadě potvrdily předpoklad o přechodu neželezných kovů do přepadu hydrocyklonu a o koncentraci železa v hrubém produktu. Porovnáním dosažených výsledků při různém nastavení hydrocyklonu je zřejmé (výtěžnost Zn 30-80 %, Pb 10-70 %), že pro dosažení požadovaného cíle se v případě vysokopecních odpadů jako nejlepší jeví hydrocyklony s většími vrcholovými úhly (30, 60^o).

Při zpracování ocelárenských kalů jsou výsledky separace na hydrocyklonech méně příznivé než při zpracování kalů vysokopecních [6]. Výtěžnosti neželezných kovů do obohaceného produktu (přepadu hydrocyklonu) se pohybují v širokém rozmezí od 40 do 90 %. Vyšší hodnoty tohoto ukazatele jsou však způsobeny především vysokými hmotnostními výnosy jemnějšího produktu, což eliminuje efekt nabohacení přepadu sledovanými kovy. Z hodnot obsahů Zn a Pb v jednotlivých produktech separace je zřejmé že k určitému nabohacení přepadu vzhledem k výtoku hydrocyklonu dochází. Poměr kovnatostí přepadu a výtoku se pohybuje v rozmezí 1,2 až 3,5. Stupeň koncentrace (poměr kovnatosti přepadu a přívodu) však dosahuje velmi malých hodnot , které v případě zinku i olova kolísají kolem hodnoty $k=1,2$. Železo je distribuováno do obou produktů hydrocyklonu vcelku rovnoměrně. Na základě experimentálních prací a dosažených výsledků a vzhledem k požadovaným vyšším výkonům byl teoretickým přepočtem navržen pro zpracování sledovaných materiálů hydrocyklon průměru 90 mm s konickou částí o vrcholovém úhlu 60^o. Tento hydrocyklon má po případném úspěšném poloprovozním odzkoušení všechny předpoklady pro možné použití ve formě baterie hydrocyklonů (ve spojení s příslušnými čerpadly) [1,2,5,8,10].

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