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Processing of Anthropogenic Waste of Smelters of the Ural Mining and Metallurgical Company

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Abstract

The industrial sites of the smelters of the Ural Mining and Metallurgical Company have accumulated a lot of anthropogenic waste, the processing of which is currently economically impractical. These primarily include tailings and beneficiation tailings, as well as waste granulated and copper smelting slag. This article conducts studies on technologies for x-ray-radiometric/magnetic separation enrichment of discard slags of MMSK as well as using jigging machines. Slag and slag enrichment tailings are used for cement production and road construction. For complex processing of fine copper smelting dusts OJSC Chelyabinsk zinc plant developed, tested and implemented a special technology. After implementation of "Actions to process industrial waste generated by UMMC enterprises at metallurgical enterprises of UMMC-Holding Corp.", the following were noted: concentrators and special beneficiation facilities process slag; R&D on complete processing of concentrator's tailings was conducted; smelting dust was not stored but processed in full; the technology of implementing Waelz process for processing of steel smelting dust has been developed and commercially tested; the technology for extraction of copper and precious metals from pyrite dross is to be improved.

Keywords: anthropogenic waste, dust, tailings, slag, pyrite dross.

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The industrial sites of the smelters of the Ural Mining and Metallurgical Company have accumulated a lot of anthropogenic waste, the processing of which is currently economically impractical. These include primarily tailings and beneficiation tailings, as well as waste granulated and copper smelting slag.

Until recently, refractory metallurgical semi-products, such as sludge of treatment plants and fine dust of bag filters and ESP containing such valuable components as zinc, lead and tin, have been discarded. Such products were removed from the metallurgical production cycle due to the high content of harmful impurities (arsenic, antimony), adversely affecting the quality of blister and refined copper.

The amount of waste and metals in them accumulated by UMMC enterprises as of the beginning of the implementation of the ”Actions to process industrial waste generated by UMMC enterprises at metallurgical enterprises of UMMC-Holding Corp.” is given in the Table 1.

The “Actions” envisages further beneficiation of old slags produced by SUMZ combined with the current VF slag (VFS) and converter slag (CS) at the concentrator with a total throughput of about 1 million tons annually [1]. To increase copper extraction from hot slag the capacity of slag slow cooling equipment has been significantly increased.

The studies on technologies for x-ray-radiometric/ magnetic separation enrichment of discard slags of MMSK as well as using jigging machines are conducted [2]. Slag and slag enrichment tailings are used for cement production and road construction.

In collaboration with ”Gold Mining Corporation” they carried out integrated laboratory research of the technology for complete processing of tailings with the extraction of commercial copper, precious metals and iron.

UMMC has succeeded considerably in integrated processing of smelting dusts.

1. Processing of copper-smelting dusts

For complete processing of fine copper smelting dusts OJSC “Chelyabinsk zinc plant” developed, tested and implemented a special technology which process-flowsheet is given in Fig. 1.

Dust delivered to OJSC “Chelyabinsk zinc plant” in big-bags was briquetted with subsequent processing with other zinc-containing materials and coke fines in Waelz furnaces of L=60 m and D=4.0 m, where zinc, lead and cadmium are recovered and fumed in the gas phase.

The resulting products are Waelz oxide (Zn 55-60%, Pb 11-14%), trapped by bag filters and clinker containing up to 3% copper and precious metals. The yield of the Waelz oxide is up to 40% and clinker - up to 75% of the feed. The capacity of the furnaces is from 230 to 296 dmt/day.

The Waelz oxide contains various impurities, including chlorine and fluoride worsening the zinc electrolysis and causing the corrosion of processing equipment. The Cl and F content in the oxide reaches 1.5%, and 0.5% respectively and they are removed in the form of chlorides, zinc fluorides and lead before further hydrometallurgical processing by Waelz oxide calcination at 600 – 1100°C in tubular rotary kilns of L=40 m and D=2.5 m.

After water-soda rinsing the resulting secondary fumes and calcined oxide pass to the hydrometallurgical plant to be leached with circulating sulfuric acid, and the obtained neutral solution is used for production of zinc at the main stage.

Lead sulfate cake is carbonized to remove sulfur. The yield of carbonized cake containing Pb > 45% and Zn < 5.0% accounts for 18 – 20% of the Waelz oxide and it serves as feed for crude and ingot lead production in short-drum furnaces and refining kettles at “Non-ferrous Alloys Production”, branch of OJSC ”Uralelektromed”.

TABLE 1: INDUSTRIAL WASTES, SEMIS AND RECYCLING MATERIALS OF THE COMPANIES CONTROLLED BY “UMMC-HOLDING CORP.”

Sections	Quantity, mln. t	Cu		Zn		Pb		Sn		Sb		Au		Ag	
		Gross amount, t	Estimated recovery, t	Gross amount, t	Estimated recovery, t	Gross amount, t	Estimated recovery, t	Gross amount, t	Estimated recovery, t	Gross amount, t	Estimated recovery, t	Gross amount, t	Estimated recovery, t	Gross amount, t	Estimated recovery, t
1. Non-ferrous metal ore beneficiation tailings	187,9	470 883	68 793	590 982	47 765	7 913	–	–	–	–	–	89,6	4,4	1 168,9	32,5
2. Smelting slag	89,4	388 753	91 600	1 896190	112 000	129 611	–	–	–	–	–	19,6	1,8	890,1	55,3
3. “Old” smelting dust	0,061	1 075	422	20 544	16 961	8 185	5 886	2 598	1 596	–	–	29,8 кг	25,3 кг	5,1	4,1
4. Smelting recycling materials and semis	0,034	1 338	916,3	7 926	6 744	5 413	4 262	323,4	194	644	237	99,87 кг	90 кг	12,3	10,4
Total for UMMC	277,3	862 049	161 731	2 515642	183 470	151 122	10 148	2 921,4	1 790	644	237	109,3	6,3	2 076,5	102,4

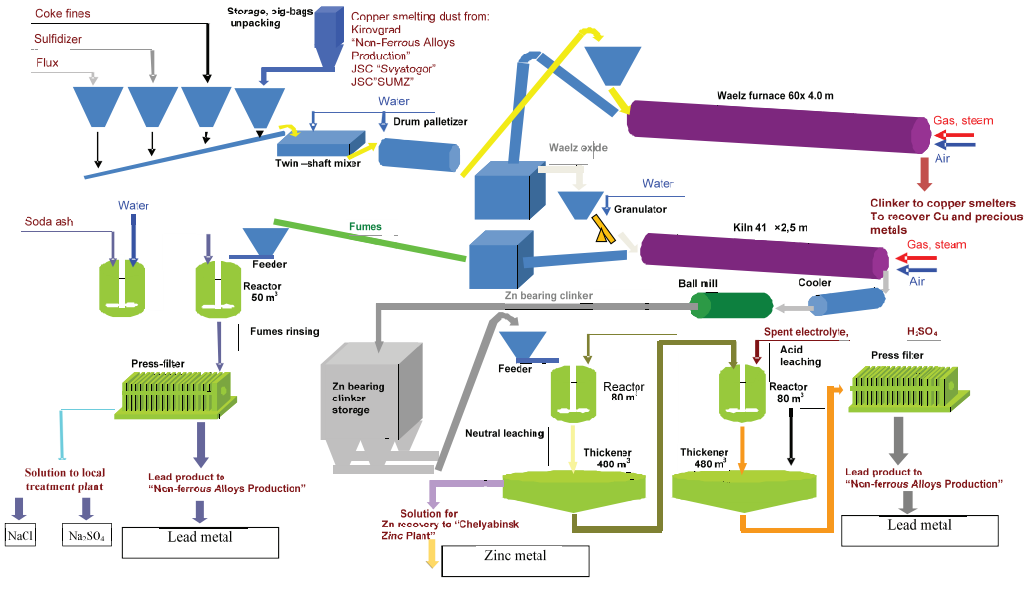

Figure 1: Process flowsheet of fine duct processing at OJSC “Chelyabinsk Zinc Plant”

In 2018 OJSC “Chelyabinsk Zinc Plant” processed 18 271 dmt of dust containing: Zn 18 – 44% (average 24), Pb – 13-19% (average 16).

2. Processing of EAF Dust

Electric arc furnace dust (EAF) is one of the main sources of secondary zinc raw materials, which is still not sufficiently involved in the processing for zinc recovery.

In July 2017 PJSC “Chelyabinsk Zinc Plant” carried out full-scale tests of processing of 567 dmt of EAF dust containing wt. %: Zn – 26.2, Pb – 1.73, Fe – 23.09, Cl – 2.73, F – 0.14. A characteristic feature of the processed dusts is 3 times higher halogen content than usual.

Waelz process was carried out in a separate furnace with subsequent calcination of the derived oxide to remove halogens. The results showed the principal possibility of such EAF dust processing, where:

- extraction of Zn and Pb in Waelz oxide was at the ordinary level of Waelz process;
- production of clinker and Waelz oxide was 57.5% and 41% respectively;
- the content of halogens in the Waelz oxide was naturally high before calcination, which affected the off-gas ducts through deposition of chlorides and fluorides;
- the chemical composition of Waelz clinker from EAF dust showed the possibility of using it as raw material for the cement industry;
- Waelz processing of EAF dust should be carried out in separate furnaces, as the clinker does not contain copper and precious metals.

3. Processing of Blast Furnace and Steel Smelter Slags

Steel production process inevitably generates large quantities of anthropogenic wastes, which mainly includes: refractory scrap, slag, scale, slime and dusts. Most of these metallurgical wastes are recyclable with extraction of iron, which is recycled into the production process, and non-magnetic masses from processing are used in construction industry.

However, the processing of such waste was established at the enterprises of ferrous metallurgy, built in the 19-20 centuries, they were exported and accumulated in dump piles. Taking into account the average annual volume of iron-containing waste at PJSC ”NMZ” 297.307 thousand tons, the total area of dumps for the long-term activity of PJSC ”NMZ” reached 47.3 hectares, and the usage fee is several tens of millions of rubles annually.

In 2001 in order to reduce the negative impact on the environment, the UMMC initiated a comprehensive program to process anthropogenic wastes in the production

and an industrial part-time work was organized for dumped metal-containing waste and slag from ferrous metallurgy of current production.

The process flow diagram of the process includes three stages: at the first stage, a part of the metal is extracted directly on the dump pile during excavation of the pile and loading of slag into dump trucks, delivering it to the crushing and screening facility. The second stage - large chunks of metal larger than 350 mm are removed on a crane rack using magnetic clamshell cranes on the grate of the receiving bunkers, where slag brought from the dump is poured. As part of the crane overpass, a combat pit for cleaning metal from slag and a section for metal fire cutting to overall dimensions are provided. The third stage is the removal of impurities (wood, rubber, bricks, etc.) and the extraction of metal from each fraction of the finished building rubble before its storage.

High-performance electromagnetic drums and mounted electromagnetic systems with rotating blade conveyors were used to extract metal.

The developed process flow diagram of slag processing allows, with an average annual processing volume of up to 606.21 thousand tons, to bring the degree of metal extraction from slag to 95%.

Process equipment of blast furnace facility:

1. Intake hopper; 2. Feeder; 3. Magnetic drum No.0; 4. Magnetic drum No.3; 5. Magnetic drum No.10; 6. Screen No. 1; 7. Screen No. 2; 8. Screen No. 3; 9. Crusher SMD-111B; 10. Crusher SMD-109; 11. Overhead self-unloading iron separator PSEZh; 12. Belt conveyor, 17 units.

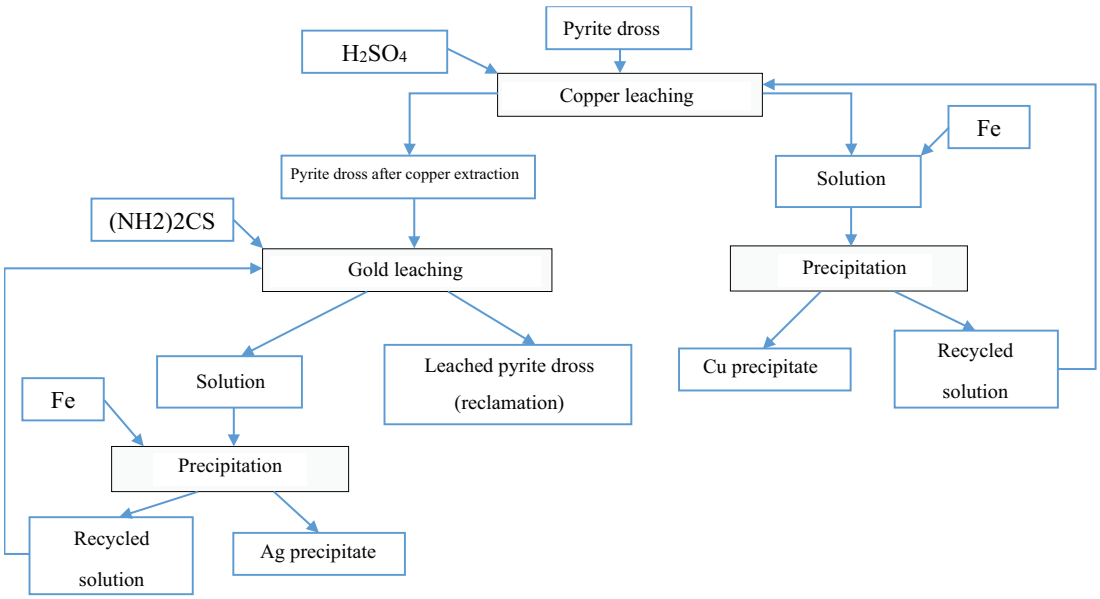

Figure 2: Processing of pyrite dross

4. Processing of Pyrite Dross

Commercial reserves of anthropogenic deposit of “Kirovgrad pyrite dross” branch of OJSC “Uralelektromed” are 6.7 million tons, including 20.8 thousand tons of copper and 7.2 tons of gold. The pyrite dross (PD) leaching process, in accordance with the process flow diagram shown on the Figure 2 was put into operation in December 2015, and included ditching on the surface of the pyrite dross pile for pumping leaching solution into them.

Oxidized and sulfate copper was leached with sulfuric acid, sulfide copper was leached due to oxidation with ferric ions and air oxygen.

After reaching a residual copper concentration of 0.3 g/dm^3 in productive solutions, thiourea was added into it for gold leaching. Iron ions (III) were also used as an oxidizing agent. Cementation of copper and gold from productive solutions was carried out on iron chips. The solutions after cementation were negotiable. Spent leach solutions were neutralized with lime.

During his work, the following indicators were achieved:

The volume of pyrite dross involved in the processing amounted to 95.5 thousand tons.

Copper content (plan/exploration data), % – 0.28/0.41.

Gold content (plan/exploration data), g/t – 1.3/0.90

The volume of leaching solutions (summer/winter), m^3/hour – 25.0/12.0

Copper recovery (plan/fact *), % - 45.0/21.4

Gold recovery (plan /fact *), % – 65.0 / 7.4

At the end of 2017, it was decided to deactivate the site due to its unprofitability. The reason was the low extraction of copper and gold, as well as a relatively small volume of circulation of leaching solutions due to the poor permeability of the pyrite dross pile.

Therefore, as a result of the implementation of the ”Program of measures to involve industrial waste of UMMC enterprises into processing at metallurgical enterprises of the UMMC - Holding”:

- slag is processed at concentrating plants and special concentrating facilities;
- R&D works on complex processing of concentrators’ tailings are conducted;
- to stop storage of metallurgical dusts a comprehensive processing of dusts is arranged;
- Waelz technology of steel-melting dust was developed and pilot-tested;

- development of technology for recovery of copper and precious metals from pyrite dross will be continues.

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