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Scientific-fundamental Approach to THE Processing of Coarse Dust Formed During the Melting of Sulfide Copper Concentrate in a Vanyukov Furnace

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Abstract*-This article describes the composition of dust formed during the smelting of sulfide copper concentrate in the Vanyukov furnace, the need for their processing, existing problems, and proposed technological solutions. In particular, an effective technological scheme for processing fine dust obtained from an electrostatic precipitator at the Almalyk MMC copper smelting plant and directions for complex separation are substantiated.*

Keywords: Dust, gas, drying, electrolysis, neutralization, electrostatic precipitator, liquid bath, press filter, hydrometallurgy, processing, leaching.

1. INTRODUCTION

Against the backdrop of the intensive development of modern industry, the introduction of environmentally safe and economically efficient technologies in the metallurgical industry has become an urgent task. In the Republic of Uzbekistan, work is actively continuing on the modernization of the mining and metallurgical industry, the development of new deposits, and increasing production volumes. In particular, the creation of a copper cluster, the development of such large deposits as "Yoshlik I" and "Yoshlik II," and the construction of new metallurgical complexes - all this, along with this, leads to an increase in technogenic waste, in particular dust [1].

Almalyk MMC JSC is a leading enterprise of non-ferrous metallurgy in Uzbekistan. Copper matte is obtained using large Vanyukov furnaces operating in the copper smelting shop of the plant. During the process, a large amount of dust is released, which is captured by electrostatic filters. Today, a large part of this dust is returned to production. However, this method is not sufficiently effective, especially from an ecological and technological point of view [2].

2. MATERIALS

Dust formation in the Vanyukov furnace The Vanyukov furnace is a large metallurgical installation that dissolves sulfide raw materials in an oxygen medium in a liquid bath. Depending on the composition of the charge supplied to it, its thermal state, and the smelting regime, the amount of dust released from the furnace is 5-15 tons per day. This dust is captured by electrostatic precipitators, and its composition is as follows:

• Pb: 15-24% • Zn: 10-12% • Ag: 50-150 g/t • Au: 1,2-1,5 g/t • Cu, Fe, As and other components

As can be seen from this composition, dust is not only a waste but also a resource rich in valuable components [3].

3. RESEARCH METHODOLOGY

At the copper smelting plant of JSC "Almalyk Mining and Metallurgical Combine," during the smelting of a copper concentrate, the sulfur in the concentrate is dispersed in the form of a dust-gas stream, and the dust in its composition is trapped in cyclones and electrostatic precipitators; coarse-grained dust makes up 85% of the total dust volume, and fine-grained dust - 15%.

Metallurgical furnace dust, in which a large amount of exhaust gases is generated, contains a high concentration of non-volatile metals (copper, lead, nickel, iron, and noble), which are mainly particles of the processed charge or the resulting products (stale, slag).

At the copper smelting plant of JSC "Almalyk Mining and Metallurgical Combine," there are several smelting furnaces designed for smelting copper concentrate, and it is in the Vanikov furnace that coarse dust is formed during the smelting process in a liquid bath.

The object of the research is ultrafine dust particles from the composition of process gases formed during the smelting process of copper matte at the copper smelting plant of JSC "Almalyk Mining and Metallurgical Combine," captured in electrostatic precipitators [4].

Table 1 Chemical composition of technogenic waste, ppm

Analyzed result

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Sample Information

Sample name	9
File name	9
Application	ummiy analiz
Date	08-apr-25 20:01
Analyzed by	M.S.K.
Counts	1
Comment	

Meas. cond.

Diaphragm DE-10mm Atmosphere Air Sample spin None Meas. order optimization Yes

Condition name	Primary filter	Tube voltage(kV)	Tube current(μA)	ST(μsec)	Meas. time(sec)	Dead time(%)
High-Z	F	60.0	200	1.6	100	10.7
Mid-Z	C	35.0	116	1.6	100	37.3
Low-Z	Open	6.5	458	1.6	100	37.4

Analyzed result(FP method)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ	Element line	Intensity(cps/μA)
1	Na	ND	mass%					
2	Mg	ND	mass%					
3	Al	0.955	mass%	0.0300	0.0737	0.221	L:Al-Kα	0.13802
4	Si	0.873	mass%	0.0112	0.0215	0.0644	L:Si-Kα	0.54064
5	P	ND	mass%	0.0024	0.0072	0.0215	L:P-Kα	0.00000
6	S	5.00	mass%	0.0139	0.0363	0.109	L:S-Kα	25.69651
7	Cl	ND	mass%	0.0022	0.0067	0.0202	L:Cl-Kα	0.00001
8	K	2.63	mass%	0.0718	0.115	0.345	M:K-Kα	0.29529
9	Ca	1.20	mass%	0.0406	0.0784	0.235	M:Ca-Kα	0.23187
10	Ti	ND	mass%					
11	V	ND	mass%					
12	Cr	ND	mass%					
13	Mn	0.108	mass%	0.0042	0.0081	0.0243	M:Mn-Kα	0.19429
14	Fe	13.2	mass%	0.0271	0.0059	0.0177	M:Fe-Kα	37.96741
15	Ni	0.0721	mass%	0.0019	0.0036	0.0108	M:Ni-Kα	0.38403
16	Cu	8.03	mass%	0.0143	0.0068	0.0203	M:Cu-Kα	54.05383
17	Zn	10.4	mass%	0.0136	0.0032	0.0096	M:Zn-Kα	98.03444
18	As	2.15	mass%	0.0173	0.0494	0.148	M:As-Kα	28.31076
19	Br	0.0247	mass%	0.0013	0.0037	0.0111	M:Br-Kα	0.38778
20	Rb	(0.0077)	mass%	0.0013	0.0041	0.0123	M:Rb-Kα	0.10727
21	Sr	0.0118	mass%	0.0009	0.0025	0.0076	M:Sr-Kα	0.17928
22	Y	0.0886	mass%	0.0028	0.0078	0.0233	M:Y-Kα	1.52123
23	Zr	0.149	mass%	0.0025	0.0030	0.0090	H:Zr-Kα	0.28742
24	Mo	1.64	mass%	0.0079	0.0023	0.0070	H:Mo-Kα	3.46448
25	Ru	ND	mass%					
26	Rh	ND	mass%					
27	Pd	ND	mass%					
28	Ag	0.0187	mass%	0.0011	0.0022	0.0066	H:Ag-Kα	0.05657
29	Cd	0.599	mass%	0.0043	0.0021	0.0063	H:Cd-Kα	1.86021
30	Sn	0.164	mass%	0.0024	0.0027	0.0081	H:Sn-Kα	0.52994
31	Sb	2.10	mass%	0.0080	0.0032	0.0097	H:Sb-Kα	6.61653
32	Ba	0.0125	mass%	0.0014	0.0037	0.0110	H:Ba-Kα	0.02457
33	La	ND	mass%					
34	Ce	ND	mass%					
35	Pr	ND	mass%					
36	Nd	ND	mass%					
37	W	ND	mass%					
38	Ir	1.16	mass%	0.0136	0.0406	0.122	M:Ir-Lα	4.32109
39	Pt	ND	mass%	0.0085	0.0263	0.0790	M:Pt-Lα	0.00000
40	Au	0.121	mass%	0.0074	0.0209	0.0626	M:Au-Lα	0.56162
41	Hg	ND	mass%					

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Analyzed result

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Date	08-apr-25 20:01
Analyzed by	M.S.K.
Counts	1
Comment	

Analyzed result(FP method)

No.	Component	Result	Unit	Stat. Err.	LLD	LLQ	Element line	Intensity(cps/μA)
42	Pb	46.6	mass%	0.0423	0.0370	0.111	M:Pb-Lα	281.29256
43	Th	1.16	mass%	0.0436	0.0693	0.208	M:Th-Mα	0.34009
44	U	ND	mass%					
45	Co	0.0495	mass%	0.0045	0.0134	0.0402	M:Co-Kα	0.21094
46	Ga	ND	mass%	0.0045	0.0144	0.0433	M:Ga-Kα	0.00001
47	Ge	ND	mass%					
48	Se	ND	mass%	0.0017	0.0056	0.0168	M:Se-Kα	0.00001
49	Nb	ND	mass%					
50	In	0.0176	mass%	0.0011	0.0026	0.0078	H:In-Kα	0.05504
51	Te	0.147	mass%	0.0023	0.0024	0.0073	H:Te-Kα	0.45988
52	I	ND	mass%	0.0011	0.0036	0.0108	H:I-Kα	0.00000
53	Cs	ND	mass%	0.0015	0.0048	0.0143	H:Cs-Kα	0.00000
54	Sm	ND	mass%					
55	Dy	ND	mass%	0.0098	0.0291	0.0874	H:Dy-Kα	0.00219
56	Hf	ND	mass%					
57	Ta	0.414	mass%	0.0271	0.0774	0.232	M:Ta-Lα	1.15119
58	Tl	ND	mass%					
59	Bi	ND	mass%					
60	Sc	0.329	mass%	0.0208	0.0486	0.146	M:Sc-Kα	0.10369
61	Tc	ND	mass%					
62	Re	ND	mass%	0.0352	0.104	0.312	M:Re-Lα	0.19225
63	Os	ND	mass%	0.0121	0.0350	0.105	M:Os-Lα	0.00000
64	Po	ND	mass%					
65	At	ND	mass%					
66	Lu	ND	mass%					
67	Yb	ND	mass%					
68	Tm	0.166	mass%	0.0134	0.0370	0.111	M:Tm-Lα	0.28075
69	Er	ND	mass%	0.0121	0.0377	0.113	M:Er-Lα	0.00000
70	Ho	ND	mass%					
71	Tb	ND	mass%	0.0070	0.0208	0.0624	H:Tb-Kα	0.00000
72	Gd	ND	mass%					
73	Eu	ND	mass%					
74	Pm	ND	mass%					
75	Pa	ND	mass%	0.0264	0.0661	0.198	M:Pa-Mα	0.03202
76	Ac	ND	mass%					
77	Ra	0.241	mass%	0.0498	0.0793	0.238	M:Ra-Mα	0.05367
78	Fr	ND	mass%					

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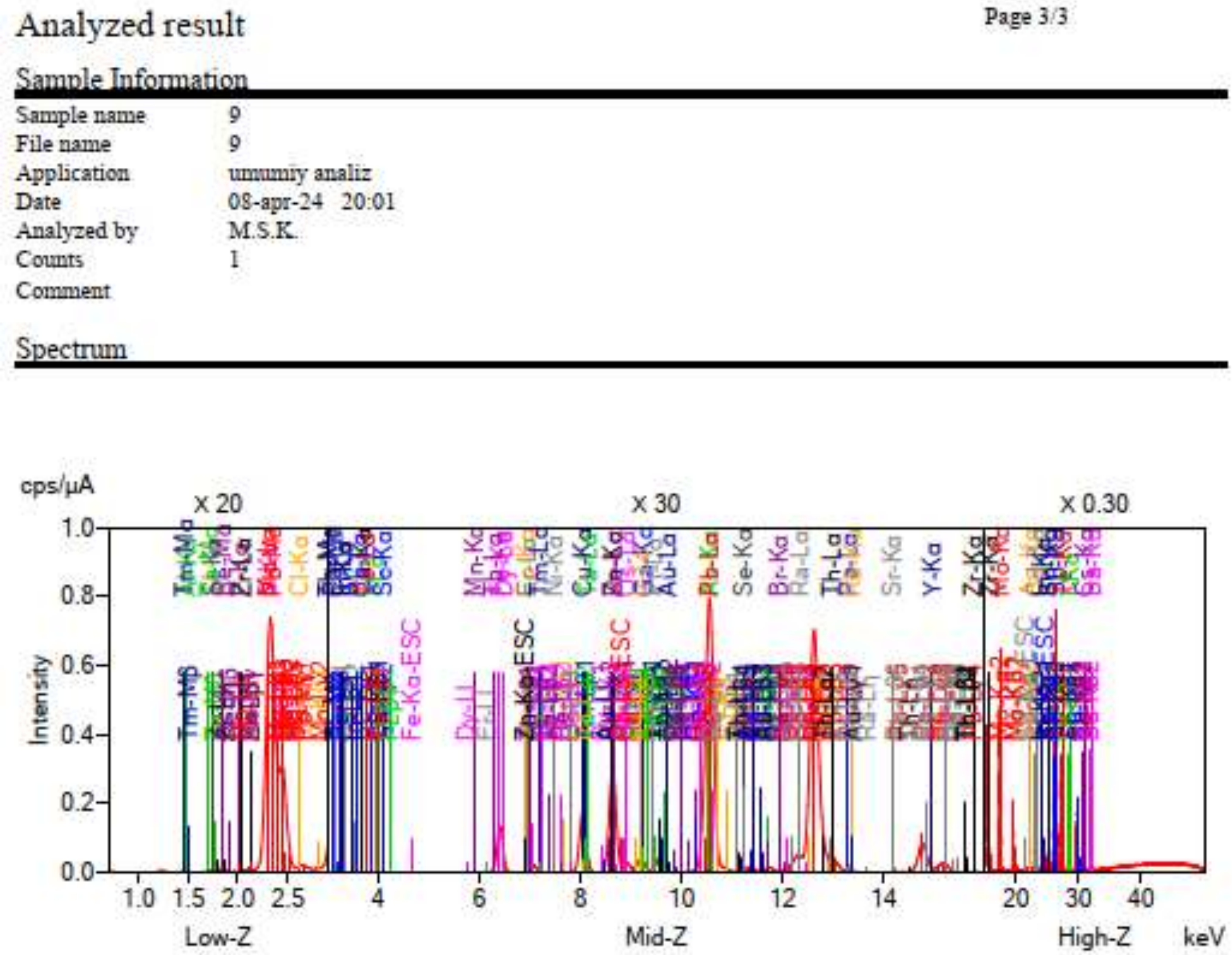

Coarse dust, formed in the copper smelting industry of JSC "Almalyk MMC," differs little in mineralogy from the initial charge and, therefore, reliably returns to the smelting process: complex sulfide forms of the main minerals predominate in coarse dust. In this case, dust loss to the chimney is 5-7% of the dust. In the 2nd stage of dust-gas flow purification, the remaining dust is captured using electrostatic precipitators. This is fine dust, which differs from the initial charge in terms of mineralogical and chemical characteristics: the main components in this dust are in water- and acid-soluble oxide-sulfate forms, which have not been processed for a long time and are being stored.

4. RESULTS AND DISCUSSION

The basis of the work is the study of methods of selective smelting of heavy non-ferrous metals from the composition of the initial product, the processes of condensation-settling of the solution, filtration of the precipitate, processing of copper from the solution by various methods of precipitation. Based on this, modern physico-mechanical, chemical, and physicochemical research methods (X-ray phase analysis, atomic emission analysis, mass spectral analysis, electron microscopy) were used in the work.

The conducted experiments show that when melting volatile dust in a mini matte, copper and zinc dissolve in sulfuric acid, and the noble metals do not dissolve and remain in the cake when filtered.

Proposed technological solution The proposed technological solution provides for dust processing in several stages:

1. Stage I leaching - metal sulfates in the dust pass into the solution;
2. Press filter - solid and liquid phases are separated;
3. Stage II acid leaching - copper and zinc metals dissolved with H2SO4 (sulfuric acid) and oxidizing agent O3 are added, and the insoluble metal transfers to 95% solution;
4. Press filter - solid and liquid phases are separated;

4. Cementation - the solutions of the two-stage melting are collected and treated with zinc powder, and copper is precipitated in metallic form, then zinc is separated from the zinc sulfate solution by electrolytic method;

5. The cake $PbSO_4$ is converted to a chlorinated form - the second stage is the selective dissolution of the waste cake with HCl;

6. Pyrometallurgical processing of the residual cake $PbCl_2$ for lead extraction - gold, silver, rhenium are extracted.

Such a technological approach allows for resource conservation, maximum separation of valuable components, environmental safety, and increased production efficiency.

5. CONCLUSION

With the transition to a complex hydrometallurgical-pyrometallurgical approach, instead of the inefficient technology for processing dust generated during the smelting of sulfide copper concentrates in the Vanyukov furnace, it is possible to extract copper, lead, zinc, gold, silver, rhenium, and other metals at a high level. The proposed technological process is important because it ensures energy and resource saving, reduces environmental pollution, and increases production efficiency. Ultimately, in-depth analysis and recovery of rare metals from technogenic solutions present a promising opportunity to increase the utilization of secondary raw material sources, facilitate the transition toward zero-waste technologies, and improve environmental safety.

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