



Study on XRT Intelligent Sorting of a Lead Zinc Polymetallic Sulfide Mine in Inner Mongolia

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Abstract. An X-ray intelligent sorting experiment was conducted on a certain polymetallic sulfide mine in Inner Mongolia. Under the condition of operating scrap rate of 43.65%, the grades of copper, lead, zinc, and iron in the tailings were 0.01%, 0.01%, 0.13%, and 3.15%, respectively. The recovery rates of copper, lead, zinc, and iron in the concentrate were 97.20%, 86.17%, 95.59%, and 88.94%, respectively. After the enterprise adopts X-ray intelligent sorting technology, it will generate an additional economic benefit of 4.5316 million yuan per year. The process can effectively reduce the discharge amount of tailing pond and improve the service life of tailing pond.

Keywords: Sulfide ore; Lead-zinc ore; Scrap; Intelligent separation.

1 Introduction

With the development and progress of pre selection and tailings disposal technology, the pre selection and tailings disposal process has become more diverse and efficient. The types of minerals that can be processed by pre selection and tailings disposal are increasing, the processing capacity of equipment is increasing, and the particle size range of selected tailings is becoming wider. The effectiveness of pre selection and tailings disposal in energy conservation, cost reduction, full utilization of mineral resources, and improvement of ecological environment protection level is becoming increasingly significant^[1].

A certain lead zinc mine in Inner Mongolia is a copper lead zinc polymetallic sulfide mine containing magnetite^[2-3]. In recent years, with the continuous increase in service life and mining depth of mines, the grade of selected ore has gradually decreased, and the cost of beneficiation has continuously increased, resulting in a continuous decrease in economic benefits for enterprises. In order to further increase the production of concentrate and improve the economic benefits of the mine, the company has conducted research on the ore disposal process before grinding^[4-5].

By utilizing X-ray sorting technology and combining the characteristics of ore properties [6-8], research on XRT intelligent sorting technology was conducted on the ore, verifying the feasibility of XRT sorting technology in the mine, achieving low-grade waste disposal of the ore, and creating relatively objective economic benefits every year [9-10].

2 Experiment

2.1 Experimental Materials and Instruments

X104 intelligent sorting machine, jaw crusher, roller crusher, oven, impact screen.

2.2 Sample multi-element analysis

The sample of polymetallic sulfide ore was taken from a lead zinc mine in Inner Mongolia, and it is a product with a particle size of -60+10mm on the crushing screen of a beneficiation plant. The sample analysis results are shown in Table 1.

Table 1. Multielement analysis results of polymetallic sulfide ore samples

Element	Cu	Pb	Zn	TFe	S	As	Mo	SiO ₂	Al ₂ O ₃
Content(%)	0.19	0.05	1.29	12.42	1.11	0.12	0.0021	33.19	3.26
Element	CaO	MgO	K ₂ O	Na ₂ O	C	Au*	Ag*	Sn	
Content(%)	23.36	1.78	0.31	0.33	0.78	0.07	11.32	0.032	

Note: The unit of gold and silver in the table is g/t.

2.3 Chemical phase analysis of copper lead zinc minerals

Grind the ore with a content of -400 mesh and 90%, and conduct chemical phase analysis on copper, lead, and zinc minerals. According to the analysis results, the copper, lead, and zinc in the ore are mainly sulfide phases. The test results are shown in Tables 2 to 4.

Table 2. Chemical phase analysis results of copper minerals

Phase	Copper oxide	Copper sulfide	Total
Copper Content(%)	0.003	0.187	0.19
Occupancy(%)	1.58	98.42	100.0

Table 3. Chemical phase analysis results of lead minerals

Phase	Lead oxide	Lead sulfide
Lead Content(%)	<0.001	0.05

Table 4. Chemical phase analysis results of zinc minerals

Phase	Zinc oxide	Zinc sulfide	Total
Zinc Content(%)	0.02	1.27	1.29
Occupancy(%)	1.55	98.45	100.0

2.4 XRT Intelligent Sorting Principle

During the sorting process, X-ray and X-ray sensors are used to detect the density and thickness characteristics of the ore laid flat on the conveyor belt, and obtain image data with image processing conditions; Subsequently, after image processing, the characteristics of the ore are determined and non-linear classification is performed. A special TM algorithm based on convolutional neural networks (CNN) is run for deep learning to intelligently and effectively distinguish between concentrate and waste ore, and output impact signals; By precisely controlling the opening and closing of the high-frequency gas valve, the ore or waste rock is struck to the corresponding ore bin.

3 Results and Discussion

3.1 Exploratory trial

In the exploratory experiment, manual selection test was carried out on the samples, and the results of manual selection test were shown in Table 5.

Table 5. Results of sample selection by hand

Sample	Productivity(%)	Grade(%)				Recovery(%)			
		Cu	Pb	Zn	TFe	Cu	Pb	Zn	TFe
Concentrate	78.07	0.25	0.05	1.60	15.22	98.89	94.68	98.61	95.89
Tailing	21.93	0.01	0.01	0.08	2.32	1.11	5.32	1.39	4.11
Total	100.0	0.20	0.04	1.27	12.39	100.0	100.0	100.0	100.0

Table 5 shows that the concentrate yield is 78.07% , the grade of copper, lead, zinc and iron are 0.25% , 0.05% , 1.60% and 15.22% respectively, and the recovery is 98.89% , 94.68% , 98.61% and 95.89% respectively.

3.2 XRT intelligent sorting test

In the experiment, multiple batches of tests were conducted on the coarse particles in the crushed ore of the beneficiation plant. The test results are shown in Table 6.

Table 6. Multiple Batch Test Results of Polymetallic Sulfide Ores

Sample	Productivity(%)	Grade(%)				Cumulative grade(%)			
		Cu	Pb	Zn	TFe	Cu	Pb	Zn	TFe
Tailing 1	15.16	0.01	0.01	0.06	2.23	0.01	0.01	0.06	2.23
Tailing 2	7.45	0.01	0.01	0.08	2.38	0.01	0.01	0.07	2.28
Tailing 3	11.20	0.01	0.01	0.11	2.85	0.01	0.01	0.08	2.47
Tailing 4	9.84	0.02	0.03	0.30	5.48	0.01	0.01	0.13	3.15
Concentrate	56.35	0.33	0.07	2.19	19.61	--	--	--	--

The analysis results are shown in Table 7.

Table 7. Analysis Results of Multiple Batch Tests on Polymetallic Sulfide Ores

Programme	Sample	Productivity(%)	Grade(%)				Recovery(%)			
			Cu	Pb	Zn	TFe	Cu	Pb	Zn	TFe
	Concentrate	84.84	0.22	0.05	1.51	14.25	99.21	96.69	99.30	97.28
Option 1	Tailing	15.16	0.01	0.01	0.06	2.23	0.79	3.31	0.70	2.72
	Total	100.0	0.19	0.05	1.29	12.42	100.0	100.0	100.0	100.0
Option 2	Concentrate	77.39	0.24	0.06	1.65	15.39	98.82	95.06	98.83	95.85
	Tailing	22.61	0.01	0.01	0.07	2.28	1.18	4.94	1.17	4.15
	Total	100.0	0.19	0.05	1.29	12.42	100.0	100.0	100.0	100.0
Option 3	Concentrate	66.19	0.28	0.06	1.91	17.51	98.23	92.61	97.88	93.28
	Tailing	33.81	0.01	0.01	0.08	2.47	1.77	7.39	2.12	6.72
	Total	100.0	0.19	0.05	1.29	12.42	100.0	100.0	100.0	100.0
Option 4	Concentrate	56.35	0.33	0.07	2.19	19.61	97.20	86.17	95.59	88.94
	Tailing	43.65	0.01	0.01	0.13	3.15	2.80	13.83	4.41	11.06
	Total	100.0	0.19	0.05	1.29	12.42	100.0	100.0	100.0	100.0

From Table 7, it can be seen that with the increase of operation waste rate, the grades of copper, lead, zinc, and iron in the concentrate gradually increase, and the recovery rate gradually decreases. The zinc grade in the sample is 1.29%, which is the main valuable element, while the other elements are associated with comprehensive recovery. When the scrap rate of the operation is 43.65%, the grades of copper, lead, zinc, and iron in the waste rock are 0.01%, 0.01%, 0.13%, and 3.15%, respectively.

3.3 Discussion

The main valuable elements in a certain lead zinc polymetallic ore in Inner Mongolia are mainly sulfide ore. The ore is sorted with a -60+10mm particle size using XRT intelligent sorting process. When the operating scrap rate is 43.65%, the grades of copper, lead, zinc, and iron in the waste rock are 0.01%, 0.01%, 0.13%, and 3.15%, respectively. The concentrate recovery rates are 97.20%, 86.17%, 95.59%, and

88.94%, effectively improving the ore grade and reducing the production cost of beneficiation, To lay a solid foundation for improving the economic benefits of mines.

4 Economic Benefit Analysis

According to the mine's processing capacity of 3000t/d and annual operating days of 330d, the annual processing capacity is 990000 tons. The ore used for XRT intelligent process for waste disposal accounts for 50% of the processing capacity of the beneficiation plant.

4.1 Costing

The processing capacity of the XRT intelligent sorting machine is calculated at 80t/(unit · h), and a total of 1 XRT intelligent sorting machine (operating time of 18.75h/d) is required. The price of each machine is calculated at 4 million yuan, and the annual depreciation cost is 500000 yuan based on equipment depreciation for 8 years. The total annual cost of belt replacement is 78000 yuan. The investment in supporting facilities and infrastructure is 1 million yuan, with a service life of 8 years and an annual cost of 125000 yuan. The annual electricity usage fee is 329800 yuan. The annual labor cost is 600000 yuan. The total annual cost is 1.6328 million yuan.

4.2 Production cost savings

The cost of crushing, grinding, and flotation (material+power) saved by throwing out the ore is 26.26 yuan/t, and the cost of tailings disposal is 1.47 yuan/t, resulting in a total increase of 28.53 yuan/t in enterprise revenue per ton of tailings thrown out.

The economic benefits of the enterprise under different operating waste rates using the XRT intelligent sorting process are calculated in Table 8.

Table 8. Calculation of Economic Benefits under Different Abandonment Rates

Discard rate(%)	Amount of waste rock(t·a ⁻¹)	Cost savings (thousand yuan a ⁻¹)	Cost of XRT(thousand yuan a ⁻¹)	Benefits (thousand yuan·a ⁻¹)
15.16	75042.0	2140.9		508.1
22.61	111919.5	3193.1		1560.3
33.81	167359.5	4774.8	1632.8	3142.0
43.65	216067.5	6164.4		4531.6

It can be seen that as the scrap rate gradually increases, the economic benefits of the enterprise continue to increase from table 8. When the waste disposal rate of the operation reaches 43.65% (equivalent to 21.83% of the original mineral rate), the economic benefits of the enterprise reach its maximum value, creating an annual economic benefit of 4.5316 million yuan (the recyclable metal from the waste stone is not priced), and reducing the discharge of tailings pond by 216100 tons per year.

5 Conclusion

(1) The test sample is a polymetallic sulfide ore, with copper, lead, zinc, and iron grades of 0.20%, 0.04%, 1.27%, and 12.39%, respectively.

(2) The sorting results of the XRT waste disposal process indicate that as the waste disposal rate gradually increases, the grade of the thrown waste rock gradually increases. When the operating scrap rate is 43.65%, the grades of copper, lead, zinc, and iron in the scrap products are 0.01%, 0.01%, 0.13%, and 3.15%, respectively. The recovery rates of copper, lead, zinc, and iron in the concentrate are 97.20%, 86.17%, 95.59%, and 88.94%, respectively.

(3) In the analysis of economic benefits, when the waste disposal rate is 43.65%, the annual increase in economic benefits of the mine is 4.5316 million yuan.

(4) The process can effectively reduce the discharge amount of tailing pond and improve the service life of tailing pond.

References

1. LUO X P, NING X H, WANG T, et al. Development and Application of Intelligent Sorting Mineral Processing Technology [J]. *Metal Mines*, 2019 (07): 113-117.
2. PENG W, HE P Y. X-ray intelligent pre selection test and practice of a certain antimony ore [J]. *Metal Mines*, 2019 (09): 92-97.
3. ZHANG J, ZONG Y F. Research and industrial application of low grade ore pre separation waste disposal technology [J]. *World Nonferrous Metals*, 2020, 19:158-159.
4. Tian Z G. Experimental research on XRT intelligent sorting machine in Fankou lead-zinc mine [J]. *Mining Research and Development*, 2019, 39 (12): 153-156.
5. DI W P, WI Z H. Study and application of waste disposal technology in intelligent photoelectric beneficiation [J]. *Non-ferrous metal (Mineral Processing Section)*, 2021(1): 117-121.
6. SONG M X, Kholso Sultan Ahmed, Lyu Fei, et al. Study on the influence and mechanism of sodium chlorate on COD reduction reduction of minerals processing wastewater separation [J]. *Minerals Engineering*, 2019, 134: 1-6.
7. Lompe K M, Menard D, Barbeau B. The influence of iron oxide nano-particles upon the adsorption of gamic matter on magnetic powered activated carbon [J]. *Water Res*, 2017,123:30-39.
8. JIANG Y, XIE Q, ZHANG Y H, et al. Preparation of magnetically separable mesoporous activated carbons from brown coal with Fe₃O₄[J]. *International Journal of Mining Science and Technology*, 2019, 29: 513-519.
9. RAN J C, LIU Q J, QIU X Y, et al. Experimental research on enhanced recovery of associated gold from a copper-lead multi-metal sulfide ore[J]. *Precious Metals*, 2017, 38(2): 47-51.
10. LIU X H, ZHANG J Q. Experimental study and application practice of particle size optimization for X-ray intelligent ore separation [J]. *Hunan Non-ferrous metal*, 2022,38(4): 14-17.

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