Analysis of Benefits Between Sales Revenue and Transportation Cost of a Gold Mineral Processing Plant in Shandong

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Abstract: With the mining of gold mines, the gold level is gradually reduced, and the transportation cost of gold concentrate is gradually increased. This study analyzes the relationship between the analysis of different concentrate grades and transportation costs, so as to find the best economic benefits of the concentrator. A function is established in this paper. It is used to find the best economic benefit in different enrichment ratios. Raising the rate of recovery is not necessarily able to increase the total economic benefit of the concentrator. It was discovered by practice that the total economic benefit increased by 1109130 yuan when the recovery decreased by 0.22%.

1.Introduction

With the depletion of ore resources, in the gold beneficiation process, the ore grade is gradually reduced, the production cost and human resource cost are gradually increased, and the profit of the concentrator is gradually reduced, so it is necessary to constantly look for profit growth points in the beneficiation production [1-3]. In this paper, the differential method is used to analyze the relationship between concentrate grade and transportation cost, and to find the best economic benefits of concentrators under different concentrate grades. I hope it can help the production of the same type of concentrator [4-6].

In the beneficiation production, if the tailings grade is unchanged, the concentrate grade will be increased, the recovery rate will be correspondingly reduced, the concentrate yield will be reduced, and the transportation cost will be reduced; On the contrary, the concentrate grade decreases, the recovery rate increases correspondingly, and the transportation cost increases. In this paper, the relationship between the transportation cost and the sales revenue under different concentrate grades is found to find the best economic benefits for the concentrator [7-8].

2.Analysis of Relationship between Mineral Processing Recovery and Enrichment Ratio

Calculation formula for theoretical recovery rate of concentrator [9-10]:

$$\varepsilon = \frac{\beta(\alpha-\theta)}{\alpha(\beta-\theta)} \quad \text{----------(1)}$$

In the formula：

ε Recovery（×100%）

β Concentrate grade（$\times 10^{-6}$）

α Raw ore grade（$\times 10^{-6}$）

θ Tailings grade（$\times 10^{-6}$）

In the process of differential deduction of the theoretical calculation formula of recovery rate, the recovery rate changes with the change of concentrate grade when the raw ore grade and tailing grade are considered as constants.

The results are as follows.

$$\varepsilon' = -\frac{1}{\alpha}\cdot\frac{\theta(\alpha-\theta)}{(\beta-\theta)^2} \quad \text{----------(2)}$$

From equation 2, it can be concluded that the reciprocal of the recovery rate is less than zero. It shows that under the condition that the grade of raw ore and tailings are set to be constant, the recovery rate of gold concentrate decreases with the increase of concentrate grade[11-15]. Although the grade of gold concentrate increases, the reduction of its yield leads to the reduction of the recovery rate. From the perspective of tailings, the tailings grade remains unchanged, the yield increases, and the amount of metal in the tailings increases, so the recovery rate decreases[16-18].

Under the assumption that the grade of raw ore and tailings remains unchanged, and without considering the transportation cost, the concentrate grade will increase, the concentrate yield will decrease, the tailings yield will increase, the metal content in tailings will increase, and the metal content in concentrate will decrease, and the sales price will inevitably decrease[19-23].

If the transportation cost is considered, there is a problem that the concentrate grade increases, the production rate decreases, and the sales price decreases, but the transportation cost also decreases. The content of

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this paper is whether there is a point or an interval between the two, which can maximize the profit of the concentrator in the actual production process.

3.Establishment of functional relationship between grade of secondary concentrate and transportation cost

In the actual production of gold mine, with the increase of concentrate yield, the amount of concentrate to be transported increases, and the transportation cost increases[24-26].

In fact, in addition to the impact of metal volume on the sales price, different concentrate grades correspond to different gold return rates, which also affect the yield of gold concentrate, thereby affecting the transportation cost of gold concentrate.

In the production and sales of gold concentrate in a gold concentrator in Shandong Province, the economic benefit can be determined as the difference between the concentrate sales price and the transportation cost. Among them, the factors affecting the sales price of gold concentrate include gold concentrate grade, gold concentrate sales volume and different return rates under different gold concentrate grades; The factors affecting transportation cost are only the quality of gold concentrate and transportation cost[27-29].

Table 1 Return rate of metals in gold concentrates of different grades

NO.	Gold concentrate grade/×10^{-6}	Rate of return/%
1	5-9	82.0
2	10-14	85.0
3	15-19	88.0
4	20-24	90.0
5	25-29	94.0
6	30-34	95.0
7	35-39	95.5
8	40-44	96.0
9	45-49	96.5
10	50-54	97.2
11	55-59	97.5
12	60-69	97.7
13	＞70	97.9

Notes：The data above are not applicable to other mines because of different gold concentrate return rate. The data in Table 1 of this paper is for reference only.

Sales income=processing volume × raw ore grade × recovery rate × international gold price × return rate

$$M_1 = Q\frac{\beta(\alpha-\theta)}{\beta-\theta}K_1K_2 \quad \text{----------(3)}$$

Transportation cost = gold concentrate quantity × transportation cost

$$M_2 = Q\frac{\alpha-\theta}{\beta-\theta}K_3 \quad \text{----------(4)}$$

The economic benefits are expressed as follows.

$$M = Q\frac{\beta(\alpha-\theta)}{\beta-\theta}K_1K_2 - Q\frac{\alpha-\theta}{\beta-\theta}K_3 \quad \text{---(5)}$$

In the formula：

M Economic benefits,
M1 Sales revenue,
M2 Transportation costs,
Q Processing capacity,
K1 International gold prices；
K2 Refining rate of gold return；
K3 Transportation cost per ton of concentrate。

In equation 5, economic benefit M varies with concentrate grade β. Differential toppling of economic benefit M can be obtained.

$$\frac{M'}{Q} = \frac{\alpha-\theta}{(\beta-\theta)^2}(K_3 - K_1K_2\theta) \quad \text{----------(6)}$$

It can be seen in Formula 6,α＞θ，

$$\frac{\alpha-\theta}{(\beta-\theta)^2} > 0$$

So，

Under normal production conditions, K1 adopts the Shanghai Gold exchange price of 267.77 Yuan per gram. The highest return rate of smelting unit to concentrator K2 is 97.9%, the cost of transportation for the concentrator is 51 yuan per ton.

$$K_3 - K_1K_2\theta = 51 - 267.77 \times 97.9\% \times 0.12 > 0$$

So, $M' > 0$.

From the above derivation, it can be concluded that proper improvement of concentrate grade is beneficial to the increase of total economic benefit in the production of concentrator. The loss of metals due to higher concentrate grade is less than the cost of transportation.

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4.Production practice verification

The processing capacity of a gold concentrator in Central Plain is 5,000 TPD. Although the gold grade of the mine fluctuates in the actual production process, the average grade of the raw ore is 1.98×10^{-6} and the concentrate grade fluctuates in the range of 30-100×10^{-6}, the average grade of tailings is 0.12×10^{-6}.

Under the condition of 30×10^{-6} concentrate grade, the recovery is 94.32%, the economic benefit is 2484389 Yuan, the recovery is 93.11% under the condition of 100×10-6, the economic benefit is 2488504 yuan. Therefore, although the recovery rate decreased by 1.21%, but the economic benefit increased by 4115 yuan.

However, the rate of return of metal in gold concentrate of different grade can be seen that when the grade of gold concentrate is greater than 70×10-6, the rate of return of gold is no longer increased to 97.9%. In practical production, the high concentration ratio sometimes leads to the increase of tailing grade, so the optimum gold concentrate grade is 70×10-6 in practical production. At this time, the enrichment ratio was 35.35

times, the recovery was 94.10%, decreased 0.22%, and the economic benefit increased 3361 yuan per day.

The comparison of economic benefits of different gold concentrate grades is shown in Figure 1.

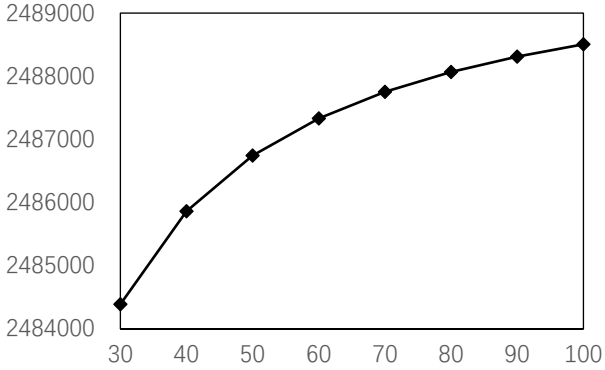

Fig. 1 Economic benefits under different concentrate grade

As can be seen from Figure 1, with the improvement of concentrate grade, the economic benefits gradually increased. And in the gold concentrate grade in the process of increasing, the economic benefit of the growth rate has a decreasing trend.

According to the annual working days of the concentrator 330 days, an increase in economic benefits 3361 yuan every day, an annual increase in economic benefits 1109130 yuan.

5.Conclusions

(1) Through the analysis of this paper, it can be concluded that the cost of reducing the transportation cost is lower than the cost of reducing the recovery rate, and the economic benefit is increased.

(2) Formula 5 is applicable to the calculation of most gold concentrators, and it is hoped that it can also be used for reference to other ore processing enterprises.

(3) From the above calculation, the economic benefit can be increased by 1.11 million yuan per year by adjusting the enrichment ratio in production.

References

1. 2004 NASA cost estimating handbook[R]. NASA Cost Annlysis Divisiom.2004.
2. He F, Zhang L. Prediction model of end-point phosphorus content in BOF steelmaking process based on PCA and BP neural network[J]. Journal of Process Control, 2018,66:51-58.
3. Singh V, Rao S M. Application of image processing and radial basis neural network techniques for ore sorting and ore classification[J]. Minerals Engineering,2005, 18(15):1412-1420.
4. Mccoy J T, Auret L. Machine learning applications in minerals processing: A review[J]. Minerals Engineering,2019,132:95-109.
5. Le E Z Q. Sulfur flotation reagent test in a concentrator [J]. Modern Mining,2019 (9) :133-135.
6. Liu Z Z, Liu Y.He X J,et al. Recovery of rare earth and phosphorus from a rare earth-bearing apatite[J]. Conservationn and Utilization of Mineral Resources,2017(6):41- 44 .
7. Du J, Shang X, Shi J, et al. Removal of chromium from industrial wastewater by magnetic flocculation treatment: Experimental studies and PSO-BP modelling[J]. Journal of Water Process Engineering, 2022, 47: 102822.
8. Zarie M, Massinaei M. Flotation froth image classification using convolutional neural networks[J]. Minerals Engineering, 2020, 155(C).
9. Natsuo O, Yohei M, Narihoro O, et al. Automated Identification of Mineral Types and Grain Size Using Hyperspectral Imaging and Deep Learning for Mineral Processing[J]. Minerals, 2020, 10(9).
10. Y. F, C. A. Deep learning in mining and mineral processing operations: a review[J]. IFAC PapersOnLine, 2020, 53(2).
11. YANG J Z, MAO Y L, CHEN X Q, et al. Research on resource disposal and comprehensive utilization of a certain tailings[J].Multipurpose Utilization of Mineral Resources, 2019(6):117-122+156.
12. LI D J, GUO C H, YUAN C X, et al. Study on gold recover from cyanide tailings floatation sulfur concentrate roasting residue[J]. Multipurpose Utilization of Mineral Resources,2019(5):107-110.
13. ZHANG L H. Research on the treatment of cyanide-containing wastewater by hydrogen peroxide oxidation method and activated sludge method[D]. Shanghai: East China University of Science and Technology, 2015.
14. ZHANG H Y, XIAO Z, SHEN L N, et al. Experiment and engineering application of hydrogen peroxide oxidation method to treat low-concentration cyanide-containing wastewater[J].Environmental Science and Technology, 2010, 23(3):49-51.
15. TAO D, SOBHY A. Nanobubble effects onhydrodynamic interactions between particles and bubbles[J]. Powder Technology, 2019,346:385-395.
16. ZHANG F, XING Y, CHANG G, et al. Enhanced lignite flotation using interfacial nanobubbles based on temperature difference method[J]. Fuel, 2021,293:120313.
17. LEE J G, FLUMERFELT R W. A refined approach to bubble nucleation and polymer foaming process: dissolved gas and cluster size effects[J]. Journal of Colloid and Interface Science, 1996,184(2):335-348.
18. ERIKSSON J C, LJUNGGREN S. On the mechanically unstable free energy minimum of a gas bubble which is submerged in water and adheres to a hydrophobic wall[J]. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 1999,159(1):159-163.
19. YOUNT D E, KUNKLE T D. Gas nucleation in the vicinity of solid hydrophobic spheres[J]. Journal of Applied Physics, 1975,46(10):4484-4486.
20. ZHOU W, WU C, LV H, et al. Nanobubbles

heterogeneous nucleation induced by temperature rise and its influence on minerals flotation[J]. Applied Surface Science, 2020,508:145282.

21. LU C, YANG C R, ZHANG S Q, et al. Experimental study on the centrifugal separation of grinding classification products for a gold mine in Inner Mongolia[J]. Multipurpose Utilization of Mineral Resources, 2021(3):152-157.
22. HUANG Y H, SUN J M, ZHANG Y T, et al. Application of Knelson Concentrator KC-MD3 in grinding circuit of a goldmine[J]. Mining and Metallurgical Engineering, 2019,39 (3):55-58.
23. DU S H, PAN B L, XIA L, et al. Experimental study on beneficiation of arsenic/carbon-bearing refractory of low-grade gold ore containing high sulfur[J]. Metal Mine, 2020(11):90-94.
24. TIAN S G, CUI L F, WANG J R, et al. Process mineralogy and factors affecting mineral processing for a foreign copper-lead-zinc polymetallic ore[J]. Multipurpose Utilization of Mineral Resources, 2019(1):78-82.
25. CHEN Q, YANG H Y,CHEN G M, et al. Application of Knelson Gravity Concentration in Quartz Vein Type Gold Beneficiation Process in China[J].Gold Science and Technology,2017,25(5):73-79.
26. LIANG K. Research on the key technology of leaching sulfurcontaining gold concentrate with a new type of environmental protection agent [D]. Ganzhou: Jiangxi University of Science and Technology, 2018.
27. WANG Y, WANG J, LI X Y, et al. Process mineralogy study of the gold deposit in western Sichuan area and its influence on mineral Processing technology [J]. Multipurpose Utilization of Mineral Resources, 2021(4):206-210.
28. LIU L, WU S J, ZHOU Y. Process of Gravity, Flotation and Cyanide for a High-grade Gold Ore in Suichuan Jiangxi [J]. Multipurpose Utilization of Mineral Resources, 2015(4):24- 26+34.
29. ZHU C H, MING P T, FANG H S, et al. Research and practice on mineral environmental processing technologies for a gold flotation tailings from Qinghai province [J]. Multipurpose Utilization of Mineral Resources, 2016(4):85-89.