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AASRI Procedia 7 (2014) 14 – 19

AASRI Procedia

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2013 2nd AASRI Conference on Power and Energy Systems

Optimization Study to the Ratio of Primeval Ball Loading in φ4.0 × 6.0 m Overflow Ball Mill of Yingezhuang Gold Mine

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Abstract

Optimized study to the ratio of primeval ball loading in 4.0 × 6.0m overflow ball Mill of Yingezhuang gold mine, the research results showed that it pertains to low hard and brittle ores, the accurate size ball should be used rather than big size ball due to mainly fines mineral are produced in the process of comminution. As the yield of intermediate granularity between 8 to 0.45 mm reach up to 50.34%,the intermediate particles should be strengthened in grinding, -400 mesh content is about 40% and -10um content accounts for a quarter of the grind products what showed that particles size are not satisfied and unfavorable to subsequent separation. The optimum scheme of primeval ball loading is that: φ70: φ60: φ50：φ40= 15: 15: 30: 40 for φ4.0 × 6.0m overflow ball mill, the separate sizes contents is 64.19% between 0.15~0.019mm which increasing by 19.14% compare with 44.78% and the mill -200mesh utilization coefficient increasing 12.6 percents compare with 0.14 about original program when φ4.0 × 6.0m overflow ball mill work itself alone, in addition, the mill -200mesh utilization coefficient increasing 11.71 percents compare with 0.1503 about original program when φ4.0 × 6.0m overflow ball mill and φ3.6 × 6.0m grate ball mill are working together.

Peer-review under responsibility of Scientific Committee of American Applied Science Research Institute

Keywords: Primeval ball loading; overflow ball mill; size ratio; optimize

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Peer-review under responsibility of Scientific Committee of American Applied Science Research Institute
doi:10.1016/j.aasri.2014.05.022

1. Introduction

The designed daily processing capacity is about 4700 ton and gold deposit belongs to the type of quartz vein of Yingezhuang Gold Mine. As the ores are in short supply, the φ3.6 × 6.0m grate ball mill on and off, nevertheless, φ4.0 × 6.0m overflow ball mill working all along, The underflow particles returns to regrinding and the overflow particles enter into flotation subsequent after hydrocyclone about one stage grinding products, grinding flow diagram of Yingezhuang Gold Min as the figure 1 shows. φ4.0 × 6.0m overflow ball mill is closed-circuit grinding, it need to not only own return oversize, but also the return oversize from φ3.6 × 6.0m grate ball mill, due to the φ3.6 × 6.0m grate ball mill work uncertain which bring many inconveniences forφ4.0 × 6.0m overflow ball mill. The Plant scheme of primeval ball loading is that: Φ 100: Φ 80: Φ 60=20:40:40 for φ4.0 × 6.0m overflow ball mill, coarse particles (>0.15mm) is a larger, the yield of -200 mesh is between 18% to 20% and the size composition is irrational in grinding products. This paper aims to optimize the Ratio of Primeval Loading Ball and the size composition of grinding products.

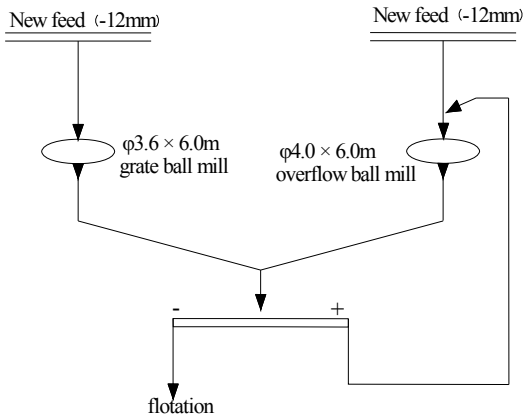

Fig. 1. Grinding flow diagram of Yingezhuang gold mine

2. The study on the ore mechanics properties

The uniaxial compressive strength and fragility measurement results are shown in table 1 from two mines ore:

Table 1. The compressive strength and Poisson's ratio test results

Block number	Compressive strength (kg/cm^2)	Average strength (kg/cm^2)	Poisson's ratio U_{50}	Average U_{50}
A-1	638.57		0.218	
A-2	768.32	681.82	0.118	0.188
A-3	638.57		0.228	
B-1	618.67		0.147	
B-2	713.44	665.22	0.135	0.163
B-3	663.56		0.208	
Average		673.52	——	0.176

The study on the ore mechanics properties results shown that: In the mineral table of hardness, it has a rating of 6.73 that means that pertains to low hard ores; the poisson's ratio is 0.176 which means that belongs to brittle ores; The accurate size ball should be used rather than big size ball due to mainly fines mineral are produced in the process of comminution [1-2].

3. The size composition in grinding and classification

The final sizes of crushing ore is 0 ~ 12mm according to the requirements of production technology, the sample should not be less than 144kg on the basis of sampling rules, actually, the screen analysis is 256kg, The sample is representative in weight. Analyzed the size characteristic about new feeds, discharges, overflow and underflow of hydrocyclone concentrates shown in table 2:

Table 2. The size composition characteristic for φ4.0 × 6.0 m overflow ball mill

Particle size (mm)	The yield of feed (%)	The yield of discharge (%)		The yield of overflow (%)		The yield of underflow (%)	
		Single open	Double open	Single open	Double open	Single open	Double open
+12	12.26	0.31	0.89	——	——	0.77	1.26
12～8	13.47	1.19	1.95	——	——	1.93	2.01
8～5	23.73	3.85	3.34	——	——	4.53	3.22
5～2.5	5.78	1.83	2.05	——	——	1.71	1.27
2.5～0.9	13.82	4.63	3.81	——	——	5.41	3.50
0.9～0.45	7.10	11.77	11.83	0.04	0.11	10.21	10.00
0.45～0.30	4.68	14.29	16.06	1.35	3.9	18.05	19.50
0.30～0.15	2.46	19.96	19.34	1.65	3.7	17.55	18.89
0.15～0.10	2.15	4.31	3.85	12.89	14.95	11.70	9.57
0.10～0.074	2.19	14.10	12.38	9.29	9.17	12.03	12.47
0.074～0.043	1.09	5.34	4.80	6.69	5.96	4.69	4.87
0.043～0.037	3.75	8.80	8.90	25.47	22.4	7.45	7.53
0.037～0.019	1.68	2.10	2.40	10.89	7.46	0.94	1.29
0.019～0.010	1.09	1.73	1.85	6.95	5.85	0.66	0.78
-0.010	4.75	5.78	6.53	24.78	26.50	2.37	3.83
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 2 results indicated that: (1) The maximum particle diameter is 14.33 of new feed by the 95% of the sieving particle size and the yield of less than 200 mesh is 11.27%, it said that pertains to brittle ores, the accurate size ball should be used rather than big size ball due to mainly fines mineral are produced in the process of comminution and the intermediate particles should be strengthened in grinding because the yield of Intermediate granularity between 8 to 0.45 mm reach up to 50.34%. (2) Needed to grind coarse particles(>0.2mm) contents are 83.03% for new feed based on the requirements of grinding process, Decreased 25.47 percent after grinding and the grind efficiency ($E_{+0.2}$) is 30.58% and it's lower when the φ4.0 × 6.0m overflow ball mill working alone, In the same way, the grind efficiency ($E_{+0.2}$) is 28.82% when two mills working together, thus it can be seen grinding efficiency is low which single open or double open. (3) The coarse particles (>5mm) content is only between 6% to 7% and the fine particles (<0.2mm) content up to 40% in underflow whatever single open or double open, its said that raise the classification efficiency and will

be the direction that we work hard to study from now on. (4) In both single open and double open, the particles size is not satisfied for grinding products , fine-grained (<400 mesh) content is about 40% and less than 10um content accounts for a quarter of products, which has unfavorable influence on consequent processing. The size composition unreasonable caused by the ball diameter is too large in the first, of course, it also related with screening efficiency. So we should not only improve grinding, also improve the screening efficiency [3-6].

4. Study on the Ratio of primeval ball loading

Used the particle sizes ratio of 1:1 with mill new feeds and underflows as full feed, the accurate ball diameter has calculated for new feed size which respectively are 15mm，12mm，10mm，8mm and 5mm according to the ore average mechanical intensity what is 673.52 kg/cm^2, the working conditions of φ4.0 × 6.0m overflow ball mill and Duan's semi-theory formula. Then Determined the ratio of each balls by the principle of roughly equivalent with the each particles group contents (shown in Table 3). Finally got a Ratio of primeval ball loading as follows: Recommended scheme 1: φ70: φ60: φ50: φ40 = 15: 15: 30: 40 and average ball diameter is 50.5mm; For convenience the recommendatory scheme 2 is φ70: φ60:φ50: φ40 = 25: 25: 25: 25 and average ball diameter is 55.5mm; selected two schemes that larger than recommended scheme for average ball diameter in order to be plenty comparative selection, there are large scheme 3 and 4 respectively, large scheme 3 is Φ80: φ70: φ60: φ40 = 15: 15: 30: 40 and average ball diameter is 56.5mm, large scheme 4 is Φ80: φ70: φ60: φ40 =20: 20: 20: 40 and average ball diameter is 58mm; The scheme 5 used plant what is φ100: φ80: φ60 =20: 40: 40 and average ball diameter is 76mm, to compare with plant scheme, selected a larger scheme what is φ100: φ80: φ60 = 60: 30: 10 and average ball diameter is 90mm [7-8].

Table 3. Calculated at accurate ball diameter according to Duan's semi-theory formula

d_f（mm）	15	12	10	8	5
Calculated diameter（mm）	74.6	66.9	59.2	43.8	35
Determined diameter（mm）	80	70	60	40	30

Loaded 100kg balls and 12kg specimens in the D×L is 450×450 mm discontinuous mill, each grinding time was determined 18 minutes through exploring test to ensure the yield of -200mesh between 60% to 65% (Recovery can reach 95%). Test to primeval ball loading about recommendatory, large, plant and larger scheme in the same grinding conditions. In order to compare, using the following seven indexes to evaluate the results of grinding which are coarsest particles percentage content between 0.9mm to 5mm, unqualified size percentage content between 0.2mm to 0.9mm, the yield of fine particles of less than 200 mesh, the percentage content of selectable size between 0.15 to 0.019mm, the yield of over-grinds (<0.01mm) , the utilization coefficient of -200mesh (t/m^{3}h) that express the productivity and these schemes with a multiple of plant scheme . The results are shown in table 4 and 5:

Table 4. Compared the grinding effect about all kinds of schemes when the φ4.0 × 6.0m overflow ball mill working itself alone

Scheme number	1	2	3	4	5	6
Coarsest particles content (0.9~ 5mm, %)	0.12	0.01	0.00	0.10	0.20	0.02
Unqualified size content (0.2~0.9mm, %)	17.36	12.19	1.64	4.73	8.21	4.77
Content of selectable size (0.019~ 0.15mm, %)	48.3	44.78	64.19	52.21	59.21	49.58
The yield of fine particles (< 200 mesh, %)	49.91	54.56	65.82	61.12	61.15	60.95

The yield of over-grinds (<0.01mm,%)	18.07	19.20	21.46	20.66	20.59	20.75
Utilization coefficient of -200mesh (t/m3 h)	0.125	0.140	0.176	0.161	0.161	0.161
With a multiple of plant scheme	0.893	1.000	1.257	1.150	1.150	1.150
Comprehensive evaluation result	Worst	Worse	Best	Better	Average	Average

Table 5. Compared the grinding effect about all kinds of schemes when two mills working together

Scheme number	1	2	3	4	5	6
Coarsest particles content (0.9~ 5mm, %)	0.09	0.00	0.00	0.03	0.11	0.02
Unqualified size content (0.2~0.9mm, %)	18.85	18.19	3.26	5.01	9.06	4.64
Content of selectable size (0.019~ 0.15mm, %)	44.46	52.5	53.55	50.13	59.22	61.21
The yield of fine particles (< 200 mesh, %)	56.05	57.78	65.79	62.96	61.11	61.14
The yield of over-grinds (<0.01mm,%)	19.51	19.86	21.73	21.81	20.53	20.63
Utilization coefficient of -200mesh (t/m3 h)	0.145	0.1503	0.176	0.176	0.161	0.16
With a multiple of plant scheme	0.960	1.000	1.171	1.111	1.071	1.071
Comprehensive evaluation result	Worst	Worse	Best	Better	Average	Average

The comparative results of table 4 and 5 shown that: (1)The diameter of ball so too larger that grinding area is small and lack of impact times which lead to coarse particles is too much, the higher unqualified size content, the yield of fine particles and less than 200mesh is low in grinding productions for larger scheme and plant scheme, so them continue to not use in grinding process. (2) Recommended scheme is highly targeted, high fine proportion, -200mesh content and Productivity, the first scheme is best especially, the separate sizes contents is 64.19% between 0.15~0.019mm which increasing by 19.14% compare with 44.78% and the mill -200mesh utilization coefficient increasing 12.6 percents compare with 0.14 about original program when φ4.0 × 6.0m overflow ball mill working itself alone, in addition, the mill -200mesh utilization coefficient increasing 11.71 percents compare with 0.1503 about original program when φ4.0 × 6.0m overflow ball mill and φ3.6 × 6.0m grate ball mill working together. (3) The large scheme is smaller than larger or plant scheme and bigger than recommended scheme, therefore, the grinding effect in between and can be counted as "average". After the comprehensive comparison of the conclusion: there is a good grinding effect for φ4.0 × 6.0m overflow ball mill what ever φ4.0 × 6.0m overflow ball mill work itself alone or there are working together and the first scheme is ensured primeval ball loading what is: φ70: φ60: φ50: φ40 = 15: 15: 30: 40.

5. Conclusions

In the mineral table of hardness, it has a rating of 6.73, which means that pertains to low hard ores; the poisson's ratio is 0.176, which means that belongs to brittle ores, the accurate size ball should be used rather than big size ball due to mainly fines mineral are produced in the process of comminution.

The maximum particle diameter is 14.33 of new feed by the 95% of the sieving particle size, the yield of less than 200 mesh is 11.27% and the yield of Intermediate granularity between 8 to 0.45 mm reach up to 50.34%, these said that the intermediate particles should be strengthened in grinding, grinding efficiency is low whatever 4.0 × 6.0m overflow ball mill working itself alone or there are working together and raise the classification efficiency and will be the direction that we work hard to study from now on.

The optimum scheme of primeval ball loading is that: φ70: φ60: φ50: φ40 = 15: 15: 30: 40 for φ4.0 × 6.0m overflow ball mill and there is a good grind effect whatever φ4.0 × 6.0m overflow ball mill work itself alone or they are working together. The separate sizes contents is 64.19% between 0.15~0.019mm which increasing

by 19.14% compare with 44.78% and the mill -200mesh utilization coefficient increasing 12.6 percents compare with 0.14 about original program when φ4.0 × 6.0m overflow ball mill working itself alone, in addition, the mill -200mesh utilization coefficient increasing 11.71 percents compare with 0.1503 about original scheme when they are working together.

Acknowledgements

This work was financially supported by Yunnan Province Application Basis Foundation (2013FZ022), The authors would like to thank Professor Xixiang Duan for the opportunity to express his prejudices on the subject.

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