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The Effect of Fine Grinding Medium Feature on Grinding Results

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Abstract

This article introduced an accurate to ascertain the size of fine grinding medium. Comparative grinding tests are done by using cast iron segment steel ball. Grinding test results showed that mill capacity and grinding efficiency of cast iron segment could be really superior to steel ball. Grinding and flotation indexes have gotten obvious improvement when applying optimized fine grinding medium for industrial experiment.

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Keywords: Fine grinding; grinding medium; cast iron segment; grain size characteristic

1. Introduction

As the world has industrialized, the demands for mineral resources are increasing. As far as our country, billions of tons mineral was grinded by using grinding equipment. Grinding production indexes improvement can make grinding's follow-up homework indexes optimized, such as increasing further valuable mineral liberation degree and reducing valuable mineral over grinding thereby improving concentrate grade, recovery rate of valuable mineral can be increased and metal loss is reduced, etc[1-4]. However, along with the deepening of the exploitation of mineral resource, coarse dissemination size and high grade free milling ore less and less. In order to meet the need of production, people had to mine the refractory low-grade ores which the component is complex and fine-grained dissemination. -200 mesh must up to 80% when these low grade,

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fine, impure and refractory minerals was grinding. So most of the concentrators need to have fine grinding process.

2. The precision of fine grinding medium size and stage matching on fine grinding

In fine grinding, steel ball size is very important. If steel ball over size, crushing force becomes strong, this will lead to penetrability crushing and make ore over crush. If steel ball under size, hitting force becomes lighter, this will make ore less fine. Fine grinding medium is determined exactly, the aim is to form accurate crushing force to grind ore and improve fine grinding efficiency. However, most concentrators generally there is the problem of fine grinding medium over sized. This problem has become more and more serious[5-8].

2.1 The optimal ball size is determined through tests

Comparative experiments are one of the most effective, reliable and directive methods to determine the optimal ball size. In the lab, under the same grinding condition doing experiment with different grinding medium. By comparing the effect of grinding and determine the best grinding medium size. In the case of Haikou phosphate rock (PR) concentrator in Yunnan province and optimize it with optimal grinding medium size. The grinding medium size was φ60mm in the secondary stage fine grinding before tuning it. This is obviously larger. So far, Duan's half-theory formula is the most accurate method for calculating the diameter of the steel ball[9-10].

$$D_b = k_c \frac{0.5224}{\psi^2 - \psi^6} \cdot \sqrt[3]{\frac{\sigma_{\text{press}}}{10 \cdot \rho_e \cdot D_o}} . d_f \qquad (1)$$

According to the ball mill's working conditions on the job. The size of the ball diameter is calculated. The result was shown in table 1 and size composition of the grinding product by using different sizes of ball diameter is shown in table 2.

Table 1. The needed for the size of steel ball

Th size of the feed （mm）	5.0	1.0	0.3	0.15
The size of ball diameter by calculating （mm）	40	30	25	20

Table 2 .The size composition of grinding product by using different sizes of ball diameter

Ball diameter（mm）		φ60	φ40	φ30	φ25	φ20
Size fraction	+0.3mm coarse fraction	0.05	0.09	0.35	2.08	4.00
	+0.1mm unfine fraction (%)	16.98	7.49	20.27	33.06	36.06
	-0.1mm fine fraction (%)	83.02	92.51	79.73	66.94	63.94
	-200 mesh fraction (%)	72.94	82.76	65.25	56.66	54.01
	-0.028mm over grinded (%)	20.45	18.53	14.05	12.02	13.81
	-0.010mm over crushed (%)	7.09	5.89	4.35	3.34	2.69
The best ball diameter			Best			

The result of table 2 shows that with the diameter decreasing, the contents of -500 mesh(over grinded) and -0.01mm(over crushed) decreased, but the content of the coarse particle and the unfine grinding particle

increased gradually. The optimal ball size isφ40mm, because the yield of -200 mesh and -0.1mm is the highest and the content of the coarse fraction is the lowest. The result is in accordance with the results of the theoretical calculations. φ60 mm was used in the former manufacturing process is obviously oversize.

2.2 The research on determine ball diameter ratio

In the secondary stage fine grinding process, the optimal ball size is 40mm, but different size is better than single size. So we researched the best ball diameter ratio in the end. According to the size composition, we can determine the best ball diameter ratio. The calculated data of the ball diameter in the initial stage was shown in table 3.

Table 3. The calculated data of the ball diameter in the initial stage

Fraction (mm)	Yield (%)	The yield of the waited grind (%)	The suitable ball diameter(mm)	Ball ratio(%)
5.0~1.0	7.13	①10.84	40	15
1.0~0.3	17.32	②26.34	30	25
0.3~0.15	29.21	③44.43	25	40
0.15~0.10	12.09	④18.39	20	20
-0.10	34.25	——	——	——
Total	100.00	——	——	100.00

According to the table 3, the best ball diameter ratio is φ40:φ30φ25:φ20=15:25:40:20

3. The applied research of the cast iron segment as the fine grinding medium

According to the ball ratio φ60:φ50:φ40:φ30=40:30:20:10, the average ball diameter is 50mm, the total weight is 14kg. And let cast iron segment into a model group, because two new size were added, the large size phenomenon markedly reduce. The size of 35×40, 30×35, 25×30, 20×25 take up one fourth of the cast iron segment group. The two mix groups were grinded in the same test condition in practice. The grinding result was shown in table 4.

Table 4. The grind result of the two group grinding medium

Medium / group / Size fraction	Mixed steel ball group			Mixed cast iron segment group		
Fraction(mm)	γ (%)	$\sum\gamma_{up}$ (%)	$\sum\gamma_{down}$ (%)	γ (%)	$\sum\gamma_{up}$(%)	$\sum\gamma_{down}$ (%)
+0.3	0.05	0.05	100.00	0.05	0.05	100.00
0.3~0.2	0.04	0.09	99.95	0.07	0.12	99.95
0.2~0.15	0.28	0.37	99.91	0.59	0.71	99.88
0.15~0.10	6.91	7.28	99.63	4.68	5.39	99.29
0.10~0.074	14.93	22.21	92.72	9.73	15.12	94.61
0.074~0.038	31.39	53.60	77.79	40.68	85.80	84.88

0.038~0.028	26.45	80.05	46.40	21.48	77.28	44.20
0.028~0.019	10.57	90.62	19.95	13.79	91.07	22.82
0.019~0.010	4.45	95.07	9.38	4.07	95.14	9.93
-0.010	4.93	100.00	4.93	4.86	100.00	4.86
Total	100.00	-	-	100.00	-	-

As was shown in table 4: Because the grinding area of cast iron segment is bigger than the steel ball, the grind result of the mixed cast iron segment is better than the mixed steel ball group. The product fraction constitute of the cast iron segment is better than the steel ball, not only the yield of the unfine is reduce, but also the yield of the over grinding is reduce, moreover the easy selection fraction (0.074mm~0.038mm) is 9 points bigger than the steel ball group. The fineness(-200mesh) of the cast iron segment is bigger than the stell ball group.

4. The effect of fineness medium optimize on flotation indexes

The results of fineness medium optimize are used to do industrial test and the flotation indexes in the concentrator are by statistical in a year. The flotation indexes are shown in table 5. The contrast of the flotation indexes between the before industrial test and the after industrial test are shown in table 6.

Table 5. The flotation indexes of the concentrator

Items / Month	Grade of P_2O_5 raw ore (%)	Grade of P_2O_5 concentrate(%)	Grade of P_2O_5 tailings(%)	Yield of P_2O_5 concentrate(%)	Recovery(%)
2012. 3	21.45	28.5	8.96	63.92	84.93
2012. 4	21.63	28.5	9.16	64.48	84.96
2012. 5	20.86	28.48	9.63	59.58	81.34
2012. 6	21.02	28.53	9.45	60.64	82.30
2012. 7	21.08	27.66	9.67	63.42	83.22
2012. 8	20.91	27.73	9.56	62.47	82.84
2012. 9	21.88	27.8	8.96	68.58	87.13
2012. 10	21.89	28.22	8.52	67.87	87.49
2012. 11	23.28	28.12	9.08	74.58	90.09
2012. 12	23.83	27.9	8.56	78.96	92.44
2013. 1	21.34	28.49	8.31	64.57	86.2
2013. 2	22.36	27.91	8.66	71.17	88.83

Table 6 The contrast of the flotation indexes

Month	Grade of P_2O_5 raw ore (%)	Grade of P_2O_5 concentrate(%)	Grade of P_2O_5 tailings(%)	Yield of P_2O_5 concentrate(%)	Recovery (%)
2012.7~2012.10	21.44	27.85	9.18	65.58	85.17

2013.1~2013.2	21.85	28.20	8.49	67.87	87.52
Difference	+0.41	+0.35	-0.69	+2.29	+2.39

After the industrial test, the yield of P_2O_5 concentrate growing by 2.29 percent more than before the industrial test, the recovery of P_2O_5 concentrate growing by 2.39 percent. The improvement of the yield and the recovery of the P_2O_5 concentrate depend largely on the improvement of the grinding product size composition characteristic and the enhance of the mineral liberation degree after optimize the fineness grinding medium. The application of the selective grinding new process improve the grinding process and the flotation index process overall[11].

5. Conclusions

Fine grinding is a inefficiency and high consumption process. The fine grinding directly affects the quality and efficiency of mineral separation. How to choose fine grinding medium scientifically is the best way to solve the problem.

Fine grinding has a narrow feed particle size range, the ball radio is the subproblem, determining the steel ball size more accurately is the first question. As studies have proven that Duan's half-theory formula is the best formula to determine the size of steel ball accurately.

Steel ball is the traditional fine grinding medium. But it is not the best fine grinding medium. Frist, its grinding area is small and has big hitting power. On geometrical shape analyzes the cast iron segment has a big grinding area and a good turn function, the effect of fine grinding is superior to the steel ball. The fine grinding process mainly on grinding and support by a slight shock, so grinding medium is made of cast iron material which has wear-resisting and low cost, it can avoid weaknesses.

The cast iron segment can increase grinding efficiency and mineral single separation degree, cast iron segment group is better than the stell ball group on the process of fine grinding. So as for the size, material, shape aspect, choosing the fine grinding medium scientifically is the basic solution to solve the poor efficiency and high consumption problems, it is also the most scientific way to improve the flotation indexes.

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