COST REDUCTION OF CEMENTING FILL IN KANGJIAWAN MINE①

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ABSTRACT On the basis of analysis of tailings cementing fill cost, the ways to reduce the fill cost in Kangjiawan Mine were discussed such as the addition of slag, the adoption of cementing rockfill and the prolongation of continuous filling time. If the measurements suggested are adopted, the fill cost can be greatly reduced and better economic benefit can be achieved.

Key words fill cost cement consumption continuous filling time cementing rockfill

1 INTRODUCTION

Kangjiawan Mine is a large deposit in Hengyang, Hunan Province, which adopts cementing fill method with artificial bottom pillar to extract its lead, zinc and gold ores under several water-bearing layers. The cement-tailings ratios of fill were 1∶5 (accounts for 40.5%), 1∶10 (39.8%) and 1∶15 (19.7%) respectively. The fill cost reached 51.33 RMB Yuan/m^3 (or 16.37 RMB Yuan/t) on the average, which was almost a half of ore direct cost and varied obviously with different cement-tailings ratios. It is necessary, therefore, to find the ways to reduce the high fill cost. Based on the analysis of fill cost composition with 1∶5 cement-tailings ratio, the ways to reduce fill cost are discussed in the paper.

2 THE BRIEF INTRODUCTION OF CURRENT FILL

According to the designed annual output of 300 000 t, there will be a 100 000 m^3 worked-out space to be filled. Current filling system was designed and constructed for its first stage production of 100 000 t per year. Its filling capacity, therefore, is only 31 800 m^3 per year.

2.1 Filling materials

The aggregate is the naturally classified crude tailings in the old tailing pond. Their average grain size is 0.134 mm and only 5.83% particles are less than 0.03 mm in diameter. The dry tailings are extracted and conveyed to tailing bin by shovel and trucks. Cement No. 425 acts as the cementing material[1].

2.2 Filling system

The filling system is arranged as shown in Fig. 1. Tailings in horizontal tailings bin (200 m^3 in volume) are conveyed to stirring tank by scraper and G×d400 mm stirring screw conveyor, where they are mixed with cement from cement bin and water. The slurry finished flows to the stope to be filled through a d76 mm pipe.

3 COST COMPOSITION OF 1∶5 CEMENTING FILL

The fill cost of 1∶5 cement-tailings ratio in Kangjiawan Mine comes to 60.49 RMB Yuan/

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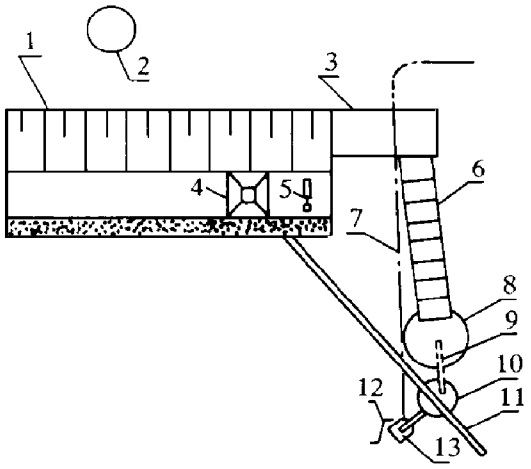

Fig. 1 The arrangement of fill system

1—tailing bin; 2—water sump; 3—cement house; 4—hopper; 5—14 kW scraper; 6—cement corridor; 7—pipe; 8—cement bin; 9—feeding governor and G × d200 mm stirring screw conveyor; 10—stirring tank; 11—G × d400 mm stirring screw conveyor; 12—entrance of incline; 13—gathering hopper

m^3 (as shown in Table 1), of which, the sum ofcement (66.31%), tailings transport (13.16%) and fillers' salary (12.56%) is up to 92.03%. In general, tailings transport cost is basically fixed, then the key to reduce fill cost is to lower cement consumption and salary expenditure.

Table 1 Fill cost composition of 1∶5 cement-sand ratio (censured in 1993)

Item	Cost /Yuan·m^{-3}	Proportion /%
Cement*	40.11	66.3
Extract	1.04	1.72
Transport**	7.96	13.16
Wood	0.34	0.56
Steel	1.56	2.58
Other materials	0.413	0.68
Salary	7.6	12.56
Power	0.463	0.77
Depreciation*** charge	0.3578	0.59
Others	0.5162	0.86
Total	60.49	100.00

Note: * self product, 177 RMB Yuan/t;
** convey cost 0.35RMB Yuan/(t·km);
*** depreciation rate: 8.8%.

4 THE WAYS TO REDUCE FILL COST

4.1 Cement consumption

Because large amount of cement used as bonding material leads to high fill cost, the reduction of cement consumption should be firstly considered. There are three ways to reduce cement amount, i.e. using additive agent, replacement materials and cemented rockfill.

(1) Additive agent

The accelerator could increase largely the particle size, reduce cement-water factor when cement hydrates and keep cement and fine particles from loss. Hydraulic binder may reduce water amount, and improve slurry's flowability. The adequate addition of both accelerator and hydraulic binder will raise compressive resistance of fill and reduce cement consumption. Otherwise, negative effects would be resulted from inadequate addition. Because it is difficult to control the adding amount in fill so that additive agent is seldom suggested.

(2) Replacement material

The practical replacement materials of cement are the furnace slag and the fly ash. Several metallurgical plants near the mine can supply enough slag with overall cost of 21.26 RMB Yuan/t. Slag has high content of SiO_2 and Al_2O_3, and the SiO_2-Al_2O_3 ratio is about 3∶2, almost the same as that of cement. The following cement-sand fill test has proved that the slag is a suitable replacement material of cement.

In test, raw slag from the plants (gradation composition is listed in Table 2) was used so that the cementing property of unmilled slag could be examined. The experimental results are summarized in Table 3. When 12% slag is added to cement-sand filling of 1∶6 cement-sand ratio, the strength is 61% higher than that of the fill without slag, being equivalent to that of 1∶5 filling.

Table 2 Gradation composition of slag

Grade range /mm	20~10	10~5	5~2
Content /%	5.3	31.8	27.8
Grade range /mm	2~0.5	0.5~0.25	<0.25
Content /%	16.2	5.6	13.3

That is to say, if 12% slag added, cement-sand ratio could be reduced from 1∶5 to 1∶6. Cement

content in 1∶ 5 and 1∶ 6 cement-sand fillings is 226. 7 kg/ m^3 and 194. 30 kg/ m^3 respectively. In that case, cement consumption is 32. 4 kg/ m^3 lower. Even though 163. 2 kg slag were added, fill cost still could be reduced by 2. 26 RMB Yuan/ m^3 (3. 7% lower). Thinking of the 40 500 m^3 fillings needed, 91 500 RMB Yuan could be saved. If slag were milled to the matching grade for cement, cement consumption could be reduced by 30% ~ 40%. Even though the milling expenditure were considered, the fill cost would be reduced by 8. 47 RMB Yuan/ m^3.

Table 3 Experimental results of slag

No	Cement-sand ratio	Slag content/ %	Compressive resistance/ MPa
1	1∶ 5	0	1. 56
2	1∶ 6	0	1. 00
3	1∶ 6	8	1. 40
4	1∶ 6	12	1. 61
5	1∶ 6	16	1. 12

(3) Cementing rockfill

What is called cementing rockfill is that certain amount of rock fragments are added to cement-sand grout so that the strength of fill may be raised and cement consumption reduced. In some mines in Kazkhstan, the fill cost was reduced by 30. 3% ~ 54. 8% when waste rock is used as filling aggregate. In Kangjiawan Mine, if cemented rockfill were adopted (cement∶ tailings: fragment= 1∶ 3∶ 6), cement content could be 60% lower (from 226. 70 kg/ m^3 to 136. 0 kg/ m^3) and the strength of fill would be as high as 6. 6 MPa (pure tailings cementing fill is only 4. 57 MPa), and at the same time, waste rock needn't be hoisted to surface ground.

4. 2 Enlarging the capacity of tailings bin

The designed capacity of the filling system is 31 800 m^3/ a, but the practical fillings needed may reach 23. 64 m^3/ h, depleting 47. 3 m^3 tailings. The daily filling time would be only 6 h even though tailings were continually added to the small tailings bin while filling, which seriously affects filling efficiency. If the of the fillings bin can enlarge expanded to 400 m^3, the continuous fill time would be 10 h/ d and 89. 5 d/ a could be saved. The prolongation of continuous fill time can not only reduce salary of fillers by 1. 79 RMB Yuan/ m^3 but also cut auxiliary operation cost.

5 CONCLUSIONS

Through the use of cementing tailings fill technology, the difficulty of mining under water-bearing strata is solved, but mining cost becomes higher. Cementing fill cost would be expected to reduce greatly by following recommended measures:

(1) Adding 12% slag, if possible, milling it to fine grade.

(2) Pouring waste rock to tailed cement grout.

(3) Enlarge the capacity of tailings bin (at least to 400m^3) and related facilities in order to prolong continuous fill time.

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