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Goseong Mine Copper Concentration Test Report

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Contents:

Location
Goseong Mine, Goseong-Gun, Kyeongsangnam-Do

A. Gravity Separation

1. Test Purpose

This test is aimed to verify whether a high-grade Copper Concentrate could be satisfactorily produced by conventional gravity separation equipment, such as a Jig and Table, with a good recovery. According to the client's request, the samples were crushed into the size range of 3/4~1 inch and then obtained 7% Cu as a lump ore.

2. Sample Properties

The requested samples are ore rocks which mainly contain Chalcopyrite and Pyrite as well as a little Enargite and Azurite. Chalcopyrite exists dominantly >0.6mm (about 28 mesh) and generally contains fine-grained Pyrite inclusions. Gangue minerals are mainly Quartz and a little Calcite.

The grade of the raw materials in Table 1 is as follows. Its grade is 1.72% Cu and the average specific gravity is 3.07g/cc. For this test, the hand-picked tailings feed sample is 1.36% Cu.

3. Test Method and Results

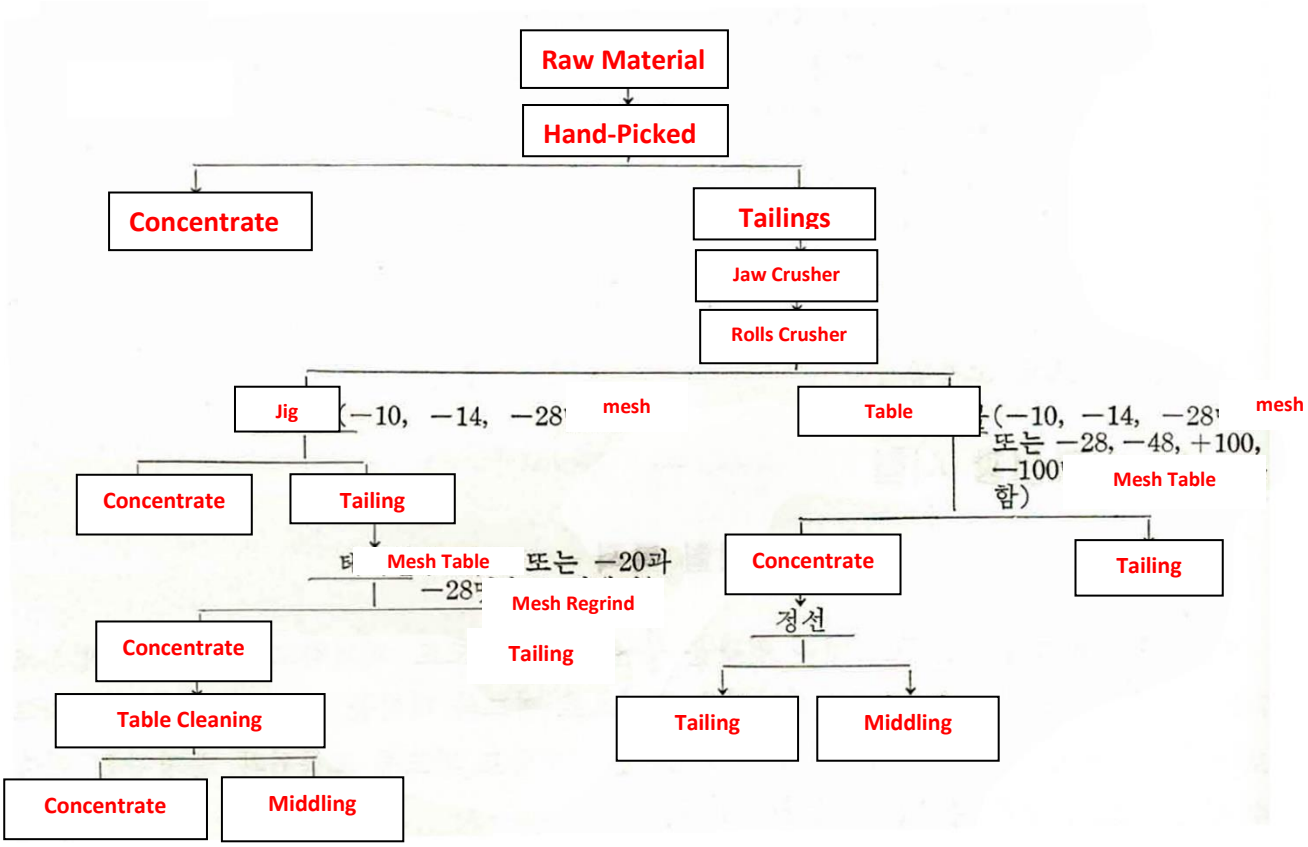
The hand-picked, from the raw materials of >3/4~1 inch test is as follows:

Table 1. Hand-Picked Test Result

Products	Weight Kg	Weight %	Assay						Recovery %	
			Cu %	Pb %	Zn %	Fe %	S %	Au g/t	Ag	Cu
Hand-picked Concentrate	30.8	5.99	7.34			21.90	14.00	1.00	82.6	25.6
Hand-picked Tailings	483.2	94.01	1.36			8.45	3.90	0.50	59.5	74.4
Total	514.0	100.0	1.72			9.26	4.51	0.53	60.9	100.0

Gravity separation was first carried out on the Hand-picked Tailings. It examined the effectiveness in the use of a Jig Table.

The Test Flow Sheet in Figure 2, is as follows:



From fractographical results, the dominant size of copper minerals is 0.6mm, >28 mesh. Therefore, it was re-ground to -10 mesh or 14 mesh by a Rod mill, so that it could reduce grinding expenses and increase recovery.

(a) Test Used Combined Jig and Table

The process result of Copper Concentrate collected using a Denver Mineral Jig and then the Jig Tailing being treated with a Wifly Table, followed by One Cycle of Cleaning is compared with the process result of a Concentrate being collected using a Jig and then being re-ground and then being treated by Table, is as follows:

Table 3. Test Result Using Combined Jig and Table (1)

Product	Weight %	Grade		Recovery %		Notes
		Cu	%	Cu		
Jig Concentrate	5.30	9.30	8.50	43.5	61.4	1. After the -10 mesh was treated by Jig, it was Cleaned by Jig once more. 2. After Jig Tailing was re-ground to -20 mesh, it was treated by Table and then Cleaned once. 3. Slime was removed before separated by Jig and Table.
Table Concentrate	2.90	7.00		17.9		
Table Middlings	7.60		1.50		10.0	
Table Tailings	66.20		0.18		10.5	
Slimes	18.00		1.14		18.1	
Totals	**100.00**		**1.14**		**100.0**	

Table 4. Test Result Using Combined Jig and Table (2)

Product	Weight %	Grade		Recovery %		Notes
		Cu	%	Cu		
Jig Concentrate	9.90		6.90		51.4	1. The -14 mesh was treated by Jig and then No Cleaning. 2. The Jig Tailing was treated by Jig and then one Cycle of Cleaning
Table Concentrate	2.60		7.60		14.8	
Table Middlings	8.70		1.90		12.8	
Table Tailings	66.90		0.29		14.8	
Slimes	11.90		0.70		62.0	
Totals	**100.00**		**13.10**		**100.0**	

Table 5. Test Result Using Combined Jig and Table (3)

Product	Weight %	Grade		Recovery %		Notes
		Cu	%	Cu		
Jig Concentrate	3.99		10.10	30.7	64.6	1. The -28 mesh was treated by Jig. 2. The Jig Tailing was treated by Jig and then one Cleaning Cycle. 3. Before separation by Jig, the -400 mesh Slimes were removed.
Table Concentrate	3.80		11.80	33.9		
Table Middlings	8.98		1.20		7.9	
Table Tailings	51.80		0.24		9.5	
Slimes	31.40		0.70		18.0	
Totals	**100.00**		**1.31**		**100.0**	

(b) Test of Using Table Only

The Test Results of which the sample was ground to -14 mesh and -28 mesh, then Slimes (<400 mesh) was removed, and then treated by Wifly Table and then one Cleaning Cycle are Table 6 and 7, as follows:

Table 6. Test Result of Using Only Table (1)

Product	Weight %	Grade %	Recovery %	Notes
Concentrate	5.6	6.30	25.8	Ground to -14 mesh.
Middlings	36.6	1.70	44.1	
Tailings	45.8	0.75	23.8	
Slimes	12.0	0.70	6.0	
Total	100.0	1.38	100.0	

Table 7. Test Result of Using Only Table (2)

Product	Weight %	Grade %	Recovery %	Notes
Concentrate	7.2	8.60	47.1	Ground to -28 mesh.
Middlings	10.4	2.90	23.4	
Tailings	55.6	0.30	14.0	
Slimes	26.8	0.80	15.5	
Total	100.0	1.31	100.0	

The feed was separated into -28 +48 mesh, -48 +100 mesh and -100 mesh size fractions. After -400 mesh Slimes were removed in advance, their respective results treated by Wifley Table are as in Table 8.

Table 8. Test Result of Using Only Table after Separating Feed Size Fractions

Product	Weight %	Grade %	Recovery %	Note
-28+48 mesh Concentrate	3.8	11.2	30.6	1. Ground to -28 mesh. 2. Total Concentrate grade is 11.2% Cu and its Recovery 63.9%.
-28+48 mesh Middling	11.0	0.79	6.2	
-28+48 mesh Tailing	31.4	0.18	6.3	
-48+100 mesh Concentrate	2.0	11.20	15.9	
-48+100 mesh Middling	1.3	3.70	3.3	
-48+100 mesh Tailing	16.6	0.19	2.3	
-100 mesh Concentrate	2.1	11.40	17.4	
-100 mesh Middling	1.6	2.40	2.8	
-100 mesh Tailing	13.3	0.70	7.8	
Slimes	14.9	0.70	7.4	
Total	100.0	1.39	100.0	

4. Discussion

Gravity separation using Combined Jig and Table for the hand-picked Tailings resulted in poor grade and recovery of a Copper concentrate. The reasons for this could be as follows:

(a) Reasons why the recovery is not high are;

(1) The raw ore materials were hand-picked, but only produced about 25% Concentrate from the total copper contained. This may be caused by the very-low grade 1.36% Cu of the hand-picked Tailing.

(2) It has produced excessive Slime which contains 15% of copper in -400 mesh Slime. Finally, it has lost much as Slime.

(b) Reasons why the grade is not high are;

(1) Copper minerals (mainly Chalcopyrite) could not be clearly separated because the specific gravities of contained Pyrite and Enargite minerals are much higher.

(2) Chalcopyrite, which is the important economic mineral, usually contains pyrite within it, therefore, it is not easy to separate unless finely ground.

(c) The Feed size for the Jig was about -10 to -14 mesh but this size had poor recovery. Therefore, it is recommended finer grinding of the Feed to -20 mesh.

(d) Comparison of the test results using Combined Jig and Table with the test results of using only Table, the grade of Copper concentrate is 10-11% and the recovery 64%. The difference is not significant. For Table Separation, it is recommended that the Feed should be screened into the various size fractions.

Results may have been better if the Tailings had been treated one more time at Table 5, using Combined Jig and Table. In addition, if the Feed at Table 8 had been treated separately, the grade and the recovery would likely be higher than that of using only Table.

Owing to having only about 8% of Jig concentrate from the raw materials, the quantity of Jig Tailing which will be treated by Table could not be reduced below that of Feed using only Table. It will cause negative effects that could result in increased process complications. It will be fine to use a Combined Jig and Table operation in order to ensure Separation because of the economical operating costs of a Jig.

5. Conclusions

(A) After being ground to -20 mesh, a 10-11% Copper Concentrate grade can be produced by either gravity separation of Jig and Table or using Table only. The recovery rate is 64%.

(B) To ensure adequate Separation, a Combined Jig and Table will be better than using Table only.

B. Flotation Test.

1. Test Purpose

This test is required because the previous gravity separation test reported on September 30, 1963, which was conducted to determine if an economical mill plant could be established for Goseong Mine, resulted in a recovery of only 64%.

Therefore, this Flotation Test used about 4 tons of new sample, with the following objectives:

- Firstly, to verify the applicability of the Flotation method,
- Secondly, to evaluate the economic advantages and disadvantages between Gravity Separation and Flotation,
- Thirdly, to acquire data for the design of a new Mill plant or the potential use of a Mobile mill plant.

2. Sample Properties

The sample Properties accepted for Flotation Test and Pilot Plant use are similar with that of Gravity Separation use. The main minerals are Chalcopyrite and Pyrite and minor accessory Enargite and Azurite. The gangue minerals are Quartz and Calcite.

Table 1. Analysis Result of Raw Material.

Cu %	Fe %	S %	Pb %	Zn %	Au g/t	Ag g/t
1.25	**8.35**	**3.47**	**0.06**			

3. Test Method and Results

Iron Sulfide accompanying the Copper Concentrate can be used for manufacturing of Sulfuric Acid. Therefore, at the client's request, it was attempted to make a Synthetic Concentrate that could Recover a higher grade of Iron Sulfide in spite of loss of some copper grade. This Synthetic Flotation places emphasis on decision of grinding size so that it could be satisfied with recovery of Copper grade. In case of copper grade's improving, in order to examine effectiveness of Separation, the method of floating test for only Copper was also fulfilled under the conditions of suppressing Iron Sulfide at the level of excellent grinding for Synthetic Flotation.

The Test methods and Results are as follow;

(a) Case of Synthetic Flotation

1kg raw materials was ground into -36, -48 and -65 mesh by a Rod mill and then 24% ore solution was floated using Denver Sub-A Flotation Cell with the following reagents. The concentrate was cleaned only once and no reagents were added after that.

Table 2. Synthetic Flotation Result

Flotation Result					Floating Conditions
Grinding Size	**Products**	**Weight %**	**Grade %**	**Recovery %**	
-38 mesh	Concentrate	9.59	10.10	84.20	Condition : PH=8.5 Sodium silicate 300g/t Potassium Amyl Xanthate 70g/t Pine Oil 72g/t Cleaning : One time without Reagent
	Middling	3.44	0.48	1.44	
	Tailing	86.97	0.19	14.36	
	Total	100.00	1.15	100.00	
-48 mesh	Concentrate	12.20	9.41	93.4	Condition : Potassium Amyl Xanthate 70g/t Pine Oil 72g/t Cleaning : One time without Reagent
	Middling	7.30	0.23	1.40	
	Tailing	80.30	0.08	5.20	
	Total	100.0	1.23	100.00	
-48 mesh	Concentrate	9.98	10.90	93.70	Condition : PH=8.0 Sodium silicate 300g/t Potassium Amyl Xanthate 70g/t Pine Oil 72g/t Cleaning : One time without Reagent
	Middling	3.53	0.33	1.00	
	Tailing	86.49	0.07	5.22	
	Total	100.00	1.16	100.00	
-65 mesh	Concentrate	11.30	10.80	94.23	Condition : PH=8.5 Sodium silicate 300g/t Potassium Amyl Xanthate 70g/t Pine Oil 72g/t Cleaning : One time without Reagent
	Middling	4.10	0.38	1.20	
	Tailing	84.60	0.07	4.57	
	Total	100.00	1.29	100.0	

(b) Case of Priority Flotation for Copper

With suppression of Iron Sulfides (Pyrite, Enargite), the results of Copper Priority Flotation is as follows Table 3;

Table 3. Result of Priority Flotation for Copper

Flotation Result					Floating Conditions
Grinding Size	**Products**	**Weight %**	**Grade Cu %**	**Recovery %**	
-48 mesh	Concentrate	6.93	16.50	92.54	Condition : Lime PH=9.5 Sodium silicate 300g/t Sodium cyanide 100g/t Potassium Amyl Xanthate 120g/t Pine Oil 72g/t Cleaning : One time without Reagent
	Middling	6.57	0.35	1.86	
	Tailing	86.50	0.08	5.60	
	Total	100.00	1.23	100.00	

4. Discussion

(a) Grinding Size

It was confirmed from Microscope observation that Chalcopyrite and Gangue were mostly liberated in the size of 28 mesh. To save grinding expense, it was floated in size of -35 mesh but its recovery was only 84.2% even if the grade of Copper concentrate was 10.1% in a good state.

It is necessary to be ground to -48 mesh so that its complete liberation and recovery were improved. In this case, the grade is 10.9% that is not much different with that of -35 mesh but its recovery is improved to 93.8%

In the case of -65 mesh, the grade was 10.8% and the recovery was 94.2% which was not much different with -48 mesh.

(b) Reagents

It was compared the cases of routinely using Amyl Xanthate and Pine Oil for Synthetic Flotation and of additionally using Soda Ash and Silicate Soda at Table 2. The cases of -48 mesh were not much different with recoveries but the grade has an advantage when using a restrainer.

(c) Comparison between Synthetic and Priority Flotation

In the case of -48 mesh, the copper grade of the concentrate of Synthetic Flotation is 10.9% and its recovery is 93.8%.

For Copper Priority Flotation, it is 16.5% Cu grade and 92.5% Recovery. It has a higher copper grade than Synthetic Flotation but is lower in Recovery.

The Recovery of Synthetic Flotation was achieved easily about 93% but that of Priority Flotation was lower than 90%, except for one time 92.5%.

Therefore, Synthetic Flotation has an advantage over Priority Flotation.

(d) Comparison between Flotation and Gravity Separation

The gravity separation which had reported on the date of September 30, 1963, tested with the method of used jointly Jig and Table with -20 mesh, has shown 10~11% of copper in grade and 64% in recovery.

In this test, Synthetic Flotation, shows 10~11% of copper in grade and 93% in recovery with -48 mesh. Therefore, Synthetic Flotation has about 30% higher in recovery than that of Gravity Separation but has similar grade.

With treating 1 ton of 1.25% of the raw materials such as these samples, what the recovery 30% higher, means that it could be produced more than 3.75kg per kg. If it is converted to price, in case of 100won per kg, it means 375won recovered per kg.

In contrast, Flotation costs are more expensive than that of Gravity Separation. If the daily capacity of mill plant is 50 ton per day, the gravity separation expenses is about 250won per ton and Flotation's costs are about 400 won. In spite of more expensive about 150 won than that of Gravity Separation, the profit of Flotation is 375 won per ton more than that of Gravity Separation. Therefore, Flotation would make about 225 won more profit from the raw materials.

The Flotation plant is more expensive than that of Gravity Separation and is about 1.5 times the capital cost.

5. Conclusions

(a) The results of the Flotation Testwork demonstrate the optimal method for Goseong ore is Synthetic Flotation if Cu grade is not a priority.

(b) Synthetic Flotation can produce a concentrate of 10-11% Cu grade at a Recovery of 93%, if the ore is ground to -40 mesh and reagents comprising Soda Ash, Silicate of Soda, Amyl Xanthate and Pine Oil are used.

(c) It is recommended Pilot Plant testwork be conducted to confirm the results of this test.