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Recovery of Nickel and Copper from Scraped Nickel Condensers

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ABSTRACT

Magnetic separation and sulphidization-flotation for recovery of nickel and copper from two types of scraped condenser wastes, containing 8-14% nickel and 2-4% copper, were studied. The effects of magnetic field intensities, classification, and grinding on the recovery of nickel and copper were investigated. According to the characteristics of nickel and copper in the scraps, classification-magnetic separation, different magnetic field intensities, and stages-grinding-cleaning of rough concentrate were investigated. The nickel concentrates containing 38-65% nickel with 84-97% recoveries and the copper concentrates containing 25-43% nickel with 35-60% recoveries were obtained by classification-magnetic separation. In addition, copper concentrates containing 26-45% copper with 76-88% recoveries were obtained by sulphidization-flotation from magnetic tailings and middling products.

Keywords: Recycling, Nickel, Copper, Condenser scrap, Magnetic separation, Flotation

1 Introduction

Laminated ceramic chip condensers are of high capacity and small-sized. They are gradually replacing traditional circular ones as dominant condensers on the market. Because it is difficult to shape fine-powder layers, 15%-20% of laminated ceramic chip condensers are not up to standard and rejected as wastes. Therefore, it is desired to recover the metal contents (nickel and copper) from the scraped condensers for the sake of economical and environmental considerations.

As nickel has a high magnetic susceptibility, it is not very difficult to recover nickel from condensers by magnetic separation. A nickel concentrate containing more than 20% nickel with higher than 70% recovery was obtained from sample B by a single-stage magnetic separation [1,2,3]. However, the nickel recovery was lower and the copper was left behind by this approach. Therefore, it is the objective of this investigation to improve the nickel recovery and grade as well as to recovering the remaining copper content.

Due to the poor liberation of nickel and copper from barium titanate in the scraps, the grinding has to be used in order to obtain a copper concentrate and a nickel concentrate. In this research, techniques used for recovering nickel and copper from two types of scraped condensers were investigated by both magnetic separation and flotation. In other words, according to the characteristics of nickel and copper in the scraps, the processes such as classification-magnetic separation, different magnetic field intensities, stages-grinding-cleaning of rough concentrate, and sulphidization-flotation were studied in order to optimize both nickel and copper recoveries with a high grade.

2 Experimental

2.1 Samples

Two laminated ceramic chip condenser scrap samples were supplied by Yokohama Metal Co. Samples A and B contain 8.0% Ni, 3.8% Cu and 13.1% Ni, 2.1% Cu, respectively. Their matrix compositions are barium titanate. The details of their chemical analyses are listed in Table 1.

Table 1 Chemical analyses of scraped condenser samples

Particle Size, μm	Sample A										Sample B									
	Weight %	Grade, %		Distribution, %		Weight %	Grade, %		Distribution, %	
		Ni	Cu	Ni	Cu		Ni	Cu	Ni	Cu
+74	2.34	19.84	46.99	3.54	51.87	3.60	13.34	27.68	6.01	25.96
74-53	3.30	39.84	17.03	10.04	26.53	5.40	20.65	9.43	13.95	13.26
53-38	6.59	31.41	4.02	15.79	12.49	10.15	11.64	6.02	14.78	15.92
-38	87.77	10.55	0.22	70.63	9.10	80.85	6.45	2.13	65.25	44.86
Total	100.00	13.11	2.12	100.00	100.00	100.00	7.99	3.84	100.00	100.00

2.2 Magnetic separation test

The magnetic separation experiments were performed in a wet magnetic separator (Figure1). A slurry feed contains 15 grams of scraped condenser and 600 ml water were introduced into a 1000 ml agitation vat. The mixture was then dispersed by ultrasonic wave for five minutes. After dispersion, the pulp was agitated at 500 rpm for one minute, and then pumped through the magnetic separator. The flowsheet of magnetic separation test is shown in Figure 2. The magnetic field intensities and the pulp flow rates were set at 0.1T, 700 ml/min; 0.3T, 400 ml/min and 0.2T, 500 ml/min for Roughing 1, Roughing 2 and the Cleaning, respectively. Stages-grinding-magnetic separation was used in cleaning stage except in the separation of the −38 μm fraction.

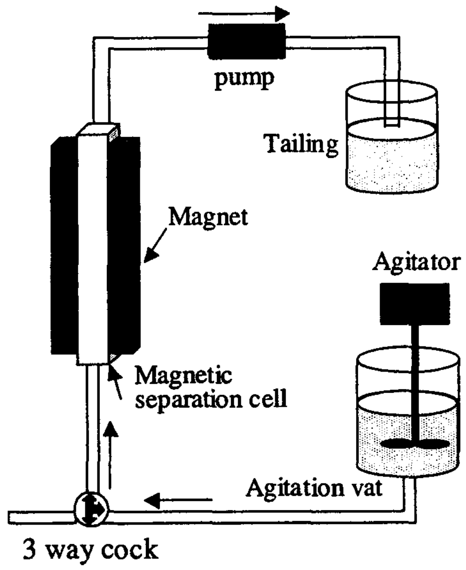

Figure 1 Magnetic Separator

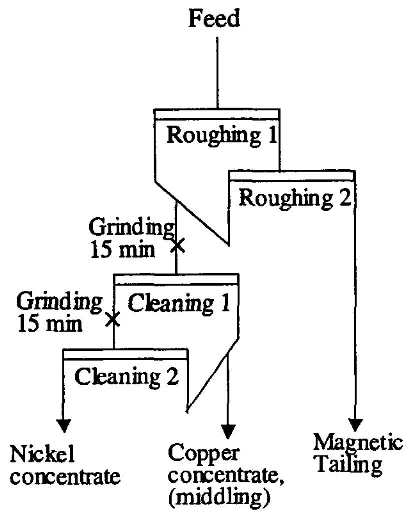

Figure 2 Magnetic Separation Flowsheet

2.3 Sulphidization-flotation test

Flotation studies were conducted on the magnetic tailing and middling in a 100-ml MS cell. The magnetic tailing and middling pulps were dewatered by precipitation. The precipitate was re-pulped in distilled water and then added 2 ml sodium sulfide solution (2%wt.) as a sulphidization agent. The pulp was conditioned at 60℃ for 20 minutes. After sulphidization, the appropriate quantity of xanthate solution was added, followed by adding frother (MIBC) two minutes later. The pulp was further conditioned for one minute and then introduced air into the flotation cell. Flotation was conducted at 25℃ for five minutes.

3 Results and Discussion

3-1 Recovering of nickel and copper with magnetic separation

Pervious experiment results had shown that magnetic field intensity, pulp flow rate and liberation degree affected significantly on the recoveries and the grades of nickel [3]. Therefore, the effects of classification and

Table 2 Recoveries of nickel and copper by two-stages rougher magnetic separation only

	Product	Weight (%)	Grade (%)		Recovery (%)	
			Ni	Cu	Ni	Cu
Sample A	Rougher concentrate	26.04	51.82	7.92	98.81	88.85
	Tailing	73.96	0.22	0.35	1.19	11.15
	Feed	100.00	13.66	2.32	100.00	100.00
Sample B	Rougher concentrate	25.80	29.12	3.94	90.69	26.02
	Tailing	74.20	1.04	3.90	9.31	73.98
	Feed	100.00	8.29	3.91	100.00	100.00

Table 3 Results of rougher concentrate grinding-cleaning

	Product	Weight (%)	Grade (%)		Recovery (%)	
			Ni	Cu	Ni	Cu
Sample A	Nickel concentrate	18.23	70.65	5.10	94.30	40.05
	Middling	7.81	7.89	14.50	4.51	48.80
	Tailing	73.96	0.22	0.35	1.19	11.15
	Feed	100.00	13.66	2.32	100.00	100.00
Sample B	Nickel concentrate	18.59	38.00	1.98	85.45	9.34
	Middling	5.98	6.50	10.60	4.70	16.06
	Tailing	75.43	1.08	3.90	9.85	74.60
	Feed	100.00	8.27	3.94	100.00	100.00

grinding on recovering nickel and copper were emphasized in this investigation. The recoveries of nickel and copper using rougher magnetic separation (two-stages) only are shown in Table 2. The results demonstrate that magnetic separation of Sample A is better than that of Sample B. A rougher concentrate of Sample A containing 52% nickel with 98% recovery has been obtained along with a 88% copper recovery. It is observed from the results of Table 1 and Table 2 that the nickel and copper particle sizes are relatively larger in Sample A and they are more easier to be liberated from barium titanate. For Sample B, it is more difficult to further increase nickel recovery by merely increasing magnetic field intensity. Probably, both nickel and copper particle sizes in Sample B are finer and more difficult to be liberated.

The magnetic separation with the addition of a dispersant (sodium silicate solution) was tried to improving the nickel grade of rougher concentrate. Although the result indicates that the grade of nickel was increased from 30% to 33% by the addition of dispersant, but the difficulty of solid-liquid separation on the tailing slurry and the significant decrease in the flotation recovery of copper, it was decided not to use the dispersant in the consequent tests throughout this investigation

Effect of grinding was investigated to improve the nickel grade in the final concentrate, and to separate copper from nickel in the rougher concentrate. Initially the grinding-magnetic separation of feed was carried out. It was found that this process had slight effect for increasing nickel grade and recovery, but it caused difficulty for solid-liquid separation due to over grinding of barium titanate. Therefore, the process of rough concentrate grinding-cleaning was carried out in the consequent tests. The results are shown in Table 3. A nickel concentrate with higher grade (71% for sample A and 38% for sample B) and recovery (94% for sample A and 85% for sample B) was obtained with this process, but copper grade of middling was lower (14% for sample A and 10% for sample B).

The classification with a 400-mesh screen followed by a magnetic separation was also conducted on both Sample A and Sample B. Results of Table 4 and Table 5 demonstrated that nickel recovery and grade in the combined nickel concentrate by classification-separation were slightly higher than those by direct separation, and the copper content in the combined nickel concentrate was lower. The amount of material fed into the copper flotation circuit was reduced. A combined copper concentrate containing 25-43% copper was obtained with a recovery of 35-60%.

Table 4 Results of classification-magnetic separation of sample A

Size	Product	Weight (%)	Grade (%)		Recovery (%)	
			Ni	Cu	Ni	Cu
+38 μ m	Ni concentrate	52.43	57.00	7.40	94.21	24.32
	Cu concentrate	24.27	6.90	43.65	5.28	66.41
	Tailing	23.30	0.69	6.35	0.51	9.27
	Feed	100.00	31.72	15.95	100.00	100.00
-38 μ m	Ni concentrate	15.33	68.35	0.91	98.64	63.09
	Cu concentrate	7.29	0.29	0.27	0.20	8.90
	Tailing	77.38	0.16	0.08	1.17	28.00
	Feed	100.00	10.62	0.22	100.00	100.00
Total	Ni concentrate	19.86	64.69	3.00	97.34	27.82
	Cu concentrate	2.97	6.90	43.65	1.55	60.40
	Tailing	77.17	0.19	0.33	1.11	11.77
	Feed	100.00	13.20	2.15	100.00	100.00

Table 5 Results of classification-magnetic separation of sample B

Size	Product	Weight (%)	Grade (%)		Recovery (%)	
			Ni	Cu	Ni	Cu
+38 μ m	Ni concentrate	6.42	37.50	3.50	87.55	9.80
	Cu concentrate	5.81	4.90	25.00	10.35	63.36
	Tailing	7.23	0.80	8.50	2.10	26.83
	Feed	19.46	2.75	2.29	100.00	100.00
-38 μ m	Ni concentrate	10.94	39.10	0.85	81.46	5.06
	Cu concentrate	12.92	3.50	4.70	8.61	33.01
	Tailing	56.68	0.92	2.01	9.93	61.94
	Feed	80.54	5.25	1.84	100.00	100.00
Total	Ni concentrate	17.36	38.51	1.83	83.55	7.69
	Cu concentrate	5.81	4.90	25.00	3.56	35.15
	Tailing	76.83	1.34	3.07	12.89	57.16
	Feed	100.00	8.00	4.13	100.00	100.00

3-2 Recovery of copper and nickel by sulphidization-flotation

For improving the copper recovery, sulphidization with sodium sulfide was applied. Table 6 shows the recovery of copper by sulphidization-flotation from the tailing and middling of magnetic separation. By one stage flotation roughing and cleaning, the copper concentrates containing 26-45% copper with 76-88% recoveries were obtained, while more than 74-62% of nickels were recovered into the concentrates.

3-3 Recovery of copper and nickel by the combination of magnetic separation and sulphidization-flotation

Table 7 shows the recovery and grade results of nickel and copper from two scraped condenser samples by the combined processes of classification-magnetic separation, grinding-cleaning of rough concentrate and sulphidization-flotation of the tailing and middling of magnetic separation. For sample A, a nickel concentrate containing 65% nickel with 97% recovery and a copper concentrate containing 43% copper with 68% recovery were obtained. For sample B, a nickel concentrate containing 38% nickel with 86% recovery and a copper concentrate containing 26% copper with 78% recovery were obtained.

Table 6 Results of sulphidization-flotation from tailing and middling of magnetic separation

	Product	Weight (%)	Grade (%)		Recovery (%)	
			Ni	Cu	Ni	Cu
Sample A	Cu concentrate	12.53	4.10	45.00	73.7	88.71
	Tailing	87.47	0.21	0.82	26.3	11.29
	Feed	100.00	0.70	6.35	100.0	100.00
Sample B	Cu concentrate	9.32	7.30	26.50	62.5	76.42
	Tailing	90.68	0.45	0.84	37.5	23.58
	Feed	100.00	1.09	3.23	100.0	100.00

Feed of sample A: Magnetic tailing of +38 μ m fraction only. Feed of sample B: Magnetic tailing of +38 μ m fraction and tailing and middling of -38 μ m fraction. Concentrations of ethyl xanthate and MIBC: 100mg/l and 40 mg/l in roughing, 30mg/l and 10 mg/l in cleaning, respectively.

Table 7 Final results of nickel and copper recovered from condenser scraps by the combined processes of classification-magnetic separation, grinding-cleaning of rough concentrate and sulphidization-flotation

	Product	Weight (%)	Grade (%)		Recovery (%)	
			Ni	Cu	Ni	Cu
Sample A	Ni concentrate	19.86	64.69	3.00	97.33	27.82
	Cu concentrate	3.33	6.60	43.79	1.66	67.89
	Tailing	76.81	0.17	0.12	1.00	4.29
	Feed	100.00	13.20	2.15	100.00	100.00
Sample B	Ni concentrate	17.36	38.51	1.83	85.6	7.47
	Cu concentrate	12.97	6.23	25.83	10.3	78.76
	Tailing	69.67	0.45	0.84	4.0	13.77
	Feed	100.00	7.81	4.25	100.0	100.00

4 Summary

1) The magnetic separation results of sample A were better than that of sample B due to that nickel and copper particle sizes of sample A are relatively larger than that of Sample B. The copper and nickel particles are easily being liberated from barium titanate from Sample A than from sample B.

2) Stages-grinding-cleaning of rough concentrate improved the nickel grade and decreased the copper content in the nickel concentrates. The copper content in the nickel concentrate was further decreased by the classification-magnetic separation, and the copper concentrates containing 25-43% nickel with 35-60% recoveries were obtained

3) Copper concentrates containing 26-45% copper with 76-88% recoveries were obtained from the tailing and middling of magnetic separation by the sulphidization-flotation.

4) By the combined processes of classification-magnetic separation, grinding-cleaning of rough concentrate and sulphidization-flotation, the nickel concentrates containing 38-65% nickel with 85-97% recoveries and the copper concentrates containing 25-43% copper with 68-78% recoveries were obtained.

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