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Effect of Roasting with Ammonium Sulfate and Sulfuric Acid on the Extraction of Copper and Cobalt from Copper Converter Slag

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NOTE

Effect of Roasting with Ammonium Sulfate and Sulfuric Acid on the Extraction of Copper and Cobalt from Copper Converter Slag

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Abstract

Copper converter slag, provided by Ergani Copper Co. of Etibank and containing 2.56% copper and 0.22% cobalt, was roasted with ammonium sulfate. The effects of such parameters as temperature (200–600°C), duration of roasting (15–120 min), and amount of ammonium sulfate (0.5–2.5 times stoichiometric) have been studied. Under optimum conditions (slag size, −100 mesh; stoichiometric requirement of ammonium sulfate; roasting temperature of 400°C for 60 min), we obtained 88% Cu and 67% Co by extraction. Similar studies were carried out with concentrated sulfuric acid. The influence of experimental variables such as roasting temperature (25–300°C), roasting period (30–120 min), and amount of sulfuric acid (0.5–2 times stoichiometric) has been studied. Under atmospheric conditions, i.e., at 200°C and a roasting period of 60 min with 1.5 times the stoichiometric amount of sulfuric acid, recoveries of copper and cobalt were 82 and 96%, respectively.

INTRODUCTION

In recent years, because of the increasing importance of the extraction of copper and cobalt from converter slag, extraction studies using sulfating agents have been carried out (*1*).

Various studies on leaching copper converter slag have been carried out in the laboratory by using ferric chloride with or without prior reduction (*2*, *3*) and sulfuric acid with or without pressure (*4*). Sulfuric acid is a widely used solvent in hydrometallurgical processes (*1*).

The effectiveness of ammonium sulfate as a sulfating agent for copper,

TABLE 1
Chemical Analysis of Copper Converter Slag
(mass %)

	Cu	Co	Fe
Sample 1	2.56	0.22	49.00
Sample 2	2.93	0.22	50.03

zinc, and lead in complex sulfides was studied (*5*). Ammonium sulfate was found to be very good and selective.

We have investigated the recovery of cobalt and copper by roasting the copper converter slag with ammonium sulfate and sulfuric acid and then leaching with water (*6*). The influences of temperature, duration of roasting, and amount of sulfating agent required for complete sulfation of cop-

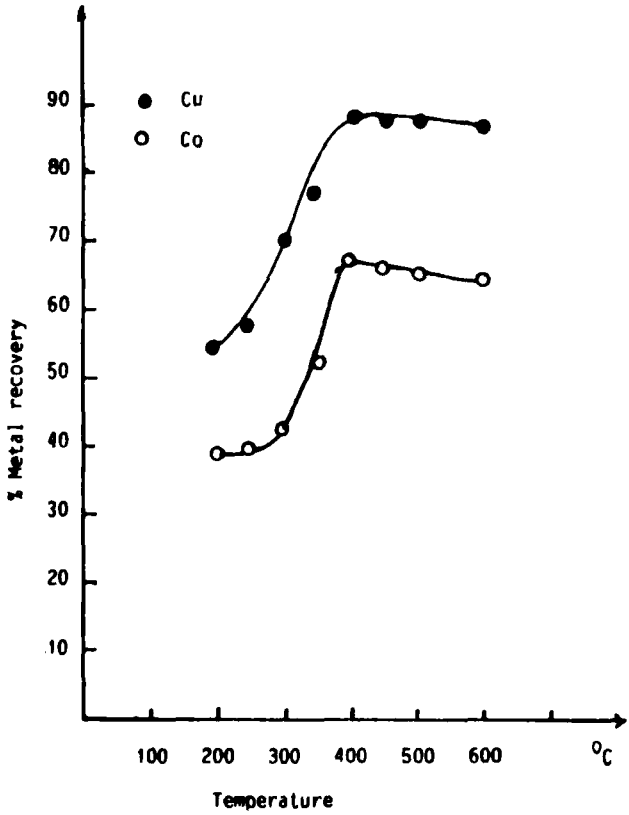

FIG. 1. Effect of temperature on recovery of copper and cobalt.

per, cobalt, and iron in the slag have been investigated. The relative merits of the two roasting processes have been examined.

EXPERIMENTAL

In this research, we used the converter slags of Ergani Copper Co. of Etibank (southeast of Anatolia, Turkey). The compositions are given in Table 1. Ammonium sulfate (Merck) and concentrated H_2SO_4 (Merck) were used for roasting of the first and second samples, respectively.

Slag samples were initially ground by a jaw crusher, and then they were sifted under 100 mesh. After the addition of the sulfating agent, the samples were placed in a muffle furnace (Hereaus K.R. 170 mod.) in a silica dish at the desired temperature.

After roasting, the sample was removed from the furnace, cooled, and leached with water. The solution was filtered, and the quantities of copper

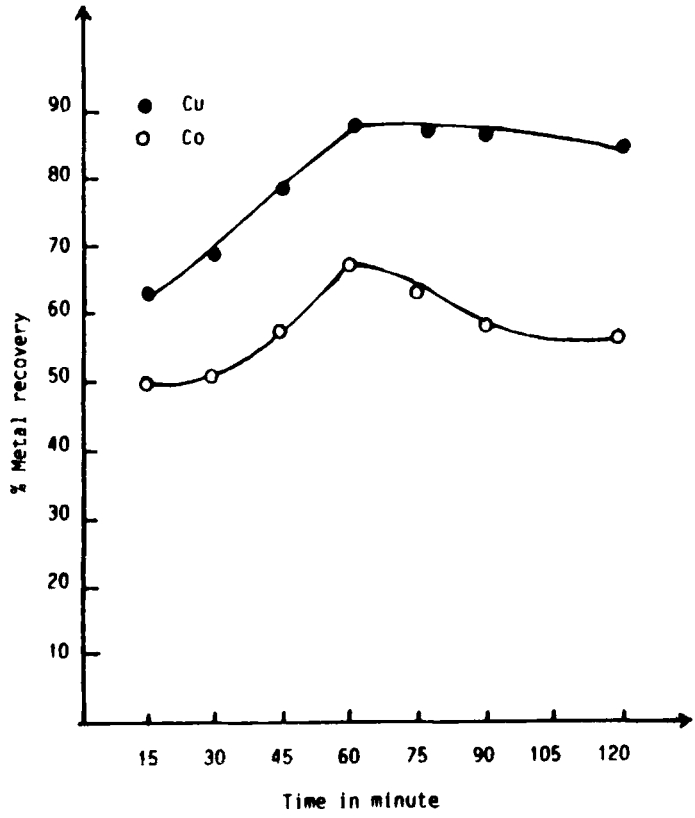

FIG. 2. Effect of roasting period on recovery of copper and cobalt.

and cobalt in the solution were determined with a spectrophotometer (Varian Techtron Mod. 1200).

RESULTS AND DISCUSSION

A) Studies on Sulfation with Ammonium Sulfate

Effect of Temperature

The first converter slag sample was mixed with the stoichiometric amount of ammonium sulfate (1.35 g/g slag) and roasted at different temperatures (200–600°C) for 60 min. The recoveries of copper and cobalt are plotted in Fig. 1.

Because the best results were obtained at 400°C, the rest of the studies to determine the other parameters were carried out at this temperature.

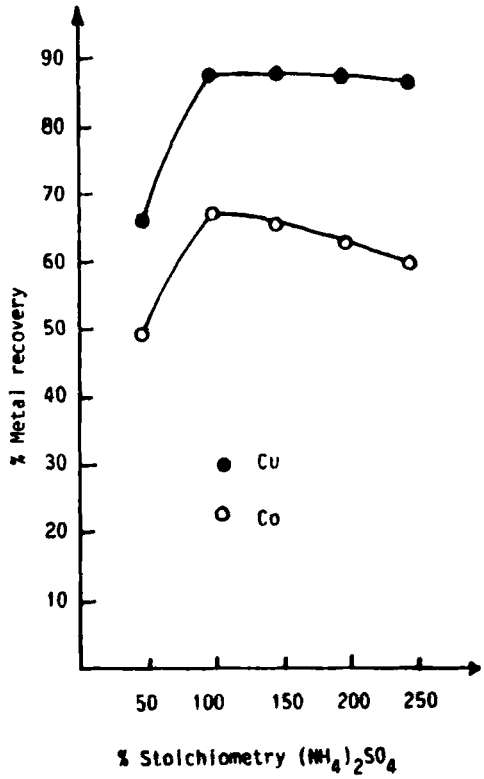

FIG. 3. Effect of ammonium sulfate amount on recovery of copper and cobalt.

Effect of Roasting Period

The roasting period was changed from 15 to 120 min at 400°C while using a stoichiometric amount of ammonium sulfate. The recovery of metal for different time periods is shown in Fig. 2. Roasting for 60 min was optimum. Further studies on other variables were carried out by roasting for 60 min at 400°C.

Effect of Ammonium Sulfate Amount

The effect of the amount of ammonium sulfate on sulfation was studied by changing it from 0.5 to 2.5 times the stoichiometric amount (400°C and 60 min of roasting). The results are given in Fig. 3. The stoichiometric amount of ammonium sulfate was considered to be optimum.

B) Studies on Sulfation with Concentrated Sulfuric Acid

Similar studies were carried out by using concentrated sulfuric acid as the sulfating agent.

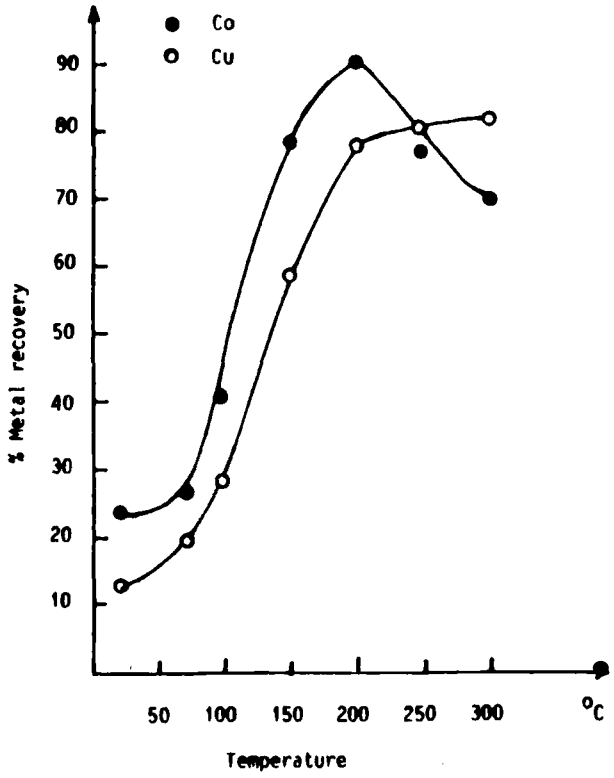

FIG. 4. Effect of temperature on sulfate roasting of converter slag.

Effect of Temperature

Initially, the slag was mixed with sulfuric acid in an amount 25% in excess of the stoichiometric requirement. The temperature was changed from 25 to 300°C. The results are shown in Fig. 4.

The optimum temperature was considered to be 200°C. Studies of other parameters were undertaken at this temperature.

Effect of Roasting Period

The effect of the roasting period was studied at 200°C from 30 to 120 min (Fig. 5). A roasting period of 60 min was considered to be optimum.

Effect of Sulfuric Acid Amount

The amount of sulfuric acid was changed from 0.5 to 2 times the stoichiometric amount. The mixture was roasted at 200°C for 60 min and

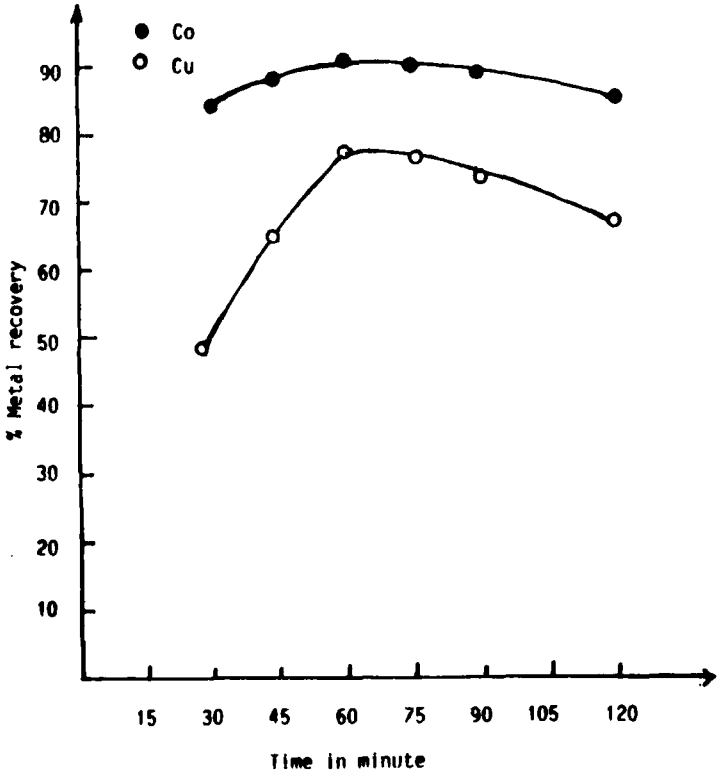

FIG. 5. Effect of roasting period on recovery of copper and cobalt.

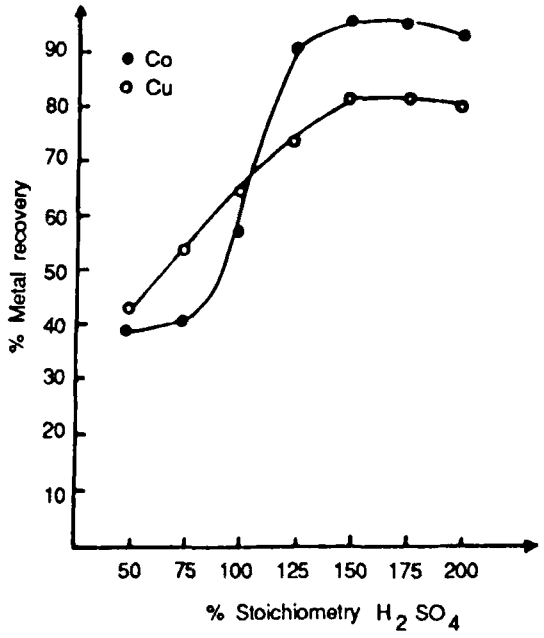

FIG. 6. Effect of sulfuric acid amount on recovery of copper and cobalt.

leached (Fig. 6). It is clear that 1.5 times the stoichiometric amount is adequate for sulfation.

CONCLUSIONS

Under optimum conditions, i.e., at 400°C and a roasting period of 60 minute with the stoichiometric amount of ammonium sulfate, recoveries of copper and cobalt were 88 and 67%, respectively.

When sulfuric acid is used as the sulfating agent, satisfactory conditions were found to be 1.5 times the stoichiometric requirement of sulfuric acid and a roasting temperature of 200°C for 60 min for an extraction of 82% copper and 96% cobalt.

According to our results, sulfuric acid is better than ammonium sulfate as a sulfating agent. Because the temperature for sulfation by sulfuric acid is lower, i.e., 200 vs 400°C, cobalt recovery is higher and sulfuric acid is cheaper than ammonium sulfate. Further, recovery of ammonia and sulfur oxide gases is necessary for economic viability when ammonium sulfate is used. If we compare the two sulfation processes, sulfuric acid appears to be more attractive economically than ammonium sulfate.

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