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NICKEL AND CHROMITE RECOVERY FROM TURKISH CHROMITE ORE

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ABSTRACT

Ore samples collected from different locations of Aladağ chromite deposit (Turkey) were subjected to this experimental study. The blend ore sample assayed 14.31 % Cr_2O_3, 0.233 % Ni, 32.64 % MgO, 8.60 % FeO, 2.31 % Al_2O_3, 0.65 % CaO, 0.01 g/t Au, 0.01 g/t Pt and 0.02 g/t Pd. Shaking table tests were performed to produce chromite and olivine concentrates using ground samples below 1 and 0.5 mm. Best results were obtained below 0.5 mm where the chromite concentrate was produced with 48.23 % Cr_2O_3 and 78.2% recovery. 90% of nickel remained in the tailings with 0.266% Ni content thus acidic leaching tests were conducted on the tailings. The effects of acid concentration, temperature and leaching time were the parameters tested on the Ni dissolution efficiency. Optimum leaching conditions were found as 200 g/L of acid concentration, 60°C temperature, 2 hours leaching time, solid/liquid ratio of 1/10 and agitation speed of 400 rpm, and 99.2% Ni dissolution was achieved where acid consumption was 996.7 kg/t. By gravity separation of leach residue containing 7% Cr_2O_3 a concentrate assaying 46.7% Cr_2O_3 was produced with 38.1% recovery. As a result of this experimental study a proposed flowsheet is developed for the treatment of this chromite ore.

KEY-WORDS: Nickel recovery, chromite cocentrate, acidic leaching

1. INTRODUCTION

Turkey is one of the top countries together with South Africa, Zimbabwe, India, and Finland in terms of chromite ore potential (Onal et al. 1986). Turkey has about 300 million tons of chromite ore reserve which makes 4% of the world total and most of them are in Adana region of Turkey. These reserves are considered to be low grade ones and have to be evaluated due to their large reserves. They also contain considerable amount of nickel. In the earlier studies, it was found that nickel is mostly accumulated in chromite concentration tailings (Gül et al. 1995, Arslan et al. 1996). Therefore, the aim of this study was to recover chromite and nickel from Aladağ region chromite ores located in the mentioned part of Turkey.

2. MATERIAL AND METHOD

The samples taken from 9 different levels of the Aladağ (Adana) region (Turkey) chromite mine were blended by taking equal amounts. Aladağ Blend Ore contains 14.31 %Cr_2O_3, 0.233 %Ni, 32.64 %MgO, 8.60 %FeO, 2.31 %Al_2O_3, 0.65 %CaO, 0.01 g/t Au, 0.01 g/t Pt and 0.02 g/t Pd.

Microscopic studies revealed that chromite was formed either in disseminated or in banded structure within the rocks composed of dunite serpentinized at different degrees and to some extent harzburgite. Minerals associated with chromite are serpentine group minerals of olivine, chrysotile, antigorite and also pyroxene, talc, chlorite, chromium spinel, iddingsite, chalcedon, pentlandite, hezelvudite, magnetite, hematite, limonite. Microscopic investigation suggests that the majority of nickel comes from pecoraite minerals (nickel chrysotile) that are formed by the decomposition of isomorph nickel in the structure of magnesium rich olivine during the serpentinization of pecoraites.

Gravity concentration tests (Shaking and Mozley Tables) were used for the production of chromite concentrate and acidic leaching experiments were performed for nickel recovery.

3. RESULTS AND DISCUSSION

3.1 Shaking Table Experiments

Shaking table experiments were carried out with two samples all ground below 1 and 0.5 mm. Aladağ blend ore ground under 1 mm was screened and three groups of material were collected as -1+0.5, -0.5+0.2 and -0.2 mm. Shaking table experiments were performed with these ores in the different size ranges and results are given in Tables 2 and 3.

Combined results of shaking table experiments (Table 2) shows that 15.2% of the feed was recovered as a chromite concentrate with 47.38% Cr_2O_3 content and approximately 51% recovery while most of MgO and Ni are collected in the middlings and tailings.

Table 2. Combined results of shaking table experiments carried out with the blend ore ground below 1 mm.

Products	Amount (%)	Cr_2O_3 (%)		MgO (%)		Ni (%)	
		Content	Recovery	Content	Recovery	Content	Recovery
Concentrate	16.8	47.67	54.5	17.07	8.7	0.103	7.4
Middlings	24.4	13.15	21.7	34.40	25.4	0.241	25.1
Tailings	50.3	5.75	19.7	37.32	56.5	0.267	57.5
Slime	8.5	7.10	4.1	36.64	9.4	0.275	10.0
Total	100.0	14.71	100.0	33.14	100.0	0.234	100.0

Aladağ blend ore ground under 0.5 mm was screened and separated as -0.5+0.2 and -0.2 mm groups and the experimental results of shaking table and the combined results are given in Tables 3 and 4, respectively..

As it can be seen from the Table 3, small increases in chromite content of concentrate are observed with decreasing size range where chromite content of tailings remains almost the same. MgO and Ni are mostly accumulated in the middlings and tailings.

By examining the combined results (Table 4) it is found that a chromite concentrate (23.4 % of feed) with 48.23%Cr_2O_3 is produced with 78.2% recovery while MgO and Ni are mostly collected in tailings. Therefore, acidic leaching experiments are carried out.

Table 3. Combined results of shaking table experiments carried out with the blend ore ground below 0.5 mm.

Products	Amount %	Cr_2O_3 (%)		MgO (%)		Ni (%)	
		Content	Recovery	Content	Recovery	Content	Recovery
Concentrate	21.8	48.53	68.6	19.53	12.6	0.094	9.1
Middlings 1	5.0	22.01	7.1	32.92	4.9	0.191	4.2
Middlings 2	14.1	6.10	5.6	37.47	15.7	0.242	15.1
Tailings	52.2	4.51	15.3	38.19	59.2	0.274	63.5
Slime	6.9	7.71	3.4	37.07	7.6	0.265	8.1
Total	100.0	15.43	100.0	33.68	100.0	0.226	100.0

Table 4. Combined results of shaking table experiments carried out with the blend ore ground below 0.5 mm calculated by distribution of middlings 1 and slime.

Products	Amount %	Cr_2O_3 (%)		MgO (%)		Ni (%)	
		Content	Recovery	Content	Recovery	Content	Recovery
Concentrate	23.4	48.23	78.2	19.53	13.6	0.094	9.8
Tailings	76.6	4.10	21.8	38.00	86.4	0.266	90.2
Total	100.0	14.43	100.0	33.68	100.0	0.226	100.0

3.2 Leaching Experiments

As a result of gravity concentration tests with the ore sample under 0.5 mm in size, a tailing containing 0.27%Ni, 4.1%Cr_2O_3 and 38%MgO is produced and subjected to the acidic leaching tests in order to recover Ni. In the tests, the effect of acid concentration, temperature and leaching time on Ni dissolution is investigated and results are presented in Figures 1, 2 and 3. Solid/liquid ratio (S/L) of 1/10 and stirring speed of 400 rpm are kept constant throughout the tests.

As it is seen from Figure 1, Ni dissolution efficiency increased up to 200 g/L acid concentration and leveled off after that point. Therefore, 200 g/L acid concentration is found optimum and used in the following tests.

Figure 2 shows that increasing temperatures increase the Ni dissolution efficiency up to almost 100% at 60°C and no changes were observed after that point. Therefore 60°C was chosen as an optimum and the following tests were carried out at 200 g/L acid concentration and 60°C temperature.

Effect of time on Ni dissolution efficiency can be seen in Figure 3. According to results 2 hours of leaching is found to be sufficient.

According to three group of leaching tests, the optimum leaching conditions were found as: 200 g/L acid concentration, 60°C temperature, 2 hrs leaching time, 1/10 solid/liquid ratio and 400 rpm stirring speed. At these conditions, 99.2 of Ni passed into to solution and acid consumption was 996.7 kg/t.

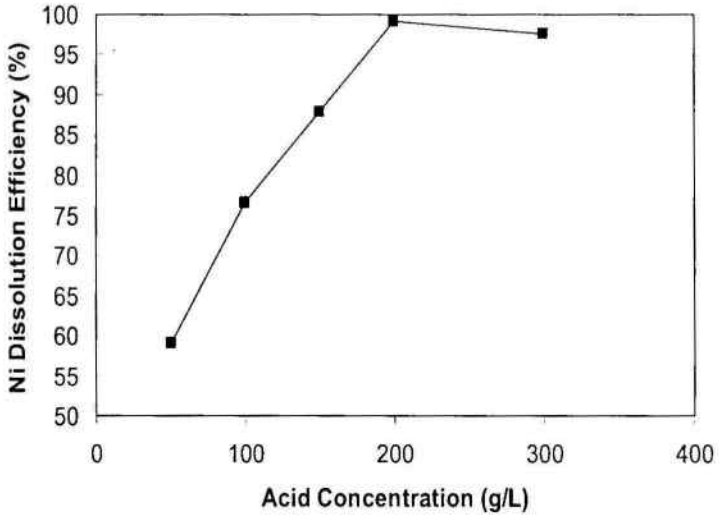

Figure 1. Effect of acid concentration on Ni dissolution efficiency.

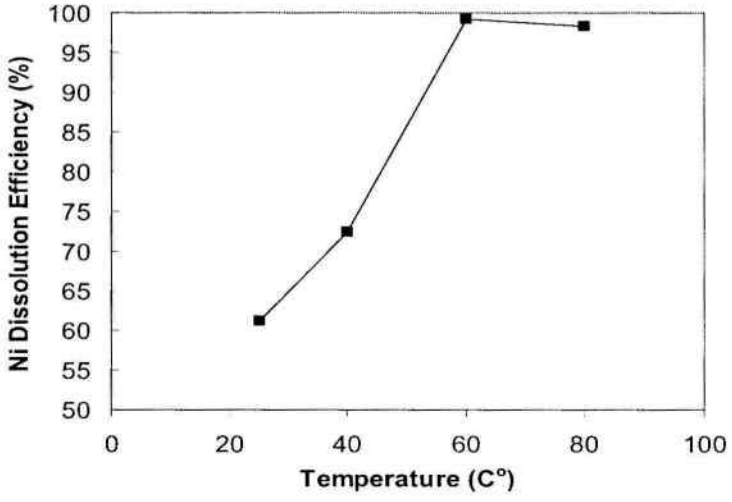

Figure 2. Effect of leaching temperature on Ni dissolution efficiency.

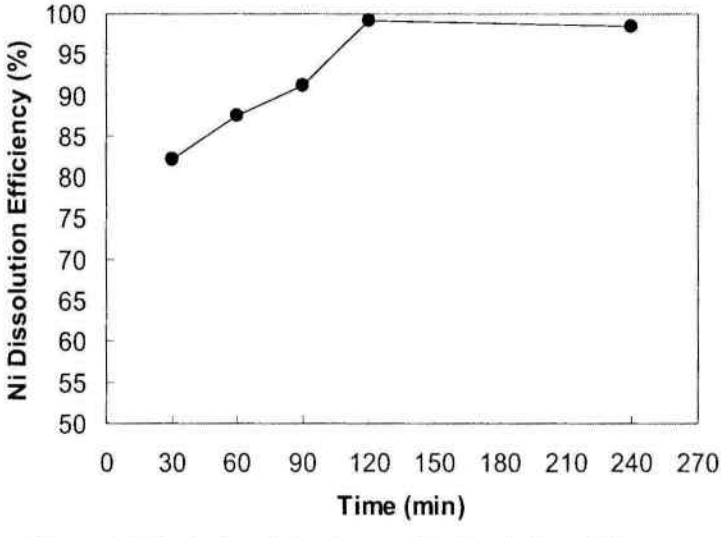

Figure 3. Effect of leaching time on Ni dissolution efficiency.

3.3 Gravity Separation of Leach Residue

A leach cake containing 7%Cr_2O_3 was subjected to gravity separation tests using Mozley Table to produce chromite concentrate and the results are given in Table 5. A chromite concentrate with 46.7 %Cr_2O_3 content was produced by 38.1% recovery.

Table 5. Results of gravity concentration test run with leach residue.

Products	Amount %	Cr_2O_3 Content %	Recovery %
Concentrate	3.4	46.70	22.7
Middlings	10.5	13.75	20.7
Tailings	86.1	4.60	56.6
Total	100.0	6.99	100.0
Combined Results			
Concentrate	5.7	46.70	38.1
Tailings	94.3	4.59	61.9
Total	100.0	6.99	100.0

3.4 Pre-Economic Studies

Preliminary economical assessment, performed according to the process flowsheet shown in Figure 4, for a concentrator processing 1,000,000 tons of ore annually revealed that the amounts of nickel and chromite concentrates will be 1,862 t/y and 254,085 t/y (48% Cr_2O_3) respectively bringing a total revenue of 27 million US $ annually (Research Project 2006).

4. CONCLUSIONS

- Mineralogical investigation showed that the ore is composed of chromite, olivine, chrysotile, antigorite and serpentine type of minerals and as well as pyroxene, talc, chlorite, chromium spinel, magnetite, hematite and limonite.
- Best results of shaking table tests were obtained with the sample below 0.5 mm where the concentrate was produced with 48.23% Cr_2O_3 content and 78.2% recovery.
- Optimum leach conditions found were: 200 g/L of acid concentration, 60°C temperature, 2 hours leaching time, solid/liquid ratio of 1/10 and agitation rate of 400 rpm. Under these conditions 99.2% nickel dissolution efficiency was achieved where acid consumption was 996.7 kg/t.
- The leach residue containing 7% Cr_2O_3 was subjected to the concentration tests using the Mozley Table to recover the chromite and a concentrate assaying 46.7% Cr_2O_3 was produced with 38.1% recovery.
- As a result of this experimental study a flowsheet was proposed for the recovery of chromite and nickel from Aladağ (Adana) region chromite ore.
- Preliminary economical assessment for a concentrator processing 1,000,000 tons of ore annually revealed that 1,862 t/y Ni and 254,085 t/y chromite concentrate will be produced bringing an annual total revenue of 27 million US $.

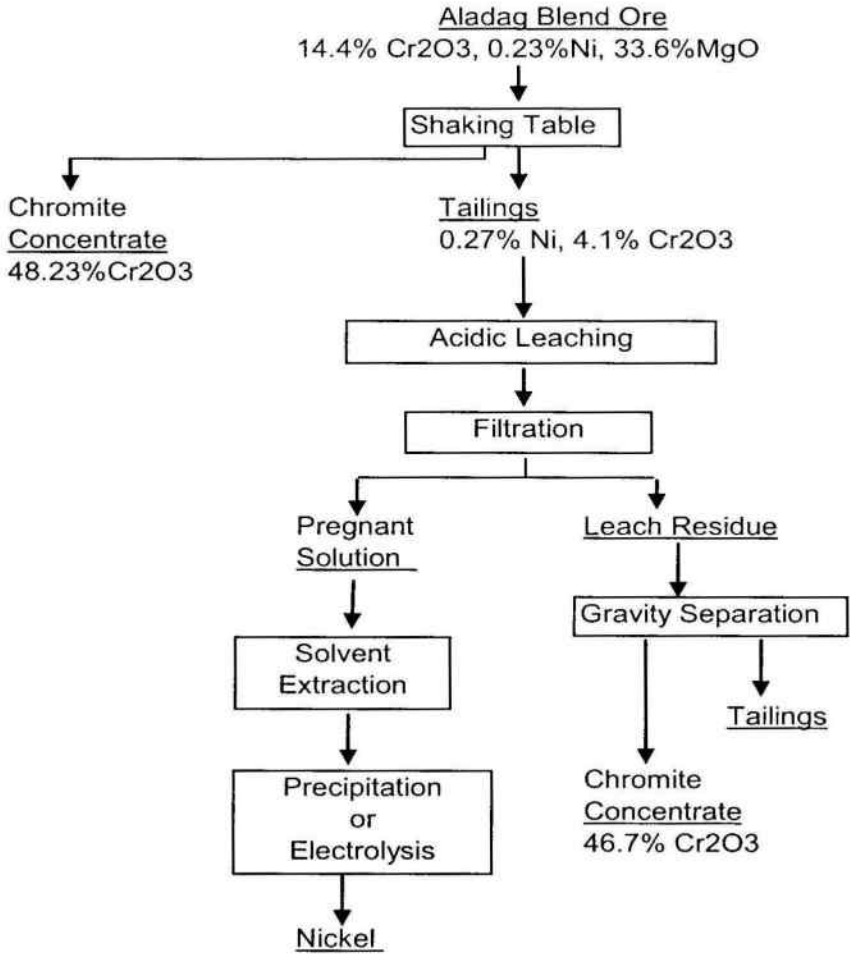

Figure 4. A proposed process flowsheet for explotation of the of Aladağ region chromite ore.

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