

Introduction of nickel extraction from chromiferous overburden by sulphatization roasting

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ABSTRACT

Various operating parameters, such as roasting temperature, time, acid concentration and role of additives were studied. Addition of moisture, during pugging, helped in the formation of insoluble ferric hydroxysulphate that maintains the equilibrium of SO₃ partial pressure. The double stage roasting improved the nickel extraction over the single stage isothermal roasting of the material at 700°C. An extraction of 85% nickel with 2-3% iron could be achieved at a temperature of 700°C when roasted for 15 mins, 25 wt% sulphuric acid and 20 wt% moisture in two stages. The nickel extraction was improved a further 8-10% by the addition of alkali and alkaline earth metal salts. The role of additives during roasting was also introduced.

Key words : nickel extraction, roasting

INTRODUCTION

Nickel bearing laterite and chromiferous overburden are the only source of nickel available in the Sukinda valley of Orissa, India. The overburden has a nickel content that ranges from 0.5 to 0.9 wt% [1].

To extract nickel from these lateritic ores, various pyro and hydro metallurgical methods have been tried. Ammonia-ammonium carbonate leaching of the reduced ore has been carried out in the presence of oxygen [2,3] and about 70--75 % of the nickel has been extracted. Leaching with sulphuric acid has also been carried out at atmospheric, as well as elevated pressure and temperature [4-6]. It has been observed that preferential sulphation of nickel over iron can be obtained with certain parametric values. Processes have also been tried with ferric sulphate, sulphuric acid leaching [7,8].

All the above processes require a high consumption of leachant and also the disposal of these leachates after treatment is tedious. Efforts have been made to extract nickel from Indian laterites [9-11] using different routes.

In another study [12-15], an attempt has been made to extract nickel and cobalt preferentially from Serpentinic ores, containing more than 1.3% nickel using pug roasting followed by water leaching and hydrogen sulphide precipitation of nickel and cobalt from the leach liquor.

In the present study, an attempt has been made to extract nickel selectively from chromiferous overburden by roasting the sulphuric acid pug of the low nickel chromiferous overburden in two stages. The role of additives on the improvement of nickel extraction and their reaction mechanism has been discussed, as well as studying the effect of other process variables.

EXPERIMENTAL METHODS

Material preparation

The ore samples obtained from R.O.M contained about 25 wt% moisture. The samples were dried at 110°C for 2 hours before grinding. The chemical analysis was carried out by standard elemental methods and the assay composition of the ore (-106~t) used in the study was Fe₂O₃ -- 66.58%, Ni-- 1.31%, Co---0.078%, SiO₂--5.6%, Cat 4.65%, Al₂O₃---4.85%, MgO--2.51%, Acid In.--1.5%, L.O.I.-12.12%.

Materials

Chromiferous overburden, analar grade sulphuric acid, NaCl, CaCl₂, MgSO₄, Al₂(SO₄)₃, Na₂SO₄, K₂SO₄ and sea water.

RESULTS AND DISCUSSION

Introduction of The effect of temperature on nickel extraction is shown in Figure 1. Interestingly, there is a sharp increase in nickel sulphation between 650~700°C, after which sulphation decreases considerably. The decrease in sulphation may be attributed to the partial decomposition of nickel sulphate at higher temperature, and secondly, above 700°C, the conversion of SO₂ to SO₃ ceases and the equilibrium shifts towards the reactant side. Due to this, there is no further improvement of nickel extraction. A two stage roasting process proved to be more appropriate to increase the nickel sulphation (Table 1), where pre-roasting is carried out at 450°C followed by roasting at 700°C.

It can be seen that there is considerable improvement, up to 700°C, in the conversion of nickel oxide to sulphate by moistening the pug prior to pre-roasting at 450°C. The pre-roasted sample subjected to second stage roasting at 700°C resulted in an improvement of 16% nickel with 3% iron. This may be due to the fact that direct pre-heating at 450°C makes the process conducive for the preferential sulphation of nickel, where partial transformation of soluble iron sulphate to insoluble basic iron sulphate takes place, liberating SO₃ gas in-situ, the gas in turn reacting with nickel oxide to form nickel sulphates.

The results obtained by the addition of sulphate and chloride salts of alkali and alkaline earth metals are shown in Table 2. It can be seen that the extraction of nickel has been improved by 10% due to the addition of salts. The improvement of nickel extraction may be attributed to the decomposition of alkali sulphate, forming pyrosulphate, at higher temperature. The pyrosulphates, thus formed, are in a mobile liquid phase which wets the surface of the sulphated layer and makes the reactant surface very porous.

Addition of sulphuric acid to the ore in different proportions, ranging from 10 to 40 wt%, has been studied and the data obtained is shown in Figure 2.

It has been observed that moisture plays an important role during pugging and pre-roasting (Table 1). The XRD data of the ore shows FeO(OH) and Fe₂O₃ as the major phases and the roasted sample indicates the conversion of iron sulphate to insoluble basic iron sulphate, Fe(OH)SO₄. at 450°C and complete conversion of iron sulphate to Fe₂O₃ at 700°C.

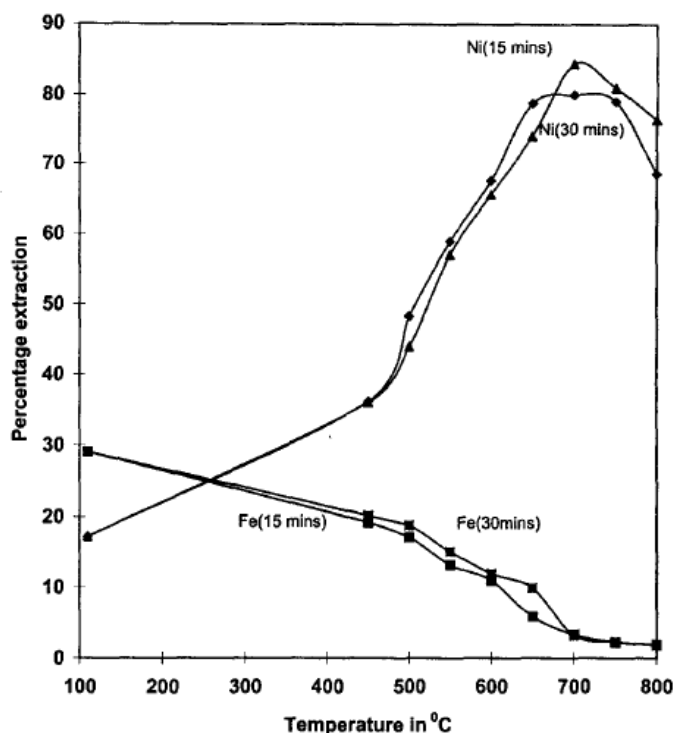


Fig.1. Extraction of nickel with time at different temperatures.

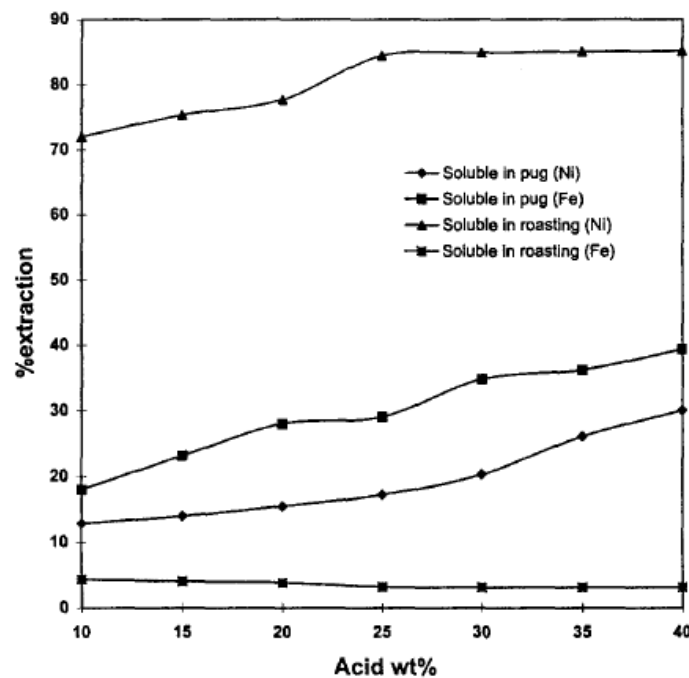


Fig. 2. Effect of acid on nickel and iron extraction.

Table1. Effect of temperature on nickel and iron extraction with and without moisture in a single stage and double stage roasting (Conditions: Sulphuric acid =25wt%, Particle size= 106 μ m, Time=15 mins, Temperature=700°C)

Additives	5wt% addition Extraction		10wt% addition Extraction		15wt% addition Extraction	
	%Ni	%Fe	%Ni	%Fe	%Ni	%Fe
Na ₂ SO ₄	90.46	3.52	94.14	3.12	96.01	3.24
K ₂ SO ₄	85.09	3.77	88.40	3.24	88.60	3.21
MgSO ₄	84.92	3.65	86.72	3.20	86.99	3.32
Al ₂ (SO ₄) ₃	85.38	3.54	87.98	3.40	90.40	3.41
NaCl	90.88	3.28	92.63	3.09	93.48	3.21
Seawater	87.64	3.13	89.21	2.99	90.32	3.19
CaCl ₂	86.45	3.00	89.98	3.09	90.98	3.22

Table2. Double stage roasting using alkali and alkaline salts of sulphates and chlorides (Conditions: Sulphuric acid =25wt%, Particle size= 106 μ m, Time=15 mins, Temperature=700°C)

Additives	5wt% addition Extraction		10wt% addition Extraction		15wt% addition Extraction	
	%Ni	%Fe	%Ni	%Fe	%Ni	%Fe
Na ₂ SO ₄	90.46	3.52	94.14	3.12	96.01	3.24
K ₂ SO ₄	85.09	3.77	88.40	3.24	88.60	3.21
MgSO ₄	84.92	3.65	86.72	3.20	86.99	3.32
Al ₂ (SO ₄) ₃	85.38	3.54	87.98	3.40	90.40	3.41
NaCl	90.88	3.28	92.63	3.09	93.48	3.21
Seawater	87.64	3.13	89.21	2.99	90.32	3.19
CaCl ₂	86.45	3.00	89.98	3.09	90.98	3.22

CONCLUSIONS

The above investigations reveal the preferential sulphation conditions and limitations of the sulphatization process. The vital factor that governs the sulphation is the contact of $\text{SO}_3(\text{g})$ with the ore at a suitable temperature.

Improved nickel extraction can be achieved by two stage roasting over single stage roasting at 700°C , 15mins roasting time with 25 wt% H_2SO_4 .

The two stage roasting has yielded 85% nickel along with 2-3% of iron. The nickel extraction is further improved by 10% with the addition of alkali metal salts.

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