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Direct solvent extraction of nickel at Bulong operations

S. Donegan *

Tati Nickel Mining Company, Hydromet, Old Matsiloje Road, Francistown, Botswana

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Abstract

Bulong Operations processed a nickel laterite resource 30 km east of Kalgoorlie, Western Australia, between April 1999 and October 2003. The Bulong refinery operated a direct solvent extraction process to recover nickel cathode from dilute leach liquor without the need for precipitation of an intermediate nickel product.

Before closing due to financial pressures, the Bulong refinery experienced significant modification and optimisation of the solvent extraction circuits. These modifications improved metallurgical performance to a level meeting or exceeding most design parameters and this paper documents the metallurgical performance of the Bulong direct solvent extraction process at the time of plant closure.

The solvent extraction process was capable of producing a nickel electrolyte suitable for electrowinning >99.8% nickel cathode, and a concentrated cobalt liquor suitable for recovering a saleable cobalt product. Typical nickel and cobalt recoveries from PLS to product liquors were 98.2% and 98.5%, respectively.

Keywords: Oxide ores; Hydrometallurgy; Electrowinning; Solvent extraction

1. Introduction

The Bulong refinery was designed to process lateritic nickel–cobalt ore, producing nickel and cobalt cathode on-site. In June 2003 it was the world's only commercial operation to have recovered Class I nickel from dilute leach liquor (<4 g/L) using solvent extraction (SX) without prior nickel precipitation. The attraction of direct SX is the potential to produce high purity, concentrated nickel and cobalt liquors at a low capital and operating cost.

The Bulong process was designed without the benefit of extensive continuous pilot scale testwork and several process deficiencies were encountered. Initially the SX circuits were unable to achieve design availability, throughput, recovery and product quality. Nofal et al. (2001) and O'Callaghan (2003) discuss several of these issues.

Subsequent process modification and optimisation greatly improved metallurgical performance. Despite this improvement, Bulong Operations was unable to overcome the considerable financial burden present since commissioning, and was closed in October 2003.

The objective of this paper is to document the metallurgical performance of Bulong's direct SX process prior to closure. It is hoped that the lessons learned and progress made at Bulong will be used to further develop direct SX, and establish it as a competitive technology for the winning of nickel.

2. Process description

In June 2003 the nickel laterite resource at Bulong comprised 150 Mt with a mineable reserve of 6.9 Mt at 1.57% Ni and 0.12% Co (non JORC compliant). The design plant throughput was 0.54 Mtpa of ore, to recover up to 9500 tpa LME grade nickel cathode and 640 tpa >99.8% cobalt cathode.

The leach plant consisted of ore preparation, pressure leaching with sulfuric acid, slurry neutralization, counter-current decantation (CCD) and solution neutralization to

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* Tel.: +267 71319635; fax: +267 2411078.
E-mail address: sdonegan@tatinickel.co.bw

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Table 1
Bulong PLS composition

g/L	Typical	Min	Max	Design
Ni	2.8	2.4	3.5	3.2
Co	0.21	0.16	0.29	0.22
Fe	0.002	<0.001	0.010	<0.001
Al	<0.001	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	0.005	<0.001
Zn	0.03	0.02	0.04	0.05
Cu	0.003	<0.001	0.01	–
Mn	0.75	0.55	0.90	0.84
Mg	16	14	20	20
Ca	0.56	0.55	0.60	–
SO_4	97	80	120	–
Cl	80	75	95	85
TSS	0.05	0.02	0.1	0.05
pH	5.5	4.5	5.8	4.5
Flow	350 m^3/h	240	410	385

produce a mildly acidic sulfate based pregnant leach solution (PLS) containing low levels of iron, aluminium and chromium, and saturated with calcium (Table 1). A detailed description of the leach plant is beyond the scope of this paper, and only those issues effecting PLS quality will be discussed herein.

A flowsheet of the Bulong refinery is given in Fig. 1. PLS was fed to cobalt solvent extraction (CoSX) where an organic containing Cyanex 272 (C272) separated cobalt, zinc, iron, copper and manganese from nickel (Tables 2 and 3). Eleven mixer-settlers were used in a five extract, one scrub, three strip, one stripped organic wash, one raffinate wash configuration.

The cobalt in loaded strip liquor (LSL) was separated from manganese and magnesium by sulfide precipitation with nickel, iron (III), zinc and copper co-precipitating. The barren liquor was sent to tails while the filtered sulfide product (Table 4) was bagged for dispatch or reslurried and processed in the cobalt refinery. The refining of cobalt sulfide at Bulong was suspended in November 2001; Sole and Cole (2003) describe the refining process.

Table 2
CoSX raffinate

g/L	Typical	Design
Ni	2.8	3.1
Co	0.003	<0.001
Zn	0.0001	–
Cu	0.0006	–
Mn	0.001	<0.001

Table 3
CoSX loaded strip liquor

g/L	Typical	Design
Co	9.0	8.0
Ni	0.03	0.01
Zn	1.1	0.8
Cu	0.1	0.07
Mn	23	30
Mg	28	40
pH	1.7	2.0

Table 4
Cobalt sulfide

%w/w	Typical	Design
Co	45	51
Ni	0.14	0.07
Fe	0.20	0.15
Zn	5.4	4.4
Cu	0.52	0.38
Mn	1.2	0.51
Mg	0.8	0.08
S	30	30
Moist	38	50

CoSX raffinate was directed to the nickel solvent extraction (NiSX) circuit where an organic containing Versatic 10 (V10) separated nickel from calcium and magnesium. Ten mixer-settlers were used in a four extract, two scrub, three strip, one V10 recovery configuration. NiSX raffinate

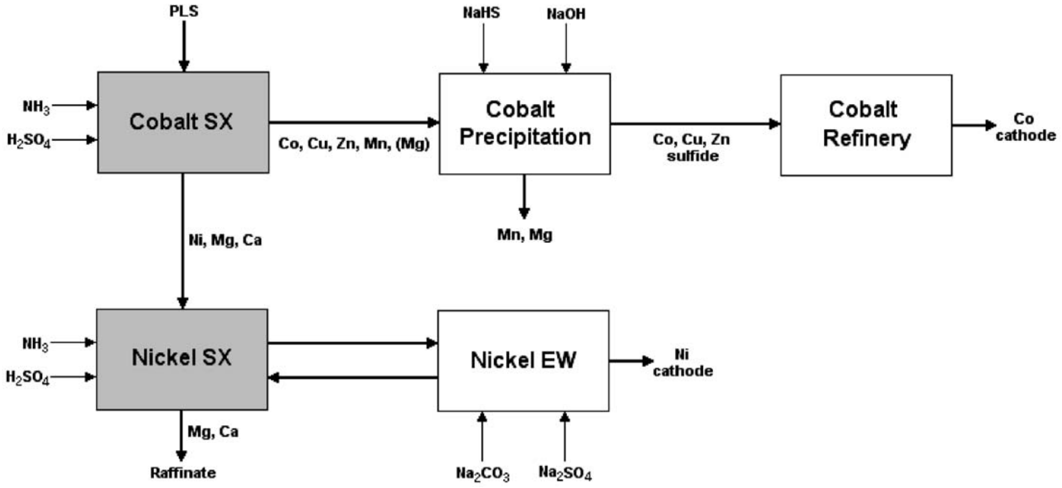

Fig. 1. Bulong refinery flowsheet.