Available online at www.sciencedirect.com
SCIENCE DIRECT®

Hydrometallurgy 82 (2006) 164–171

hydrometallurgy

www.elsevier.com/locate/hydromet

A new technique for extraction of platinum group metals by pressure cyanidation

Jing Chen *, Kun Huang

College of Chemistry and Material Engineering, Yunnan University, Kunming 650092, PR China

Abstract

At room temperature and pressures, the reaction between sodium cyanide and platinum group metals (PGMs) does not occur because of poor kinetics. However, at elevated temperatures between 120 and 180 °C, PGMs can be leached by sodium cyanide like the reaction of gold. In this work, a new technique to treat Pt–Pd sulfide flotation concentrates and spent auto-catalysts by pressure cyanidation is put forward, and the results of 5 kg-scale batch experiments in a 50 L autoclave are reported for process development. The cyanide leaching reaction mechanism is also discussed. For flotation concentrates containing about 80 g/t Pt and Pd, after pre-treating by pressure acid leaching, followed by two steps of pressure cyanide leaching, up to 90–94% Pt and 99% Pd extraction could be achieved. Final concentrates obtained from cyanide leaching solution using zinc cementation contained 70–90% of precious metals. For spent auto-catalysts containing ≈1000–2000 g/t Pt+Pd+Rh, after a pre-treatment process to remove the wrapping of the catalyst carrier and to rid surface accumulated carbon and gasoline contaminants, followed by two steps of pressure cyanide leaching, the recoveries of Pt, Pd and Rh were 95–96%, 97–98% and 90–92%, respectively.

Keywords: Platinum group metals; Flotation concentrates; Spent auto-catalysts; Pressure cyanidation; Leaching mechanism

1. Introduction

The content of platinum group metals (PGMs) in proterozoic platinum ores is about 1–10 g/t, while in Cu–Ni sulfide ores containing PGMs, the content is only 0.1–1 g/t. By flotation, the content of PGMs is concentrated to more than 100 g/t. For flotation concentrates, the traditional treatment method is matte smelting where the PGMs are concentrated in the mattes. The matte is then hydrometallurgically treated to leach and separate Fe, Co, Ni and Cu leaving a slime containing 10–50% of precious metals.

Direct hydrometallurgical processing of flotation concentrates has been considered impossible (Liu, 2001), because of the complicated solution components and low recoveries. At room temperature and atmospheric pressure, sodium cyanide cannot also react with PGMs like the reaction of gold, because of poor kinetics (Feather, 1978; Dawson, 1984). It has been reported (Bruckard et al., 1992; Bruckard, 1998; McInnes et al., 1993; Duyvesteyn et al., 1994) that when concentrates are reacted with sodium cyanide at 100–125 °C and pH 9.0–10.0 for 6 h, the Pd and Pt leached could reach 90% and 80%, respectively. However, the ore used in the best case was from Coronation Hill after amalgamation to extract

---

* Corresponding author. Tel./fax: +86 871 5032180.
E-mail address: Chjing@ynu.edu.cn (J. Chen).

0304-386X/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.hydromet.2006.03.041

gold. This ore is highly oxidized with a sulfur assay of only 0.1%. Clearly, the mineral composition of most oxidized ores is largely different from that of sulfide flotation concentrates. For sulfide flotation concentrates, it is almost impossible to extract PGMs economically using sodium cyanide. Therefore, there have been no reports so far on the treatment of such concentrates by cyanidation.

Smelting has serious environmental impacts and the lengthy overall flowsheet results in unavoidable losses of PGMs. When the mattes are acid leached to separate base metals, the content of PGMs in residues is never above 50%, leading to difficulties in the PGM refinery. To avoid these limitations a new all hydrometallurgical two-stage process for the extraction of PGMs from sulfide flotation concentrates has been suggested (Chen et al., 2005). The sulfides are pre-oxidized by pressure acid leaching to remove the base metals and expose PGM minerals; the residue is then subjected to pressure cyanidation to recover the PGMs. Up to 90–94% Pt and 99% Pd extraction could be achieved, and cementation of the final solution with zinc powder resulted in a PGM concentrate containing about 70–90% of precious metals.

Automobile catalysts have been one of the main consumers of PGMs so far, and much attention has been paid on PGM recovery from such wastes (Mishra, 1993; Hoffmann, 1988; Huang and Chen, 2004a,b). Oxidized acid leaching of spent auto-catalysts was considered unsatisfactory (Guo et al., 1999; Wu et al., 1993), partly because of high reagent consumption, severe pollution, instability of PGM extraction, and low recoveries of rhodium etc. The US Bureau of Mines (U.S.B.M.) had conducted some successful exploration trials on recovering of PGMs by high-temperature cyanide leaching (Atkinson, 1992; Desmond, 1991). However, the recoveries reported were only 80–85% Pt and Pd, and 70–75% Rh, respectively. The consumption of cyanide in the leach process was also high because the cyanide was affected by the composition of the catalyst substrate including metal, carbon and gasoline contaminants on the surface. Thus appropriate pre-treatment methods are required. A new pre-treatment procedure (Chen and Huang, 2001) was suggested, which was different to those reported elsewhere. The spent auto-catalysts are pre-treated by pressure alkaline leaching, followed by two steps of pressure cyanide leaching, which achieves recoveries of Pt, Pd and Rh of 95–96%, 97–98% and 90–92%, respectively.

Table 1
Chemical analysis results of typical Jinbaoshan flotation concentrates

Elements	Pt	Pd	Cu	Ni	Co	Fe	S	MgO	SiO_2
	(g/t)					(%)			
Content	34	52.4	3.45	3.86	0.24	14.8	13.4	19.3	26.9

Table 2
Typical content of PGMs in spent auto-catalysts from Multimetco, Inc.

Elements	Pt (g/t)	Pd (g/t)	Rh (g/t)
Content	818.3	516.7	213.8

In present paper, the results of pre-treating and leaching a copper–nickel sulfide flotation concentrate and an automobile catalyst are compared and the reaction mechanism of pressure cyanide leaching of PGMs is discussed.

2. Experimental

2.1. Samples tested

2.1.1. Flotation cons

Table 1 shows the typical chemical composition of a copper-nickel sulfide flotation concentrate sample kindly provided by Jinbaoshan Platinum Mine (Yunnan Province, PRC).

2.1.2. Auto-catalysts

Table 2 shows the typical content of PGMs in spent auto-catalysts samples, provided by Multimetco, Inc. (Anniston, Alabama 36207, USA).

2.2. Testing apparatus

A 50 L autoclave (TFYXD-50 type, 316 L stainless steel, electrical heated) was used for the tests. The max design pressure, temperature and agitation speed for the autoclave are 7.0 MPa, 350 °C and 500 rpm, respectively.

The mineralogical investigations of leaching residues were carried out by X-ray Diffraction (XRD; DMAX-RC, Japan), Scanning Electron Microscopy (SEM; JEOL, JSM-5610) and X-ray Energy Dispersive Analysis (EDAX; ThermoNoran, Vantage DSE), respectively.

2.3. Testing procedures and typical autoclave leaching conditions

2.3.1. Flotation cons

The new all hydrometallurgical technique for treating sulfide flotation concentrates containing PGMs includes the following procedures: flotation concentrates → pre-treatment by pressure oxidized acid leaching → two stages of pressure cyanide leaching → Zn cementation → precious