Leach Optimization of “Tumurtiin-Ovoo” Zinc Concentrate in Sulfuric Acid

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***Abstract*—Tsairt Mineral LLC is a joint venture of Mongolia and China. The company develops the Tumurtiin-Ovoo zinc project in Sukhbaatar province, Mongolia. Samples for investigation were taken Tsairt Mineral LLC’s zinc concentrate and roasted at 900^{0}C for 10 hours. This zinc concentrate contains 64% zinc.**

This paper is devoted to sulfuric acid leaching kinetics of Tsairt Mineral LLC’s zinc concentrate. The results of the investigation on optimization leaching conditions of zinc concentrate in diluted sulfuric acid are presented. Effect of sulfuric acid concentration, liquid volume, particle size, temperature, speed of mixer and time in the leach liquor on the rate of dissolution were determined.

The results obtained show that dissolution of about 94.41% zinc is achieved using 0.076 mm particles at a reaction temperature 70^{0}C, stirring speed 1000 rpm, with 50 g/l sulfuric acid concentration. The solid liquid ratio was maintained at a constant value of 1:40 g/ml and experiment duration was 1 hour.

Keywords: Sulfuric acid leaching, Kinetic, zinc concentrate, Tumurtiin-Ovoo, Tsairt mineral

I. INTRODUCTION

Tsairt Mineral LLC is a joint venture between Metal Impex (49%), a Mongolian firm and China Non-Ferrous Metal Industry’s Foreign Engineering and Construction Co (NFC in short, 51%). The company develops the Tumurtiin-Ovoo zinc project, in Sukhbaatar province, Mongolia. The joint venture was established in 1998, and the mine and concentrate plant went into production in 2005. According to NEC’s website, the company had produced 2.2 million tons of zinc concentrate by July 2009. The average grade is 13.6%, and the mine life is planned to be 25 years.

The company mines 350-400 thousand tons of ore per a year, and sells about 90-110 thousand tons of 50% zinc concentrate a year. The deposit was discovered in 1974 by Mongolian and German surveying teams. In 1980 the resource at the deposit was calculated to be 9.2 million tons of ores (grade B, C1 and C2 according to the Mongolian standards), which was interpreted to be 951 thousand tons of pure metal. 90% of the ore are sulfides, and the rest are carbonates and silicates [1].

Both pyrometallurgy and hydrometallurgy processes are practiced worldwide to treat zinc production [2]. We have been studying to produce zinc oxide from Tumurtiin-Ovoo zinc concentrate by hydrometallurgical method [3-4]. We used zinc concentration sample roasted at 900^{0}C for this investigation. Leaching is the first step in the hydrometallurgical route and leaching kinetics is important from the economic point of view.

The kinetics and mechanism of sphalerite leaching from complex sulfide concentrate with sulfuric acid and sodium nitrate solution at standard conditions was presented in some paper [5-8]. But there haven’t Tumurtiin-Ovoo zinc concentrate’s leaching investigation in any acid. Therefore, this paper presents the result of leaching kinetic study of Tumurtiin-Ovoo zinc concentrate in diluted sulfuric acid.

I. II. METHODOLOGY

Sample of zinc concentrate from Tumurtiin-Ovoo zinc concentrate plant and roasted at 900^{0}C during 10 hours. The chemical composition of zinc concentrate, as determined by X-ray fluorescence (XRF) spectroscopy method, is given in Table 1. Zinc concentrate’s chemical composition published in our previous study [9].

TABLE 1. CHEMICAL COMPOSITION (%WT) OF ROASTED AT 900^{0}C ZINC CONCENTRATE

AI	Si	S	Ca	Mn
0.188	0.944	0.214	0.455	4.636
Fe	Cu	Zn	Pb	O
6.682	0.161	64.071	0.264	22.385
Total 100%				

We also detect zinc content by titration method with Na**2**H**2**EDTA (complexon III) and Eriochrome Black T. Before detecting zinc in the zinc concentrate, sample was dissolved in mixture of HCI and HNO_3 completely. The solution contains certain amount of iron and manganese. Therefore solution was separated from iron and manganese before detecting zinc content. By adding ammonium solution until pH= 9, iron and manganese were precipitated from the solution. Bases of iron and manganese were separated from solution by filtration. Zinc was determined by complexon III in the presence of Eriochrome Black T.

Eriochrome Black T (EBT) forms a wine-red colored complex with Zn^{2+} ions in solution at a pH of about 10 (obtained by adding ammonia solution). Na**2**H**2**EDTA forms a stronger complex with the Zn^{2+} ions and liberates free EBT, which has a blue color. One mole of Na**2**H**2**EDTA complexes react with one mole of Zn^{2+} ions and liberate free EBT.

Na**2**H**2**EDTA + Zn^{2+} → ZnH**2**EDTA (complex) + 2 Na^+ (I)

Before detecting zinc content added sodium fluoride in the solution for covering some ions (such as AI^{3+} and Ca^{2+}). The results of zinc content determination shown in the table 2.

TABLE 2. DETERMINATION OF ZINC CONTENT IN ROASTED AT 900^0C'S ZINC CONCENTRATE BY TITRATION METHOD

№	Mass of sample, gm	Zinc content, %	Average content of zinc
1	0.5075	64.570	64.008%
2	0.4754	64.056	
3	0.5221	63.398	

XRF investigation result was shown zinc content was 64.071% in the zinc concentrate. Titration investigation results were shown zinc content was 64.008%. The results fitted very well each other. Therefore, we used the titration methods, further study detecting zinc content.

Zinc concentrate sample grinded in ceramic mortar and sieved by different size fractions 0.3, 0.15, 0.105, 0.076 mm were prepared for study.

The leaching of zinc concentrate was conducted at room temperature in H_2SO_4 acid diluted to different concentrations. The effect of acid concentration, liquid volume, particle size, temperature, mixer speed and time on the rate of leaching was determined. Determination of zinc in the leach liquor was done by titration analysis methods.

III. RESULTS AND DISCUSSION

A. *Effect of Acid concentration*

The leaching of zinc concentrate was conducted at room temperature in sulfuric acid diluted to different concentrations. The powder size was 0.45 mm and 5g zinc concentrate (roasted 900^0C) dissolved in 100 ml acid solution during 24 hour, at ambient temperature, without mixer. Sulfuric acid concentrations were 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 g/l. Determination of zinc in the leaching liquor was done by titration method. From this investigation we chose optimal sulfuric acid concentration. The effect of H_2SO_4 concentration on leaching is shown in Fig.1. Leaching in sulfuric acid was conducted 24 hours at room temperature.

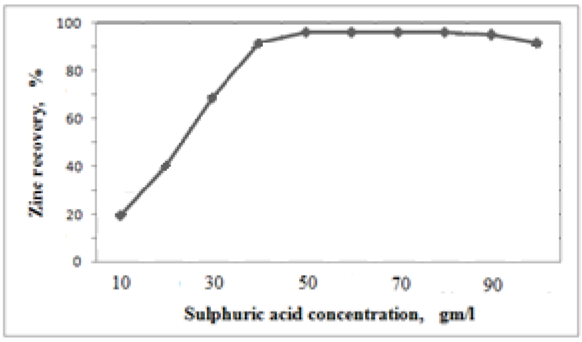

Fig. 1. Effect of acid concentration variation on zinc recovery

About 91.62% of zinc was recovered using 40 g/l acid concentration H_2SO_4. At higher acid concentration as 50 gm/l, the zinc recovery is slightly increased to 96.2%. Further increase in acid concentration leads to almost constantly to 80 g/l in zinc dissolution. From 90 g/l to 100 g/l zinc recovers slightly decreases. Subsequent experiments were conducted at 50 g/l H_2SO_4 concentration.

B. *Effect of liquid volume*

1g zinc concentrate was dissolved in different volumes (10, 20, 30, 40, 50, 60 ml) of sulfuric acid solutions (50g/l). During experiment was used cimarec-3 magnetic mixer (speed of mixer 500 rpm, 20 minute) and at room temperature. From this plot were detected optimum liquid volume of sulfuric acid and solid liquid ratio. The effect of liquid volume on the recovery of zinc from the zinc concentration sample is shown in Fig. 2. The test was conducted at room temperature for 20 minute with 50 g/l H_2SO_4 magnetic mixer, and different type of acid solution.

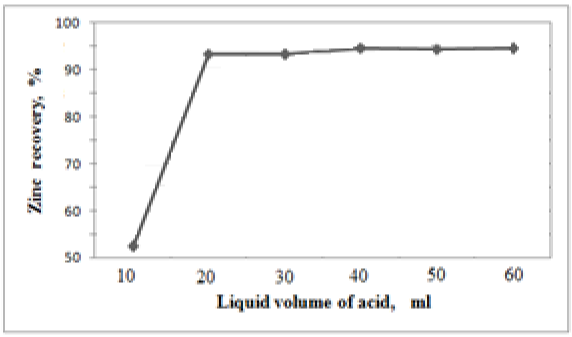

Fig. 2. Effect of liquid volume on zinc concentration

The results reveal that, the recovery of zinc increased with increasing the liquid volume. About 93.272% of zinc recovered using 20 ml acid volume H_2SO_4. Further zinc recovery almost constantly by increasing volume of acid until 60 ml H_2SO_4. Maximum zinc was recovered 94,627% when adding 40 ml H_2SO_4. Liquid volume 40 ml for 1g solid zinc concentration was selected as the optimum condition and was applied to subsequent experiments.

C. Effect of powder size

The sample was ground then sieved different size fractions by using 0.3, 0.15, 0.105, 0.076 mm mesh sieve. 1gm different size of sample was dissolved in sulfuric acid with 50 g/l concentration and 40 ml volume. Optimum powder size was detected from these plots of investigation. The effect of particle size on leaching of zinc concentration in 50 g/l H_2S0_4 acid for a period of 20 minute, with magnetic mixer is shown Fig. 3.

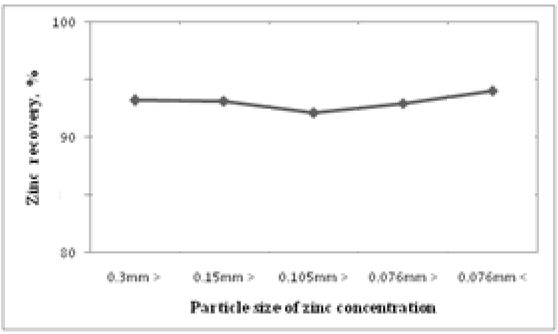

Fig.3. Effect of particle size on zinc concentration

It can be seen that, zinc in solution almost constant with a decreases in size of the particles. But particle size 0.076 mm was selected as the optimum condition and was applied to subsequent experiments. This is to be expected, as the particle size decreases the surface area increases, and hence the rate of reaction increases.

D. Effect of temperature

Maximum extraction of zinc's leaching conditions was used effect of temperature investigation. The temperatures investigated were 23^{0}C, 30^{0}C, 40^{0}C, 50^{0}C, 60^{0}C, 70^{0}C, 80^{0}C. Experiment conditions were 23-80^{0}C, mixer speed 500 rpm of cimarec-3 magnetic mixer and continued 20 minute. 1gm sample was dissolved in 40 ml sulfuric acid with 50 g/l concentrations. The temperature plot gave the maximum zinc extraction during leaching in sulfuric acid. With increasing temperature, the dissolution rate of zinc is increased slightly. The results are shown in Fig. 4.

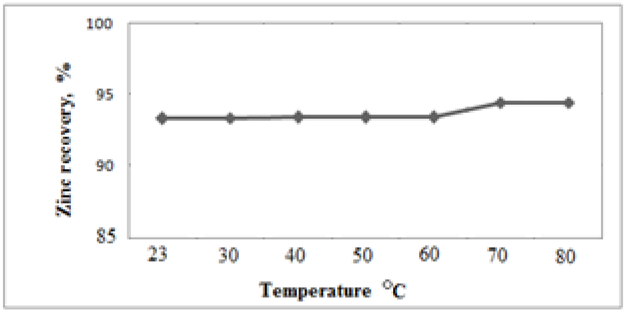

Fig. 4. Effect of temperature on zinc recovery

When temperatures were 23, 30, 40, 50, 60, 70, 80^{0}C zinc recovery were subsequently 93.273%, 93.301%, 93.348%, 93.374%, 93.348%, 94.410%, 94.381%. Maximum zinc content was recovered at 70^{0}C. But this result's difference about 1% from room temperature condition (23^{0}C). Subsequent experiments were conducted at 23^{0}C.

E. Effect of stirring speed

Cimarec-3 magnetic mixer has 10 different type of mixing speed from 100 rpm to 1000 rpm. When leaching 1 g sample was conducted in sulfuric acid were 50 g/l concentration, 20 ml volume and 20 minute continued. Grade of stirring speed were 300, 500, 700, 900, 1000 rpm. We detected optimum stirring speed when leaching process from the investigation. The effect of mixer speed on the recovery of zinc from the zinc concentration sample is shown in Fig. 5. Grade of mixer speed were 300, 500, 700, 900, 1000 rpm.

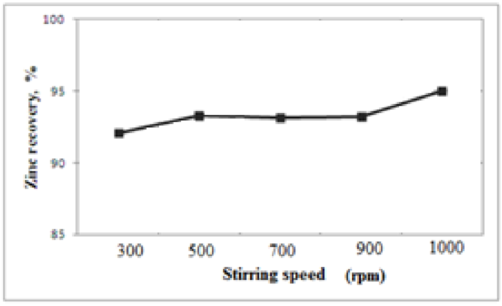

Fig. 5. Effect of stirring speed on zinc recovery

With increasing speed of mixer the dissolution rate of zinc is increased. 1000 rpm mixer speed was selected as optimum retention mixer speed when 95% of zinc dissolved.

F. Effect of time

Leaching best conditions was used to study effect of time investigation. During experiment conditions were: powder size 0.076 mm, sulfuric acid concentration 50 g/l, volume 40 ml, speed of mixer 500 rpm. 1 gm sample was leached at room temperature for 10, 20, 30, 60, 120 minutes. From a plot of zinc in solution at different times, the time that gives the maximum extraction during leaching was determined. Results of leaching of zinc concentrate at room temperature (23^{0}C) in 50g/l sulfuric acid solution for different periods of time as determined the content of zinc in the leach liquor, is shown in Fig. 6.

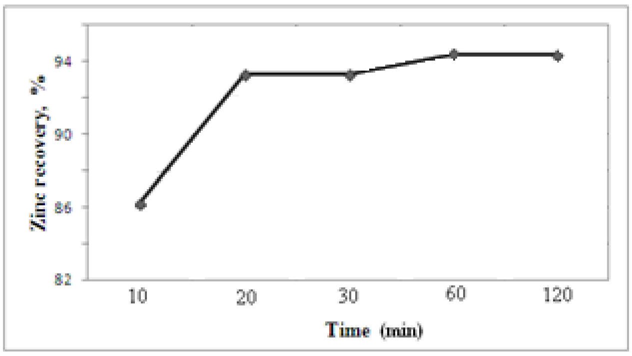

Fig.6. Effect of time on zinc recovery

More than 93.27% of zinc dissolved after only 20 minute of leaching, further increase in time lead to only a slight increase in zinc dissolution. Time of 1 hour was selected as optimum retention time when 94.4% of zinc dissolved.

IV. CONCLUSION

There was detected the optimum leaching conditions of "Tumurtiin-Ovoo" zinc concentrate in sulfuric acid solution. The effect of acid concentration, liquid volume, particle size, temperature, stirring speed and leaching time were investigated. The best condition of leaching was found to be: sulfuric acid concentration-50 g/l; solid liquid ration 1:40 g/ml, particle size under 0.076 mm, temperature 70^0C, stirring speed 1000 rpm and leaching time 1 hour. Zinc recovery was 94.41% at optimal leaching condition.

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