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TREATMENT OF GOLD-BEARING SOLUTIONS BY CEMENTATIONS WITH METALLIC ZINC

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Pregnant solutions containing dissolved gold and silver after leaching of an oxide ore by means of amino acids of microbial origin and thiosulphate ions were treated by cementations with metallic zinc to precipitate the precious metals. The treatment was carried out in cementator with mechanical stirring under batch conditions. The optimum conditions with respect to the pulp density , particle size distribution of the zinc powder , pH ,Eh , temperature and residence time were established . The prior deaeration of the gold-bearing solutions to dissolved oxygen concentrations lower than 1 mg/l facilitated the cementation process by decreasing the zinc consumption. Under the optimum conditions , more than 98% of the gold was precipitated by the cementator from pregnant solutions containing from 0.5 to 5.0 mg/l gold .

INTRODUCTION

Zinc-dust cementation for gold and silver recovery, also well-known as the Merill-Crove process is the one of the most common contact – reducing processes in hydrometallurgy (*Nicol et al., 1979*). Cementation is the electrochemical precipitation of one metal by using another metal as a reducing agent. Zinc is element that has been studied for use as cementing agent for gold/silver pregnant solutions (*Tran et al., 1991*).

$$2Au(CN)^{2-} + Zn^0 \rightarrow 2Au^0 + Zn(CN)^2{}_4$$

$$2Au(CS(NH_2)_2)^+{}_2 + Zn^0 \rightarrow 2Au^0 + 4CS(NH_2)_2 + Zn^{2+}$$

$$Au_2S_2O_3 + Zn^0 \rightarrow ZnS_2O_3 + 2Au^0$$

The treatment technologies of mineral row materials contains refractory gold ores , are an aggregate of chemical, biological, and physical processes. Gold –bearing solutions have been treated by means of different type methods. Thiosulphate leaching of gold is a proposed alternative to cyanide leaching (*Potter, 1980; Hsu et al., 1996 and McDougall et al., 1981*), in this technology are well-known that common used adsorption onto active carbon doesn't give a good results. Zinc–dust cementation are only one alternative method for the process.

Technological realizations of cementation process have to obtain and include following stages –clarification of production solution, deaeration, addition of zinc-dust, and extraction of gold-zinc dust. This succession has been determinate by factors effecting into cementation –concentration of Au/Ag in solution, preliminary deaeration, temperature, pH, stirring speed, addition of surface active agents (*Miller et al., 1990; Nguyen et al., 1997*).

Chemical reactors applying for cementation by using zinc powder possess different construction according to kind of zinc and way of reactor operation. In wide spread practice are applying following type reactors- fixed bed reactors, fluid bed reactors, drum type reactors with granular zinc , airlift reactors and stirring type reactors (*Ornelas et al., 1998*). On different examination are investigating to cement noble metals into Fe, Cu, and Al (*Zarraa, 1996; Guerra et al., 1999*).

This study focused on task to testing batch-scale reactors working with zinc powder on real pregnant solutions. Here are investigate how the factors of different suspension conditions, influence of paramilitary deaeration , resistant time affecting gold cementation performance using zinc dust. This data will be give information for scale up the cementation process.

EXPERIMENTAL

Investigation the process for treatment of gold –bearing solutions by cementation with metallic zinc was project and constructed batch –scale installation –fig.1.In this scheme in cementator are combined structures include reaction column where by mechanical stirring are suspended zinc powder and vertical settlings tank for accumulation a cementation product.

A mutual agreement on Fig.1 the way of operation in selected technological scheme is –production solution pumped into peristaltic pump 8 in deaeration column made of acrylic plastic with high 960mm and diameter 100 mm (volume 7,5 dm^3) During the operation are provide for level of liquid phase reach to 2/3 by volume of the column (volume 5 dm^3).

Table 1. Granulometric analyses of zinc dust

μm	**250**	**250 - 160**	**160 - 100**	**100 - 80**	**80 - 63**	**63 - 48.4**	**48.4 - 34.4**	**34.4 - 29.5**
%	5.45	10.42	1.76	25.78	5.09	16.12	0	8.09
μm	**29.5 - 25.5**	**25.5 - 19.3**	**19.3 -16.9**	**16.9 –12.9**	**12.9 -8.6**	**8.6 - 5.0**	**5.0 - 1.3**	**< 1.3**
%	7.06	3.65	4.22	4.17	2.68	3.19	1.65	0.67

Deaeration process was supply with oil vacuum pump "Edwards-4". Peristaltic pump "Ismatech" delivery a smoothness control for output flow in range 0÷1,150 dm^3 /min. Automatic titration system "Metrom"-7 delivery optimal pH in cementation column reactor. Production solution inflow under bottom the reactor 5 around the thrust bearing and get in touch the zinc dust suspension. The agitator shaft is overall length about 720 mm. The type of agitation system is three –section frame mixer. After precipitation of zinc product in settlings tank, pure solution outflow into collector tank 11.Here is possible to heating reaction column by water shirt with supplying on water bath 8.

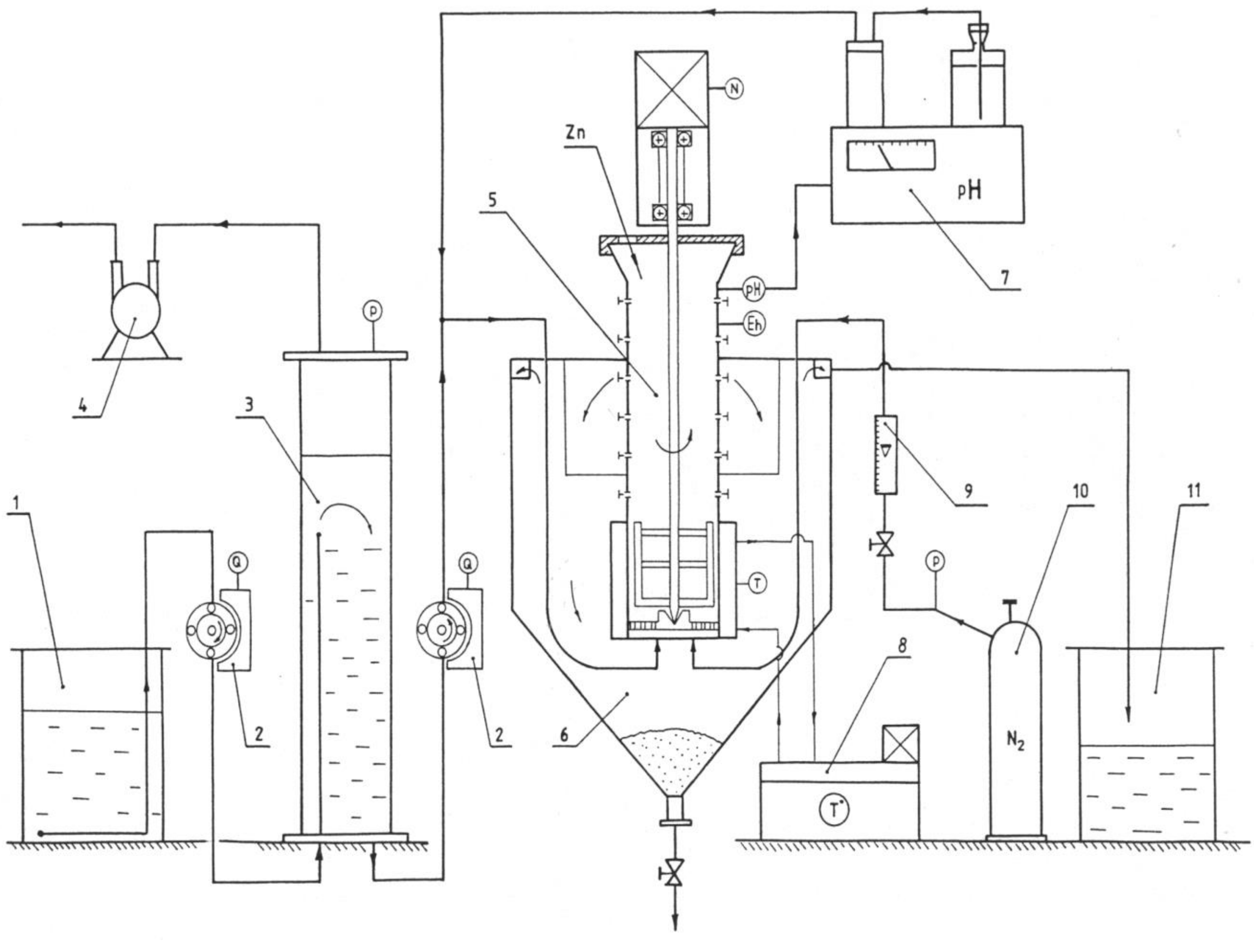

Figure 1. Batch-scale cementation installation

1 – Production solution tank, 2 – Peristaltic pump, 3 – Deaeration column , 4 – Vacuum pump, 5 – Reaction cementation column, 6 – Settlings tank, 7 – Automatic titration system, 8 – water bath, 9 - Rotameter, 10 – Nitrogen cylinder, 11 – Collector tank.

There is a possibility to feed the cementator with nitrogen from bottom into plastic distributor, each hole with range 50÷100 μm in diameter. Zinc dust with is use for the cementation process was made on "KCM"Ltd. Plovdiv with no regular granulometry, Table 1 was showed results on granulometric analyses. For establishment cementation conditions in batch scale installation was made a several group experiments.

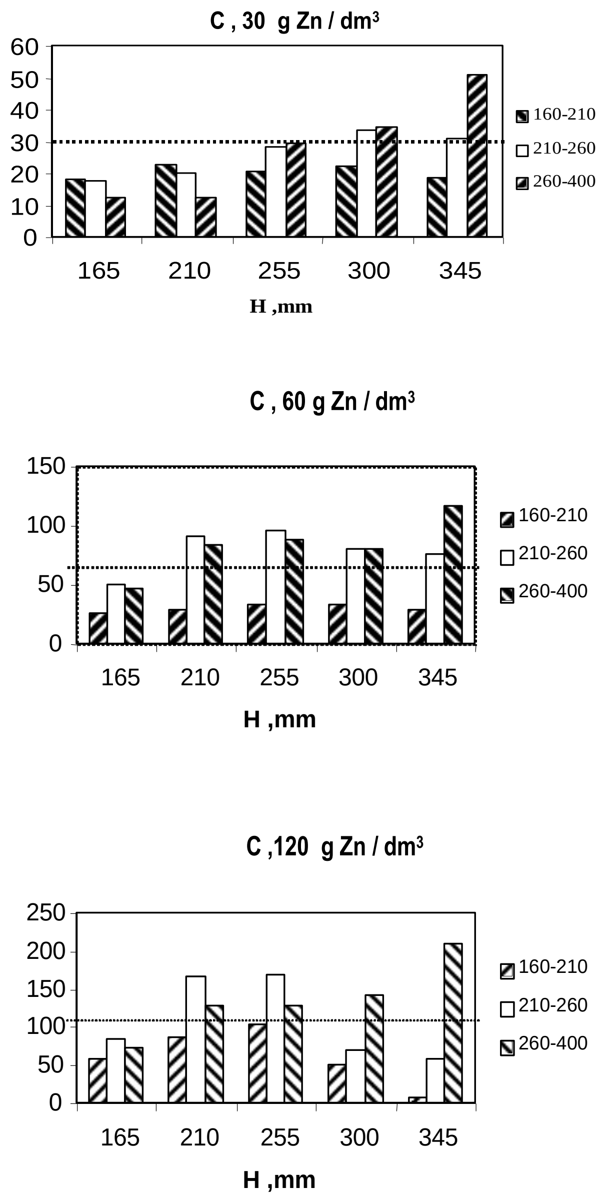

Figure 2. Dispersion of zinc dust suspension on different concentrations

The first series of experiments aim to establish suspension conditions in reactor column. This aim was needed to set conditions of suspending in reactor column volume onto three different concentration of zinc dust -3%,6%,12% . Besides the cementation conditions will be observe onto three different range of stirring (160-210 min^{-1}, 210-260 min^{-1} and 260-400 min^{-1}). Distribution of suspension was established by sampling into five column levels. The samples were filtering through "blue-line" filter paper, drying onto constant dry weight, and measured on analytical balance.

The second series of experiments aim to establish distribution on granulometry of zinc dust in reaction column. These experiments were demand for making to establish suitable conditions on suspending in reactor and sampling of three different points onto column. The granulometry of these samples were compared with starting granulometry of zinc dust.

Other main aim is setting of deaeration condition on production solution inflow to the cementation reactor. This aim have exact for measuring of dissolved oxygen onto different vacuum conditions, temperature influence, and stirring speed influence. For measuring dissolved oxygen was used polarographic sensor "Ingold".

The last experiments are connected with establishment of precipitation speed by the three different concentration s of zinc powder (3, 6, 12g/dm^3) in suspension. The test was made in measure cylinder with 1dm^3 volumes and visual reading of clear layer. The part of this experiment is testing a work of settlings tank in steady-state conditions. The mass –input flow onto settlings tank have to be less than resistant time for gold bearing solution.

RESULTS AND DISCUSSION

The distribution of zinc particles were studied of three different concentration of zinc dust on varied rotating speed. This shown on Fig.2 where distribution of zinc powder are steadiness on rotation speed between 210-260 min^{-1} and have a large deviation from average concentration in ranges 260-400 min^{-1} and 160-210 min^{-1}.

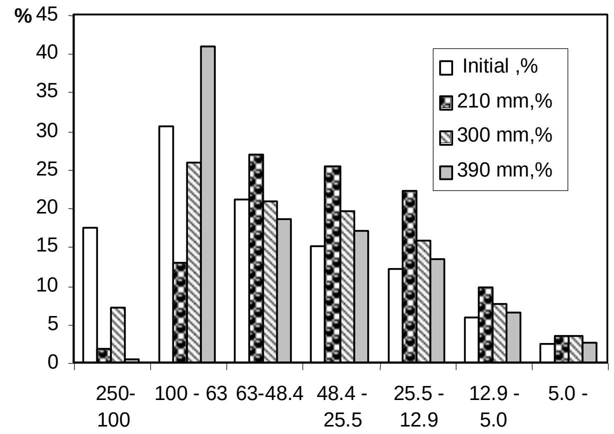

Figure 3. Distribution of classes zinc powder on column high

Distribution of different zinc dust size particles was showed on Fig.3. The reduced results on zinc particles distribution in three different high (210,300,390mm) was obtained into stirring speed 260 min^{-1}. The concentration of zinc dust in this experiment was between 6 -12% and supplying the constant level of liquid in reactor column H = 382 mm (volume 1dm^3).

The comparison between zinc dust granulometry of three different high of reaction column and initial zinc dust shown on Table1 ,be able to made a conclusion so , relative particle size classes between + 63 and -100 μm (over 30% in beginning piratical size) was increase on the high column. The coarse-grained zinc dust between +100 and -250μm, was decrease onto high to column. The fine-grained zinc dust particles between -63 and +1,3μm was distributed relatively steadiness in the middle and top of the reaction column. This results show that the zinc particles with most specific surface are present in range 210-345 mm on the column high.

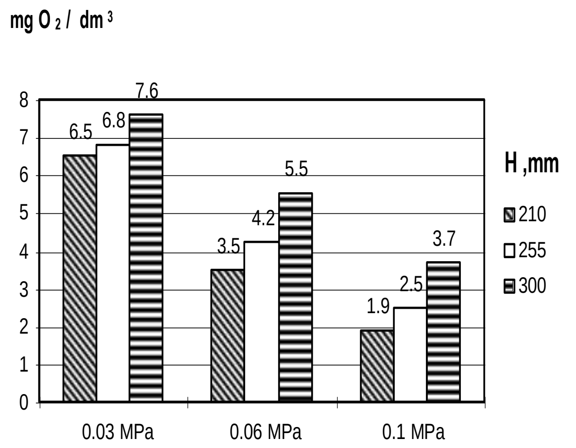

Figure 4. Dynamic of dissolved oxygen on different column high

On other group tests were measured dissolved oxygen content in reaction column with different conditions of deaeration. The input of production solution in all variants is consisting about 0,5dm^3/min. On fig.4 are showed dissolved oxygen concentrations on the column high with three different values of vacuum (0,03 MPa, 0,06 MPa, and 0,1 MPa). The temperature was 18˚C and speed of mechanical stirring 210min^{-1}. The resistant time on production solution in deaeration column was 10min (working volume 5 dm^3).

The content of dissolved oxygen on five different variants of deaeration is showed in table 2. The best results were obtained in variants with nitrogen bottom blowing and vacuum deaeration on 0,1MPa with temperature 35˚C.

Table 2 Dissolved oxygen content on different deaeration condition

№	Deaeration condition	C ,O2 mg/dm^3
1	0,1 MPa with mixing on 210 min^{-1}, 18 ^{0}C, input flow -0,5 dm^3/min	4,17
2	0,1 MPa without mixing, 18 ^{0}C, input flow - 0,5 dm^3/min	3,96
3	0,1 MPa with mixing on 210 min^{-1}, 35 ^{0}C, , input flow - 0,5 dm^3/min	1,72
4	Deaeration with N_2, 18 ^{0}C, input flow - 2 dm^3/min with mixing on 210 min^{-1}	0,93
5	Deaeration with N_2, 18 ^{0}C, input flow- 2 dm^3/min	0,72

The established dynamics of zinc dust precipitation of three different concentration of suspension are showed on Fig.5. According to obtained results was established over 95% precipitation of zinc dust for time of 300 s – 1,2 mm/s speed of settlings. In real time working the column reaction and settlings tank was established for maximally concentration of zinc dust of 22 s (input-flow 1,15 dm^3/min) in settlings tank was holed back all of zinc particles without size lower than 5 µm.

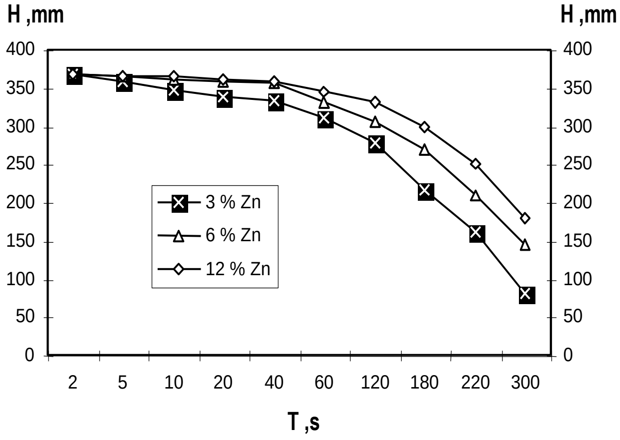

Figure 5. Precipitation diagram of different content on zinc powder

CONCLUSIONS

1. The batch scale cementator was projected and constructed for pregnant solutions containing gold and silver with 1 dm^3 working volume and 450mm high. The basic principle of work in this chemical reactor is a suspending the zinc dust with continuous precipitation in settlings tank.
2. The preparing technological scheme allows controlling cementation process with change of resistant time and, condition of preliminary deaeration.
3. The condition of suspending in cementator column was established in range 160-210 min^{-1}, 210-260min^{-1} and 260-400min^{-1}. The optimal stirring speed in cementator was obtained between 210-260min^{-1},in this conditions concentration of zinc dust change around average on the initial zinc dust material. On stirring speed between 160-210min^{-1} and 260-400min^{-1} was established no regular distribution of zinc particles.
4. Distribution of different classes zinc particles has a large variety. The coarse-grained zinc particles (between –250+160µm) was located in bottom part of column (under 165mm), the basic classes (range +63-100µm)was relatively steadiness distribute in middle part of column (165-300mm) and the fine –grained classes in range –63+1.3µm distributed steadiness in all volume of reactor column.
5. The optimal conditions of deaeration were obtained with value of vacuum over 0,1MPa in deaeration column and under the nitrogen bottom blowing in rector column. The obtained contain of dissolved oxygen in reactor column was under 1 mg/dm^3.
6. Real speed of settlings was measured on 1,2mm/s. Efficiently precipitation of zinc dust was obtain on steady-state type of workof settlings tank in maximum input-flow 1,15dm^3/min
7. Effective way of working of cementator necessary the classes of zinc dust over 160 µm and classes fewer than 5µm have to be removed.

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