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DETERMINATION OF OPTIMAL PARAMETERS FOR THE CEMENTATION PROCESS OF CADMIUM AND COPPER FROM ZINC SULPHATE SOLUTION

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Preliminary Note – Prethodno priopćenje

In the presented work, research was carried out to select the optimal parameters for the cementation process of zinc sulphate solution, from impurities in the form of copper and cadmium. This process is one of the stages of the hydrometallurgical method of zinc production, which largely determines the purity of the produced zinc. The tests were carried out in the temperature range of 20-60 °C and for the pH of the solution in the range of 3,5 - 5,0.

Keywords: hydrometallurgy, zinc, zinc sulphate, solution purification, copper cementation, cadmium cementation.

INTRODUCTION

Zinc, along with aluminum and copper, is now in the top three in terms of production volume of all non-ferrous metals in the world. The most popular technology for the production of zinc from primary sources is the hydrometallurgical method. It consists in leaching zinc oxide concentrates or roasted sulphide concentrates with solutions of sulfuric acid. The zinc sulphate solution obtained in this way, usually contaminated with copper and cadmium, is then subjected to a cementation process. The last production stage is the process of electrolytic zinc separation from the purified solution. The product of the electrolysis process is zinc which is generated on the cathode [1, 2]. One of the key stages determining the purity of the produced zinc is the cementation process of the zinc sulphate solution [4, 5].

It is also worth mentioning that the mentioned hydrometallurgical method is also widely used for the treatment of zinc oxide that is obtained from the processing of steel dust produced during the melting of galvanized steel scrap in electric arc furnaces.

As part of the presented work, research was carried out to select the optimal parameters for the cementation process of zinc sulphate solution (with the use of zinc dust), from impurities in the form of copper and cadmium. This process takes place according to the following chemical reactions:

$$CuSO_4 + Zn \rightarrow ZnSO_4 + Cu \quad (1)$$

$$CdSO_4 + Zn \rightarrow ZnSO_4 + Cd \quad (2)$$

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METHODOLOGY

A synthetic zinc sulphate solution containing 100 g/dm^3 of Zn was used as the research material. The solutions were prepared in four variants, additionally containing:

a) 0,5 g/dm^3 Cu

b) 1 g/dm^3 Cu

c) 0,5 g/dm^3 Cd

d) 1 g/dm^3 Cd

In the research, a reactor equipped with a stirrer was used to carry out the cementation process. The tests were carried out in the temperature range of 20 - 60 °C and the solution pH in the range of 3,5 - 5,0. The zinc dust was dosed with a 10 % excess in relation to the amounts resulting from the stoichiometric calculations for reactions (1) and (2), similar to industrial conditions.

Table 1 **Test results for the copper cementation process from a zinc sulphate solution containing 0,5 g/dm^3 Cu**

Solution pH	Temperature / °C	The effectiveness of cementation / %
3,5	20	32,58
	40	57,86
	60	58,18
4	20	64,34
	40	76,82
	60	90,28
4,5	20	69,37
	40	96,92
	60	97,92
5	20	70,12
	40	94,31
	60	95,67

RESEARCH RESULTS

The test results for the cementation treatment of zinc sulphate solution from impurities (copper and cadmium) with the use of zinc dust are summarized in Tables 1 - 4 and Figures 1 - 6.

Table 2 **Test results for the copper cementation process from a zinc sulphate solution containing 1 g/dm³ Cu**

Solution pH	Temperature / °C	The effectiveness of cementation / %
3,5	20	48,62
	40	65,07
	60	65,99
4	20	54,29
	40	89,06
	60	89,22
4,5	20	63,21
	40	97,16
	60	99,93
5	20	71,77
	40	94,95
	60	95,80

Table 3 **Test results for the copper cementation process from a zinc sulphate solution containing 0,5 g/dm³ Cd**

Solution pH	Temperature / °C	The effectiveness of cementation / %
3,5	20	30,99
	40	54,99
	60	56,47
4	20	78,34
	40	86.03
	60	87,41
4,5	20	88,54
	40	97,09
	60	99,80
5	20	88,12
	40	92,72
	60	94,55

Table 4 **Test results for the copper cementation process from a zinc sulphate solution containing 1 g/dm³ Cd**

Solution pH	Temperature / °C	The effectiveness of cementation / %
3,5	20	46,76
	40	59,91
	60	63,54
4	20	87,86
	40	94,10
	60	94,44
4,5	20	90,01
	40	99,23
	60	99,91
5	20	89,12
	40	95,45
	60	96,01

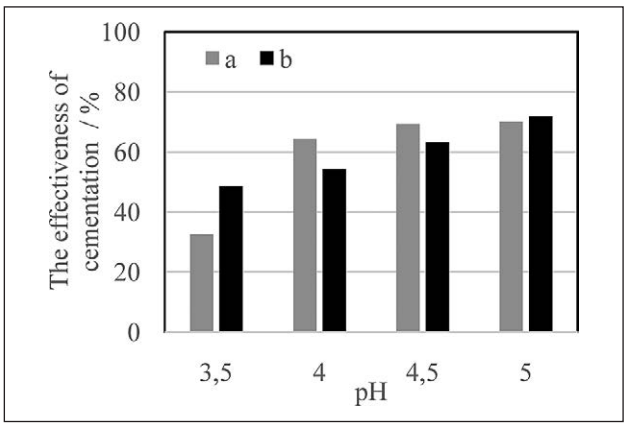

Figure 1 Efficiency of copper cementation from zinc sulphate solution at 20 °C (a – 0,5 g/dm³ Cu, b - 1 g/dm³ Cu)

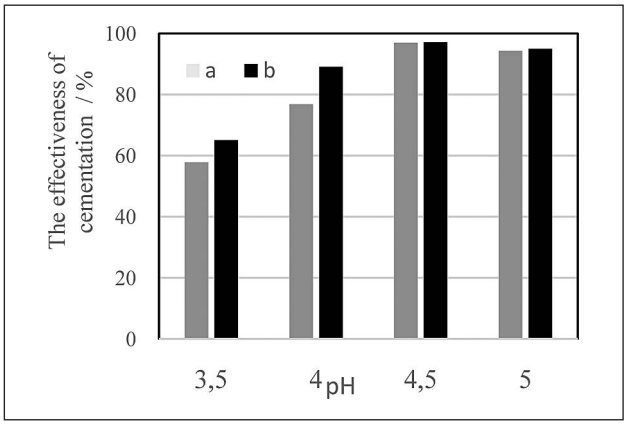

Figure 2 Efficiency of copper cementation from zinc sulphate solution at 40 °C (a – 0,5 g/dm³ Cu, b - 1 g/dm³ Cu)

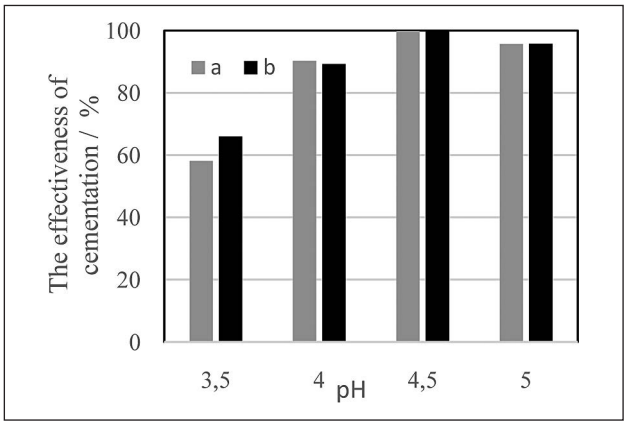

Figure 3 Efficiency of copper cementation from zinc sulphate solution at 60 °C (a – 0,5 g/dm³ Cu, b - 1 g/dm³ Cu)

SUMMARY

On the basis of the obtained results of the research on the purification process of the zinc sulphate solution from impurities (such as copper and cadmium) by cementation, it can be concluded that both the temperature and the pH of the solution have a significant impact on its efficiency.

At ambient temperature, both the removal of copper and cadmium are not satisfactory. Increasing the temperature in all cases increases the efficiency of the cementation process.

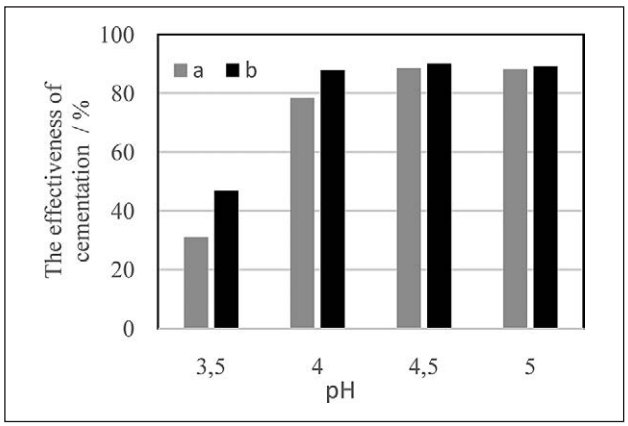

Figure 4 Effectiveness of cadmium cementation from zinc sulphate solution at 20 °C (a – 0,5 g/dm³ Cd, b - 1 g/dm³ Cd)

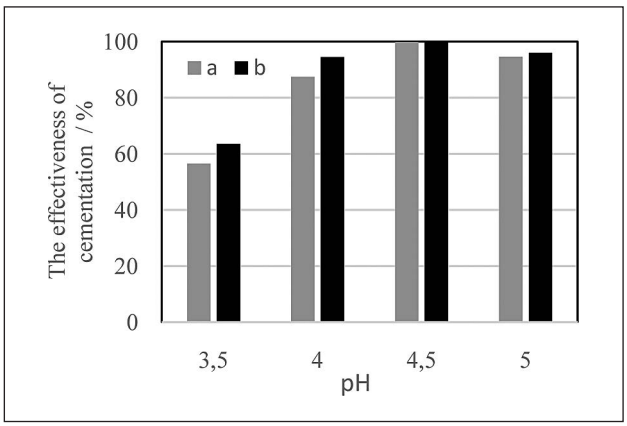

Figure 6 Effectiveness of cadmium cementation from zinc sulphate solution at 60 °C (a – 0,5 g/dm³ Cd, b - 1 g/dm³ Cd)

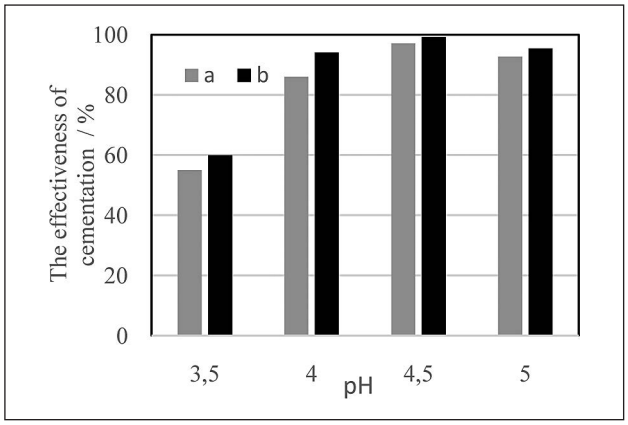

Figure 5 Effectiveness of cadmium cementation from zinc sulphate solution at 40 °C (a – 0,5 g/dm³ Cd, b - 1 g/dm³ Cd)

At the lowest pH of the solution, the effectiveness of the cementation process for cleaning the zinc sulphate solution from the above-mentioned impurities is low, i.e. between 50 and 60 %. Increasing the pH of the solution increases the cleaning efficiency, giving the best results for a value of 4,5. When the pH value is increased to 5, the efficiency of the purification process decreases.

To sum up, the most optimal parameters of the cementation process for the purification of zinc sulphate solution, both for copper and cadmium impurities is the temperature of 60 °C and the pH of the solution at the level of 4,5. The cleaning efficiency under these conditions is within the range of 99 - 99,9 %. It can therefore be concluded that the abovementioned impurities are almost completely removed. As a result, the zinc deposited at cathode during the electrolysis process will have the required high purity, i.e. at the level of at least 99,99 %.

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Note: Nowak P. is responsible for English language, Katowice, Poland