AL07 - Measurement of Metal Inventory in Pots with Zinc Dilution

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Abstract

Copper dilution process is practiced worldwide in the field of aluminium electrolysis. In this process, copper is added to the aluminium metal to establish the metal inventory in the pot by analyzing the % increment of copper in molten metal. By adding a certain amount of copper and analyzing copper content in aluminium before and after copper is added, it is possible to calculate the metal reservoir. Copper is chosen because it is neutral to bath chemistry when inserted in the liquid bath. This paper is about the use of zinc dilution instead of copper dilution for checking the metal inventory in the pot. Zinc has many advantages over copper due to its low heat of fusion, low melting point and its diamagnetic nature which is one of the most important parameters while considering any material in a high amperage potline. Zinc is also available in the market at one fourth of the price of copper. This paper uses Ellingham diagram, EMF series, Gibbs free energy for establishing the fact that zinc is a thermodynamically stable element, and that it will have no impact on bath chemistry and can be used as an alternative to copper dilution for checking the metal inventory in the pot. Many tests in the pots have shown that that the zinc dilution method is accurate, consistent and reliable.

Keywords: Aluminium pot metal inventory measurement, zinc dilution in liquid aluminium, Ellingham diagram, EMF series, heat of fusion.

1. Introduction

Copper dilution is used in the aluminium industry for checking the metal inventory in the pot. One of the major reasons for choosing copper is that it does not have an impact on bath chemistry and the purity of final finished product such as ingot, wire rod etc. obtained from cast house. Also, according to emf series a more reactive element replaces a less reactive element from its solution and as shown in Figure 1, aluminium which is more reactive element is placed above copper which is less reactive element so copper is neutral to bath chemistry.

Zinc shows the same behavior as copper as position of zinc in the emf series (as shown in Figure 1) is placed below aluminium, so it is also neutral to bath chemistry and also zinc does not affect the purity of final finished product obtained from cast house due to very low content of zinc in metal after the process of zinc dilution. While considering zinc for dilution process a number of factors are taken into account including comparison of properties of zinc and copper such as heat of fusion, magnetic properties, melting point and density in liquid phase as shown in Table 1.

As shown in Table 1 low melting point of zinc along with low heat of fusion, helps in faster dilution of zinc as compared to copper and also the diamagnetic nature of zinc is very important in a high amperage potline.

Table 1. Comparison of copper and zinc properties.

Properties	**Copper**	**Zinc**
Melting point	1083 °C	420 °C
Heat of fusion (kJ/mol)	13.2	7.32
Magnetic ordering	Diamagnetic	Diamagnetic
Density in Liquid phase(kg/m^3)	8020	6570

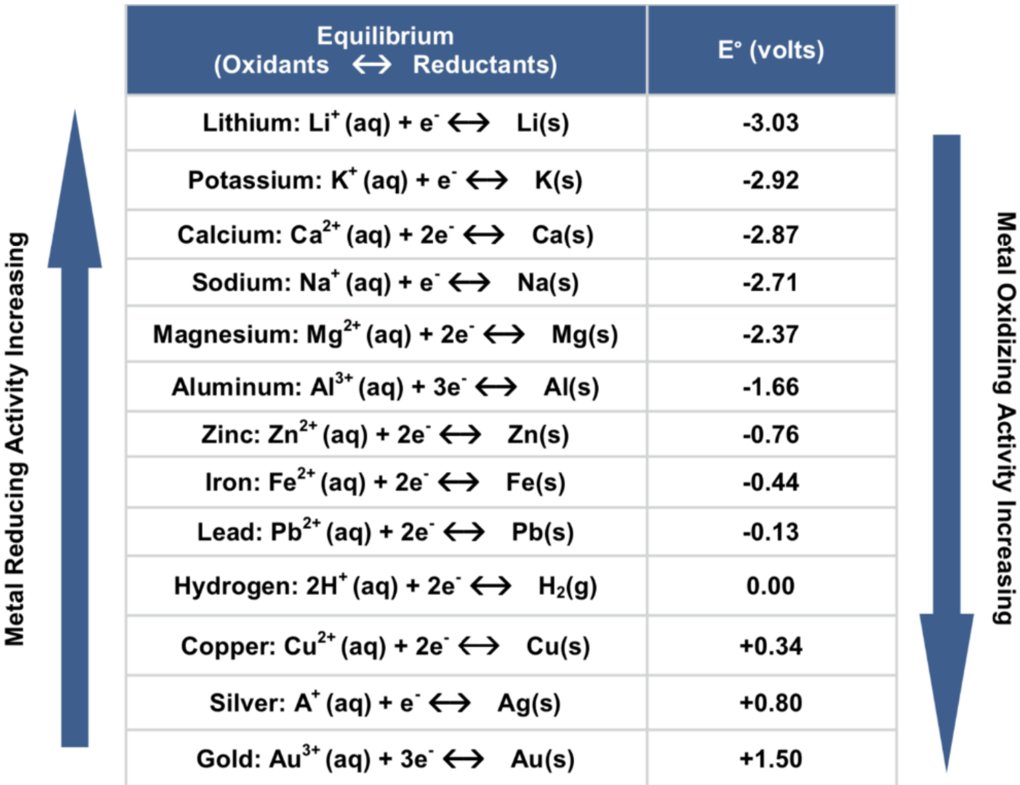

Figure 1. Electrochemical series of metals [1].

According to Ellingham diagram (plot of Gibbs free energy vs Temperature) shown in Figure 2, the change in Gibbs free energy of formation of aluminium oxide at (950-1000 °C) is more negative as compared to Gibbs free energy of formation of zinc oxide so aluminium oxide is more stable as more negative value of ΔG means the more stability of formation of oxide.

2. Experimental Procedure

To check the practical feasibility of zinc dilution in pots for calculation of metal inventory various tests are performed on 15-20 pots covering all cathode types like 100 % graphitic, 50 % graphitic and 30 % graphitic cathodes. Both zinc and copper plates are inserted simultaneously in the same pot, i.e., 2 kg each of zinc and copper plates from tap end and 2 kg each of zinc and copper plates from duct end. Purity of both zinc and copper plates is measured in central laboratory, Jharsuguda and metal/bath height (ML1) is measured at both the tap end and duct end before insertion of zinc and copper plates in the pot as shown in Figure 3. Metal sample is taken from both tap end (T_0) and duct end (D_0) before the insertion of copper and zinc plates. Voltage and line current were also recorded before starting the dilution test. After insertion of preheated zinc and copper plates metal sample is taken out from the pot 1-hour interval each up to 4 hours and poured into the mould as shown in Figures 4 and 5. The samples were numbered as T_1, D_1, T_2, D_2, T_3, D_3, T_4, D_4.

finished cast house product, which has been verified by the technician during the production of finished goods.

Overall, results of calculation of metal inventory by zinc dilution are reliable and zinc can be considered as an option for calculation of metal inventory as well as copper.

6. Acknowledgement

The authors would like to thank our unit leaders Mr. C.N Singh (CEO), Mr. GG Pal (COO) and all the members of the potline team, Vedanta Aluminium Limited, Jharsuguda for their support in conducting these trials.

7. References

1 Emf series *https://www.chegg.com/homework-help/questions-and-answers/list-electrochemical-series-developed-lab-based-experimental-values-obtained-compare-publi-q36864841,* accessed on 30 September 2020.

2 University of Cambridge, Ellingham diagram, *https://www.doitpoms.ac.uk/tlplib/ellingham_diagrams/ellingham.php*, accessed on 30 September 2020.