Decrease of Concentration Boundary Layer Thickness by Imposing Magnetic Field

Hokkaido University XU Guangye, IWAI Kazuhiko

E-mail: xugy@eis.hokudai.ac.jp

1. Introduction

In high temperature processes, mass transfer is often the rate determining step. Therefore, imposing agitation of bulk liquid has been used for the enhancement of mass transfer rate [1]. However, severe problems also occur due to the drastic agitation, like the corrosion of vessel and so on [2]. To avoid such kind of problems and enhance mass transfer rate, agitation only in the vicinity of solid-liquid interface has been proposed [3]. In this method, concentration boundary layer formed by dissolving solid copper from anode into aqueous solution, and it's thickness at the center of anode decreased when imposing a static magnetic field and current composed of AC and DC components simultaneously compared to that only the current was imposed. Therefore, the imposition of static magnetic field decreased the concentration boundary layer thickness at the center of the anode [3]. Nevertheless, the influence of the imposition of static magnetic field on the concentration boundary layer thickness in the whole vicinity area of solid-liquid interface has not been clearly studied. Thus, the fundamental experiment has been conducted in this research to make comparison in concentration boundary layer thickness by adding current with or without the imposition of the static magnetic field.

2. Experimental method

The experimental apparatus was designed based on the past research [3]. Two parallel 20mm length Cu electrodes were set in the upper and lower parts of a 10mm height transparent vessel, which was filled with 0.3mol/L $CuSO_4$+ 0.1mol/L H_2SO_4 aqueous solution. Two 5mm length insulators covered the left and right sides of the lower Cu electrode. Two experimental patterns of only imposing current (DC+2Hz AC) and the superimposition of current and a horizontal static magnetic field were conducted, with 60 seconds experimental time. Through imposing the current, the concentration boundary layer formed due to the dissolution of solid Cu into the solution. As the amount of dissolved Cu is related with the solution brightness, relative brightness, which was defined as a ratio of the brightness of the solution after the experiment (I_1) to that before the experiment (I_0), can be directly used for the evolution of the concentration boundary layer thickness in the vicinity of solid-liquid interface. The relative brightness was measured in 5 adjacent areas parallel to the anode, and the length of each area was 2mm.

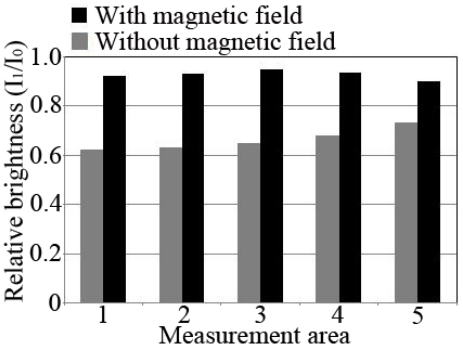

Fig.1 Relative brightness with and without magnetic field

3. Experimental results

Fig.1 indicates the relative brightness measurement results under the two experimental conditions. It can be seen that under the condition of imposing the static magnetic field, the relative brightness value is larger than that only current was applied. This means that the imposition of magnetic field could decrease the concentration boundary layer thickness in the vicinity of solid-liquid interface.

References

[1] K. Mori: Tetsu-to-Hagane 77(1991) 2077-2083
[2] Y. Miki: Bull. Iron Steel Inst. Jpn. 19(2014), 482-489
[3] T. Yokota, A. Maruyama, T Yamada, and K. Iwai: J. Japan Inst. Met. Mater 2017, 81(11): 516-521.

XU Guangye (Hokkaido University, Nishi 8,Kita 13,Kita-ku,Sapporo,Hokkaido,060-8626)