Electrical Conductivity Measurement of CaO-Al_2O_3-CaF_2 slags by van der Pauw-Ohta Method

K.Aya[1], T.Sumita[2], N.Saito[3], and K.Nakashima[4]

1. Graduate Student, Department of Materials, Kyushu University, 744, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan. Email: kenta.aya.874@s.kyushu-u.ac.jp
2. Assistant Professor, Department of Materials, Kyushu University, 744, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan. Email: sumita.takehiro.799@m.kyushu-u.ac.jp
3. Associate Professor, Department of Materials, Kyushu University, 744, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan. Email: saito.noritaka.655@m.kyushu-u.ac.jp
4. Professor, Department of Materials, Kyushu University, 744, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan. Email: nakasima@zaiko.kyushu-u.ac.jp

Keywords: electrical conductivity, ESR slag, van der Pauw-Ohta method

ABSTRACT

Electro slag remelting (ESR) is one of the methods used to produce high-cleanliness steel. In the ESR method, the product steel electrode is immersed in flux, and the electrode is melted by the Joule heat of the flux generated by the high current. CaF_2-based melts are mainly used as fluxes, but the electrical conductivity of CaF_2-based melts varies widely among researchers and measurement methods. Therefore, this experiment aims to measure the electrical conductivity of CaF_2-based melts based on the van der Pauw-Ohta method, which does not require the cell constant, which is a fundamental error factor in electrical conductivity measurement at high temperatures. The measurement temperature was set at 1600-1450 °C, and dehydrated Ar flowed through the furnace at 200 ml/min. Electrodes were fabricated by Pt-30mass%Rh alloy, and the electrodes were connected to an impedance analyzer using a four-terminal probe. The electrodes were immersed in the melt, and the impedance and phase angle were measured by AC frequency sweep (50 Hz to 200 kHz). The electrical conductivity was then calculated by utilizing the impedance's real part values when the impedance's imaginary component was zero. The electrical conductivity showed a positive temperature dependence. It was found that the electrical conductivity increased with increasing CaF_2 content, and decreased with increasing $AlO_{1.5}$/CaO ratio. The reason for the temperature dependence of electrical conductivity is thought to be that ions contribute significantly to electrical conductivity in CaF_2 melts. As the temperature increases, the diffusion path of ions increases. The increase in the $AlO_{1.5}$/CaO ratio decreases the electrical conductivity because the Ca^{2+} that compensates for the charge on Al^{3+} increases with the increase in the $AlO_{1.5}$/CaO ratio. The AlO1.5/CaO ratio increase is thought to be due to a decrease in the amount of Ca^{2+} that serves as a carrier.