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Research paper

Characteristics of sliding bubble in aqueous electrolyte: In presence of an external magnetic field

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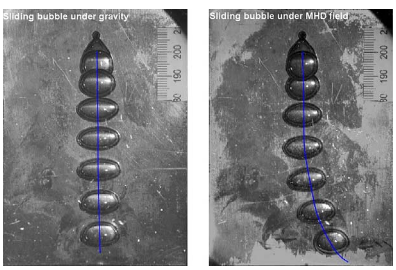
GRAPHICAL ABSTRACT



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ABSTRACT

An experment was carried out to examine the influence of an external magnetic field on a bubble in an aqueous electrolytic cell. In the electrolysis process, bubbles nucleate instateneously and the electrolytic flow is mostly caused by swarm of bubbles, which makes it difficult to quantify the impacts of various forces, in particular the magneto-hydrodynamic (MHD) and gravity forces in Hall-Héroult cells. In this paper, an aqueous-electrolytic cell was designed to allow a single bubble to slide underneath the inclinde anode in an electrolytic environment and in presence of an external magnetic field. Air was injected at a constant flow rate of 6.2 ml/min through a 3 mm diameter orifice into a quiescent conducting aqueous electyrolytic media. Experiments were conducted both with and without external-magnetic field for varying anode-inclinations ranging from $\theta = 4^{\circ}$, 6° and 8° in order to quantify the order of magnitude of MHD force in comparison to the gravity force. The data clearly shows that, in presence of the magnetic field, the bubble changes its shape and orientation at the onset of nucleation, which in turn gives rise to a non-linear trajectory across the longitudinal axis of electrode establishing a large circulatory flow within the electrolytic cell. In general, the experimental data shows that the bulk velocity was found to be dominated by the MHD driven flow overshadowing the influence of gravity force.

1. Introduction

Bubble dynamics under inclined walls in viscous media plays a key role in many industrial applications, such as, cooling of nuclear reactors, top submergence of gas injection, heat recovery in metallurgical systems [1] and particularly in gas evolving electrolytic cells. In electrolytic cells, the gas produced in molecular form is transformed to the gaseous state and subsequently nucleate in the form of bubbles at the electrode surface. The Hall-Héroult cell is a typical example where bubbles nucleate underneath the anode and slides along the anode surface causing an induced flow.

A schematic representation of an aluminium reduction cell is shown in Fig. 1. The electrical current traverses vertically through the anode, electrolyte (cryolite), molten aluminium (bath), cathode and to the cathode-bus through collectors-bars [2]. Alumina dissolves in electrolyte and is reduced to aluminium metal at the cathode. Carbon dioxide

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at the bottom of the anode nucleates as bubbles due to the typical horizontal arrangement of electrodes in a Hall-Héroult-cell. These bubbles coalesce to form bigger bubbles thereby increasing the overall resistance to current flow in the cell reducing the overall efficiency of the cell. Thus, hydrodynamics of the electrolyte cell has been the topic of interest for last two decades.

1.1. Bubble induced flow

In general, the hydrodynamics of the bulk flow in an aluminium electrolytic cell has two distinct flow regions; the first region is the bubble-laden layer underneath the anode surface, where bubbles evolve, detach and slide. The evolving bubbles change their shapes from spherical to oblate spheroid and then to ellipsoidal by displacing

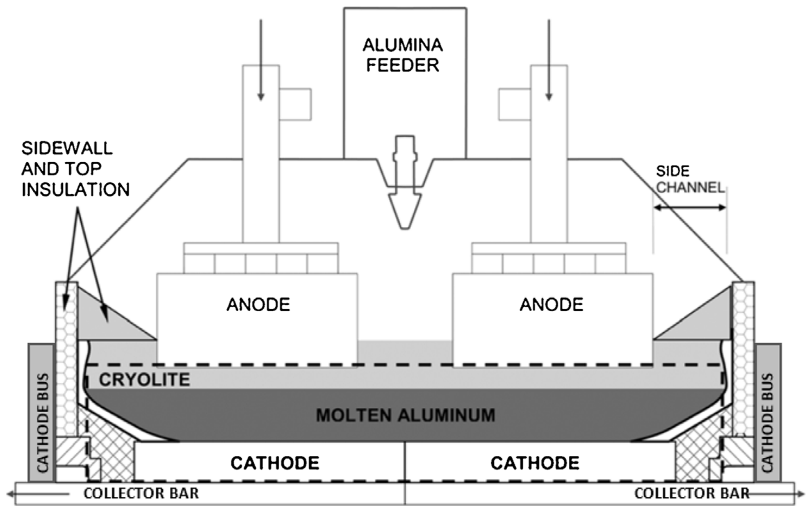

Fig. 1. Illustration of the Aluminium reduction cell.

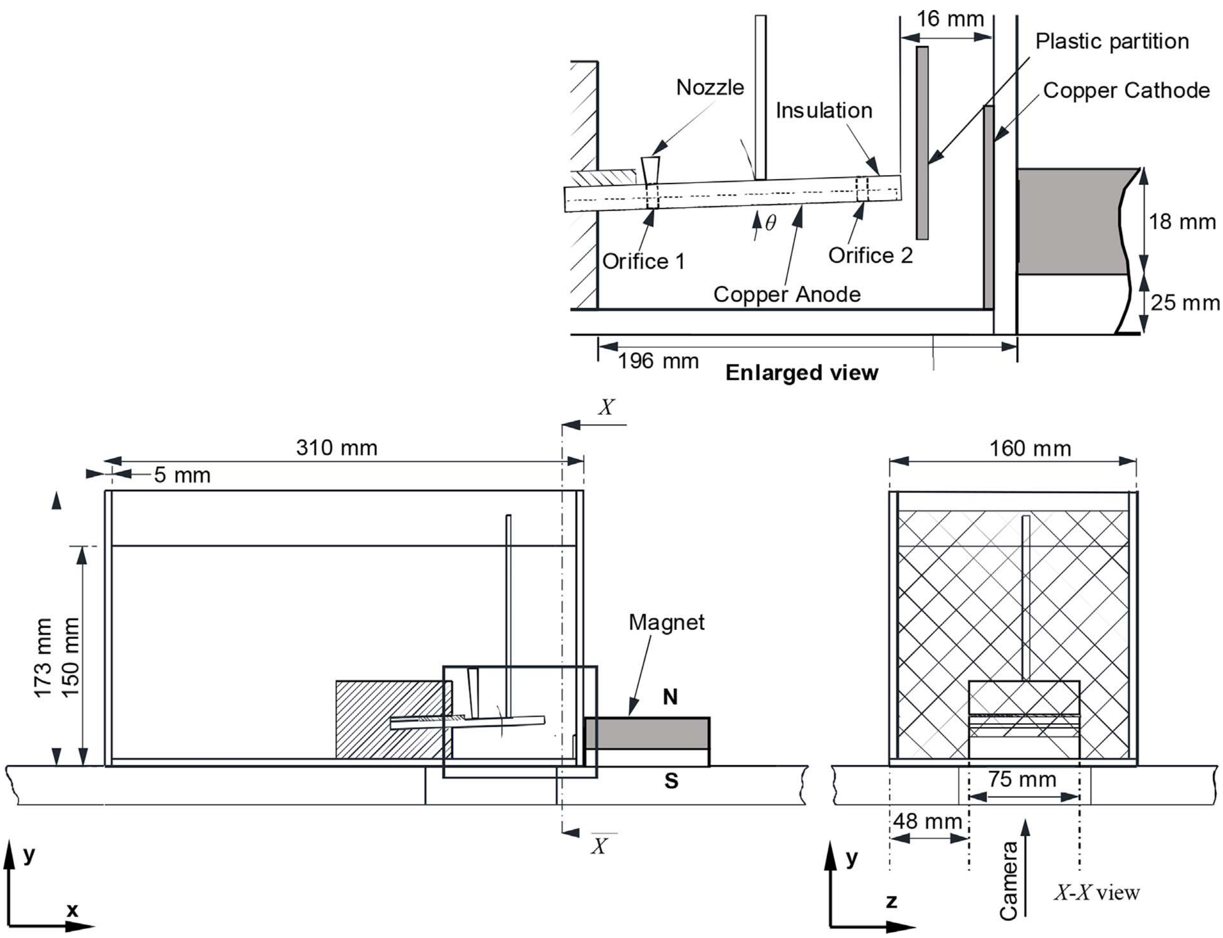

Fig. 2. Schematic of Experimental Apparatus.