The Effect of Magnetic Field on Energy Efficiency of Water Electrolysis

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1. Introduction

Water electrolysis is indispensable as a hydrogen energy system in space. However, the special design is necessary in such a microgravity condition, because of the absence of natural convection. The smaller energy efficiency caused by IR drop of bubble froth layer must be improved [1].

Many papers reported the effects of flow rate on the bulk voidage or the surface concentration of dissolved gases in the terrestrial experimental conditions [2]. The electrolyte flow was driven by the mechanical system such as pump. When the water electrolysis would be conducted continuously under microgravity condition, such a mechanical system would not be suitable, because it might frequently be clogged with the bubbles evolved by electrolysis.

MHD convection induced by the magnetic field is proposed instead of a substitute of a mechanical flow. The aim of this research is to study the effects of MHD convection on water electrolysis even under terrestrial condition as well as the microgravity environment.

2. Experimental

Water electrolysis was conducted galvanostatically. The electrolytic cell was divided by a membrane filter to keep the catholite separated from the anolite. The cell wall containing catholyte was partially cut off so as not to disturb the MHD flow. On the other hand, the cell wall around the anode was closed so that the oxygen bubbles evolving on the anode would not diffuse into the balk solution out of the cell. The working electrode and the counter electrode were made from a sheet of platinum. The Luggin probe was connected through a salt bridge to an Ag / AgCl reference electrode with saturated KCl solution. Two binds of electrolyte solutions were used of an aqueous 1 N H_2SO_4 and 2 wt % KOH solutions, which was saturated with hydrogen gas by pre-electrolysis using two platinum electrodes.

A magnetic field with magnitude up to 5T was superimposed in the vertical or horizontal electrode configuration.

3. Results and discussion

The electrode was polarized with a given constant cathodic current until its potential reached a steady value and then the current was interrupted.

Fig.1 shows the polarization curves in the various magnetic flux densities, B (0 , 1 , 3 , 5 T) in 1 N H_2SO_4 aqueous solution. At low current density less than 50 mA / cm^2, the difference of potential was not found in all magnetic flux densities. When the current density was larger than 50 mA / cm^2, the difference of potential became significant. When the higher magnetic field was applied, current density was higher.

These phenomena are explained by the MHD convection. Because these bubbles were swept away more quickly and the voidage near the electrode decreased due to MHD convection, IR drop became lower in the higher magnetic field [3]. At the same time, the MHD convection enhanced the mass transfer of dissolved hydrogen gas near the electrode surface much more than natural convection. Therefore, the concentration overpotential of hydrogen gas decreased.

Due to the decrease in these two factors, the energy efficiency of water electrolysis was improved under the magnetic field.

4. Reference

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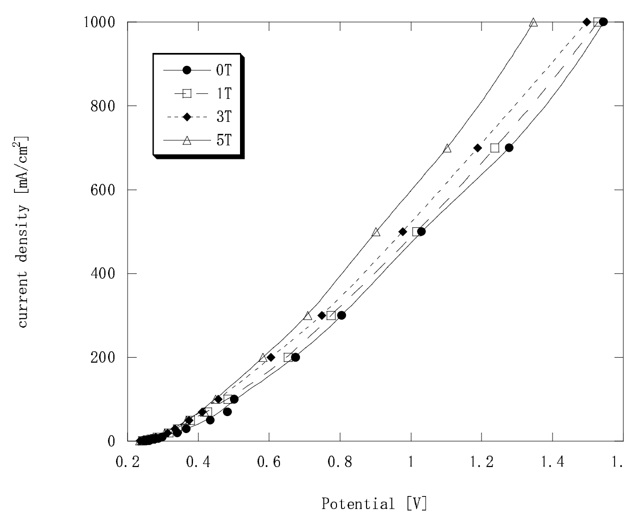

Fig. 1 Polarization curves in 1N H_2SO_4 solution in the various magnetic flux densities.