A Study on V-I Characteristics of Hydrogen-Oxygen Gas Generator

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Abstract - Water-Electrolyzed gas is a mixed gas of the constant volume ratio 2:1 of Hydrogen and Oxygen gained from electrolyzed water, and it has better characteristics in the field of economy, efficiency of energy, and environmental intimacy than acetylene gas and LPG (Liquefied Petroleum Gas) used for existing gas welding equipment. So studies of Water-Electrolyzed gas are activity in progress now a day, and commercially used as a source of thermal energy for gas welding in the industry. The object of this paper is getting a V-I characteristic of Hydrogen-Oxygen Gas Generator using DC source. First, chemical analysis of electrolysis is conducted and the relation of electrical energy and then chemical energy is investigated through the faraday's laws.

1. INTRODUCTION

The conventional water electrolysis equipment has a power supply that is supplied with direct voltage source for hydrogen-oxygen gas generator. But, it can not be achieved desirable result in both performance and efficiency. Also it has disadvantages that volume and weight of equipment are increased with general transformer. For high performance and efficiency, the water electrolysis power system could be developed with considering electrical characteristics of electrolytic cell, concentration of electrolyte and materials.

Currently, research in this area is focused on chemical analysis of electrolysis and V-I characteristic of hydrogen-oxygen gas generator. This paper is a contribution to the improvement of electrolysis equipment to reduce the volume and weight of conventional electrolysis and to increase the performance and efficiency.

2. PRINCIPAL OF HYDROGEN-OXYGEN GAS

2.1 Reaction of Hydrogen-Oxygen Gas

General electrolysis of water needs a voltage source to electrolyze. Electrolytic cell system consists of two piece of metal plates, which is difficult to oxidize, electrolyte, distilled water and voltage source to electrolyze.

In this paper, it is used catalyst electrolyte with potassium hydroxide (KOH) to bring down the over-voltage because the decomposition of distilled water (H_2O) is very difficult in low voltage [1].

Fig. 1 shows a diagram of water electrolysis. Electrolyte (KOH) dissolve in water became an ion as follows.

$$KOH \rightarrow K^+ + OH^- \quad (1)$$

During the reaction response, the electrolytes of KOH are decomposed of Potassium K^+ and OH^- anion and then try to go to negative and positive respectively. K^+ is reactive to water so that the Potassium must be kept away from the air in the laboratory because even water moisture in the air can cause oxidation violent enough to release quantities of hydrogen. The free potassium cation thus causes water to oxidize immediately on contact, reforming itself as Potassium hydroxide. In oxidation process, electrons are removed from the molecules being oxidized, so the KOH now has its full set of electrons. The K^+ ripped a hydrogen cation (H^+) from the H_2O, leaving an OH^- for itself. The resulting H^+ heads for the cathode to pick up an electron to become a full mono-atomic hydrogen atom (H) and then OH^- anion was left alone while the K^+ cation and the H^+ cation completed their part of the redox reaction.

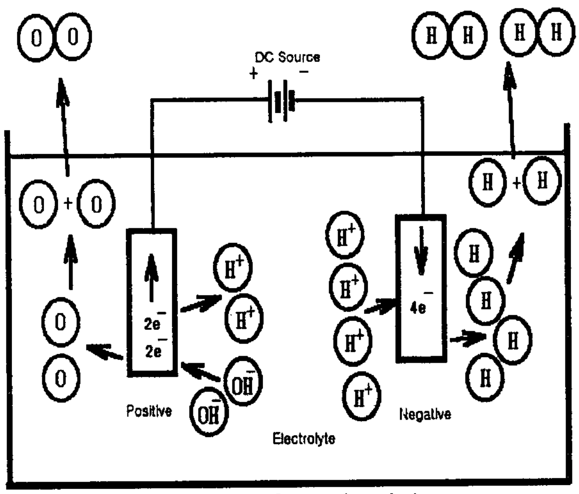

Fig.1 Diagram of water electrolysis.

The OH^- moves toward the positive plate of anode. When the OH^- reaches the anode, it is oxidized (stripped of two electrons, turning H^- into H^+) and split into mono-atomic oxygen atom (O) and a hydrogen cation (H^+). The hydrogen cation immediately leaves the vicinity of the anode on its way to the cathode. Often, it will not go directly to the cathode, it will combine with a OH^- and reform into water, then the water will be split again by K^+, when the H^+ arrives at the cathode, it pick up the electron it needs to become a proper mono-atomic hydrogen atom (H). The process is actually more complicated than reaction of electrolytic cell just described above because there are many interactions between the H_2O, KOH, OH^-, K^+, H^+ and any impurities in the solution.

It is obvious fact that reactions of oxidation and deoxidization have created electric of same quantities and chemical equation is defined as follows.

$$\begin{aligned} & 2H_2O + KOH \rightarrow 2H_2 + O_2 + KOH \\ & +\text{Pole}: 2OH^- \rightarrow 2H^+ + O_2 \uparrow + 4e^- \\ & -\text{Pole}: 4H^+ + 4e^- \rightarrow 2H_2 \uparrow \end{aligned} \quad (2)$$

2.2 Electrical Energy for Electrolysis

For the relation with electric charge and chemical equivalent, electrolysis of water is defined in faraday's law of electrolysis.

(1) The weight of a given element liberated at an electrode during electrolysis directly proportional to the quantity of electricity.

(2) When the same quantity of electricity passes through solutions of different electrolytes, the weights of the substances liberated at the electrodes are directly proportional to their equivalent weights.

In electrolysis the output rate is a function of the molecular weight of the product, its valency and the total current passing through the electrolytic cell. One Faraday is that amount of current which will produce one gram mole of a product with a valency of one. To split water, H_2O, into H_2 and O_2 takes two Faradays per mole, that is two Faradays will convert 18 grams (about 0.635 oz) of water into hydrogen-oxygen gas. Two Faradays is equivalent to 193038 Coulombs. This equals the product of the current through the cell in amps and the time in seconds for which it passes. For example, if 5 amps pass through the cell it will take 193038/5 seconds or 10.72 hours to electrolyze 18 grams of water. Thus the output of a hydrogen-oxygen gas generator operating at 5 amps would be 1.678 grams of gas per hour [2]. As above mentioned, chemical equivalent is calculated with atomic weight and valence and we get the electrical energy through the chemical equivalent.

3. ANALYSIS OF HYDROGEN-OXYGEN GAS GENERATOR

3.1 Construction of Cylinder of Unit Pole

This part of the paper shows a cylinder of unit pole as shown Fig.2 to experiment of hydrogen-oxygen gas generator. Cylinder of unit pole is connected with dc voltage source. Center pole is connected with positive and shell pole is connected with negative pole.

In conventional schemes, the electrode form is used rectangular plane. To get a large electrode surface area in the same volume for efficient electrode construction, we design an electrode cylinder [3].

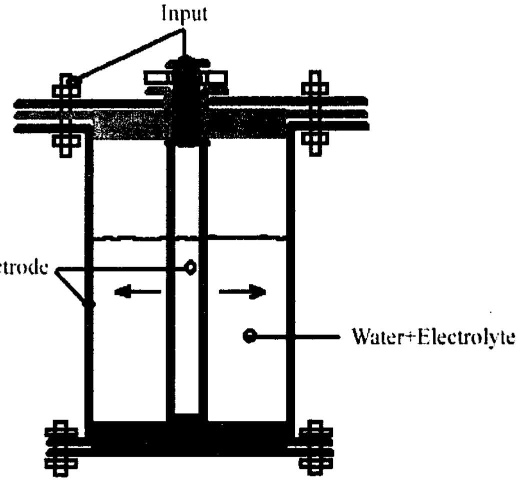

Fig. 2 The construction of the unit pole of cylinder.

Fig. 3 below shows a real cylinder of unit electrode, which are the positive and negative poles. Electrode is made of stainless steel that is difficult to oxidize. Diameter of shell pole cylinder is fixed 60[mm], but diameter of center pole is changeable to 48[mm], 52[mm] and 56[mm]. From the center pole electrode, the distance is each 6[mm], 4[mm], 2[mm] and we can get the variable experiment result. In this paper, it is used 56[mm] center pole electrode and height of electrode is 200[mm]. The size of shell electrode is fixed 376.99[mm^2]. When diameter of center pole electrode is 48[mm], 52[mm], 56[mm] respectively and then the size of each electrode is 301.59[mm^2], 326.73[mm^2], 351.86[mm^2].

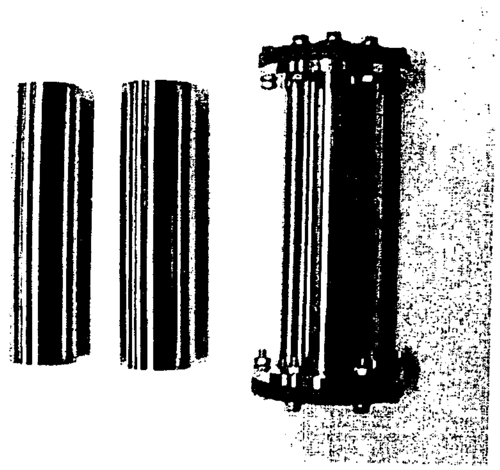

Fig. 3 The center pole and shell pole of unit pole of cylinder.

3.2 V-I Characteristic of Hydrogen-Oxygen Gas

Fig. 4 is a hardware system for hydrogen-oxygen gas generator with unit pole of cylinder. Hydrogen-oxygen gas generator system consists of voltage source, rectifier, dc-dc converter and low pass filter. For measuring electrolytic current, low pass filter output voltage is connected with anode and cathode of electrolytic cell. So current to the electrolytic cell is measured to increase input voltage to the cell.

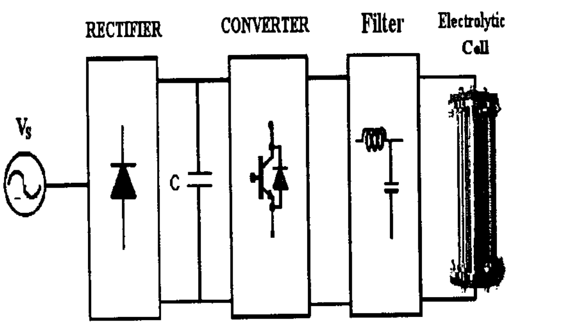

Fig.4 Hydrogen-Oxygen gas generator for unit pole of cylinder.

Fig. 5 shows V-I characteristic of electrolytic cell for unit pole of cylinder. Until the voltage goes up to reversible potential, current doesn't flow between two electrolytic cells. If the voltage goes over over-voltage range, current flows through the exponential curve. When the same quantity of electricity passes through solutions of different electrolytes, the weights of the liberated substances at the electrodes are directly proportional to their equivalent weights due to faraday's law.

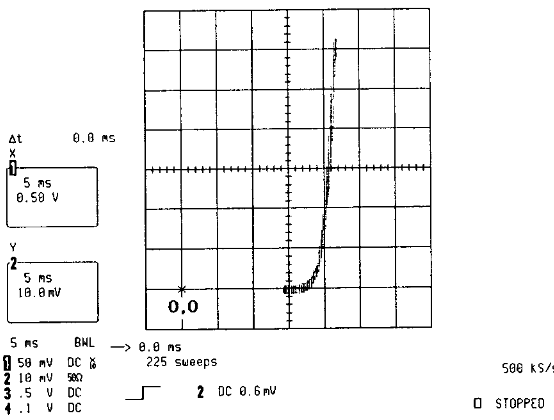

Fig. 5 V-I characteristic of electrolytic cell.
(X-axis : 0.5V/div, Y-axis : 0.5A/div)

Table. 1 shows measured terminal voltage and current value after making an experiment several times over and Fig. 6 shows the same voltage and current data as Table. 1. From the result, it is important to control current not voltage for performance and efficiency of hydrogen-oxygen gas generator. The curves feature a fairly linear drop in current during charge, until the effectively capacity is reached, at which time the current increase rapidly. Hydrogen-oxygen gas effectively with characteristic that current is increasing as input voltage increase.

Table. 1 Voltage and Current of Unit Pole Electrolytic Cell

Voltage [V]	Current [A]	Voltage [V]	Current [A]
1.86	0.16	2.04	1.16
1.88	0.21	2.06	1.44
1.90	0.26	2.08	1.64
1.92	0.34	2.10	1.90
1.94	0.43	2.12	2.19
1.96	0.51	2.14	2.54
1.98	0.67	2.16	2.80
2.00	0.84	2.18	3.04
2.02	1.02	2.20	3.27

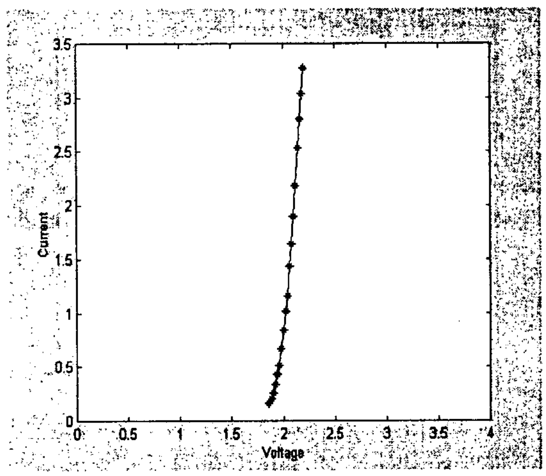

Fig. 6 Relation of voltage pole and current pole

3.3 Discharge of Electrolytic cell

For characteristic of discharge of electrolytic cell, we cut off the voltage source supplied unit electrode in 2[A], 2.2[A], 2.4[A] and 2.6[A] respectively. The discharge characteristic shows that the voltage of electrolytic cell goes down but doesn't get to zero immediately. The voltage slowly decreased for a long time in all the course of 2[A], 2.2[A], 2.4[A], and 2.6[A] respectively.

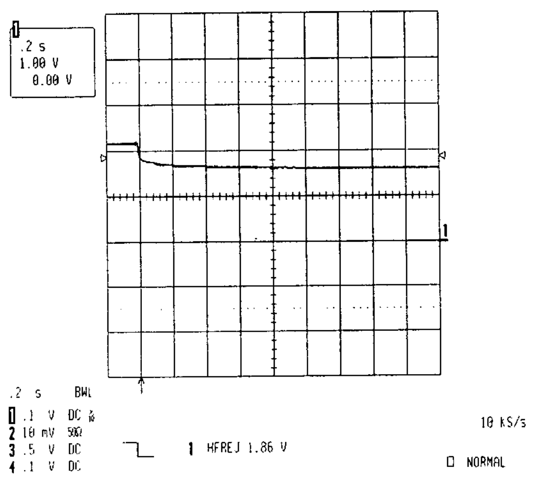

Fig. 7 Discharge characteristic of unit pole.
(X-axis: 0.2sec/div, Y-axis: 0.5V/div)

Fig. 7 shows a voltage waveform of discharge of electrolytic cell. Through the voltage waveform, we find that electrolytic cell has a characteristic like a capacitor, so capacitance of electrolytic cell is calculated by time constant in experiment of R-C series electric circuit and electrode is given electric charge like capacity.

4. CONCLUSION

This paper examines process of hydrogen-oxygen gas and electrode of V-I characteristic curve through the variable over-voltage. Characteristic of V-I curve shows that current suddenly goes up after reversible voltage. According to this result current control is desirable not voltage control in designing source of hydrogen-oxygen gas. So this paper can suppose that electrical modeling electrolytic cell include capacity by experiment of power off But after this experiment we need more detail V-I curve of hydrogen-oxygen gas to raise generate efficiency of and hydrogen-oxygen gas generator.

For this analysis more detail experiment is needed about interval of electrode, structure of electrode, kind of electrolysis.

ACKNOWLEDGEMENT

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