

Dissertation Title	A Study of Parameters Affecting Energy Consumption in Hydrogen Production using Water Electrolysis Process
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### **Abstract**

The objectives of this research is to improve the hydrogen production rate and the energy efficiency by investigating the influences of the factors that affect the hydrogen production rate and energy efficiency. The study is divided into two parts: 1) the development of the mathematical model of the void fraction, electrolyte conductivity and ionic resistance in which factors studied consist of current, solution temperature, diameter of bubble, and height of electrodes, and 2) the correlation between the factors that affect the gas production rate and the energy efficiency including the amount of current, electrode materials, flowing electrolyte, and current characteristics (frequency and duty cycle).

The results of the study can be unveiled as follows: The relative difference of the mathematical model of void fraction is 2.16% at 313 K and 0.85% at 343 K of 300 mAcm<sup>-2</sup>. At 500 mAcm<sup>-2</sup>, a relative difference of 2.87% can be found at 313 K and 0.39% at 343 K. The model developed in this work enables one to determine the averaged conductivity (resistance) over the distance between the electrodes. This model is different from other models in that it also considers a change in physical properties of the solution which would have an effect on the electrical conductivity. The gas bubbles in the electrolyte solution, in the terminal electrodes and within the electrolyzer, can cause the resistance of the electrolyte solution which can be changed during the

time of gas production. The models of electrolyte conductivity and the ionic resistance can be subsequently developed in according to the model of void fraction. By considering the effects of the factors used in the study via modeling and experiments, it has been concluded that the rise of solution temperature results in the reduction of reversible potential and the increase of electrode height causes the rise of impedance at electrode surface due to accumulation or hindering movement of gas bubbles on the electrode surface. It is also found that the smaller bubbles would move at slower velocity than the larger ones due to higher frictional force between the liquid and gas phases. Therefore, very small bubbles could cause a change in conductivity at surface electrode. Regarding the effect of the amount of current, it is observed that when the current is increased, the hydrogen production rate is increased but the energy efficiency is decreased. In the view of improving characteristics of the current signal through Pulse-Width Modulation (PWM), it can be revealed that efficiency and hydrogen production rate is increased at frequency range of 0.1 to 1 Hz and 80% duty cycle. By taking the effects of electrode materials into account, it can be unveiled that the electrodes made of stainless steel covered with nickel yields the highest rate of hydrogen production, following by those made of stainless steel and copper, respectively. This confirms that materials also play an important role on the electrode functioning since each of them has different characteristics especially the activation energy of the reaction. In addition, by considering the effect of the flowing electrolyte, it can be described that the flow of electrolyte can reduce the bubble layer thickness on the electrode surface. This is because the physical properties of the electrolyte related conductivity such as bubble layer at electrodes surface can be reduced by improving mass transport which is consisted in the electrical conductivity of the electrolyte. In conclusion, this study has demonstrated the influences of various factors on the hydrogen production which can lead to 21% improvement of the production rate.

**Keywords:** Energy Consumption/Hydrogen Production/Water Electrolysis