Faculty of Science
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Studies on Hydrogen Production Using Solar Photovoltaic Energy System

Thesis

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By

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List of Symbols and Abbreviations

Symbol	Meaning	Symbol	Meaning
AWE	Alkaline water electrolysis	I_m	Module current
PEM	Proton exchange membrane	I_L	Load current
SOE	Solid oxide electrolysis	V_L	Load voltage
PV	Photovoltaic	V_m	Module voltage
HPR	Hydrogen production rate	E	Calorific value of Hydrogen
PEC	photoelectrochemical cell	G	solar radiation intensity
TDS	Total Dissolved Solids	A	photovoltaic module area
KOH	Potassium hydroxide	η_e	Electrolyzer efficiency
NaOH	Sodium hydroxide	η_m	Photovoltaic module efficiency
SHES	Solar hydrogen energy system	η_t	Overall system efficiency
RF	radio frequency	Ar	Argon

Abstract

In this work, an alkaline water electrolyzer cell was designed and constructed to produce hydrogen gas using photovoltaic (PV) module as a source of electric power. The PV module is a mono-crystalline silicon type with maximum output power of 8W. The electrolyzer cell is a rectangular container and is made from Acrylic material. Two electrodes are used as a cathode and anode, which are partially immersed in the alkaline solution.

The work was investigated through three stages: optimization, evaluation and enhancement stage. In the optimization stage, a wide range of operating conditions, which include input voltage, gap between electrodes, cathode material, and concentration of the electrolyte, were considered, and their effects on the hydrogen production rate were explored. The optimum operating conditions, which correspond to the maximum hydrogen production rate, were determined for the system.

In the evaluation stage, the performance of water electrolyzer cell was experimentally studied using the photovoltaic (PV) module. The process of water electrolysis using the photovoltaic (PV) module was operated during a sample day in the summer season from 8:00 AM until 4:00 PM.

Finally, the performance of the system was enhanced by electrode surface modification using plasma etching system. The surface structural, morphological and optical characteristics of the etched and non-etched electrodes are studied. X-ray fluorescence (XRF) analysis indicated that the electrical conductivity of the etched electrode is higher than of the non-etched electrode. Scanning electron microscope (SEM) and laser speckles images showed that the surface area of the etched electrode is increased compared to non-etched electrode due to the process of plasma etching.

INTRODUCTION

It has been obvious that one of the major problems of today's world is in its overdependence on fossil fuels. The fossil fuels resources in the world are finite and are going to be depleted at an ever-growing rate; According to estimates by the World Coal Institute; coal, natural gas and petroleum may run out in 130, 60 and 42 years, respectively, at the present rate of consumption **(Wang, Roberts, Naterer, & Gabriel, 2012)**. Moreover, utilization of fossil fuels as an energy source is not environmental compatibility; the combustion of fossil fuels to obtain energy for transportation, power generation, etc. causes serious environmental problems such as air pollution, acid rains, ozone layer depletion, global warming and climate change.

Therefore, great efforts and deep researches have recently focused on inventing new energy resources. Renewable energy resources are attracting more attention as alternative energy sources. Solar energy is the most abundant, clean and inexhaustible of all the renewable energy resources. Nevertheless, solar energy cannot produce power steadily, since its power production rates vary with seasons, months, days, hours etc. This intermittent nature of solar energy is still one of the main issues of sustainable energy. To overcome the intermittency problem of solar energy, a storage medium or an energy carrier is required.