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PERFORMANCE ANALYSIS OF SERPENTINE MODULE WITH PARAFFINE WAX

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ABSTRACT

The overall objective of this paper is to design an innovative integrated system that utilizes renewable energy, in the form of solar and wind sources, to produce four useful outputs at the same time. Electricity, hydrogen, freshwater, and cooling, all customized to address community demands. The system also has a thermal energy storage solution in the form of paraffine wax, making it more efficient, cost-effective, and environmentally friendly. The novel feature of this multigeneration system is its sole dependence on renewable energy sources for all the outputs, making it different from other designs and giving a sustainable means of attaining net-zero carbon emissions. An extensive analysis of the system is performed using both energy and energy principles to analyze its performance based on the evaluation of energy and energy efficiencies.

Keywords:
Eco-friendly, carbon free, sustainability, green energy, environmental protection, smart technology.

INTRODUCTION

As the impact of fossil fuel use reaches communities, governments are making efforts to enact ambitious plans aimed at energy efficiency, decarbonization, and energy storage, all of which are critical to the growing energy economy. [1] The output efficiency of wafer-based crystalline as well as Thin- film Solar photovoltaic cells decrease with rise in panel temperature. It has been observed that the efficiency declines by approximately 0.5% for the rise of 1°C in panel temperature. As different communities have different energy requirements, combined systems that supply multiple outputs are crucial for optimum utilization of renewable resources. Due to this reason, much emphasis has been given to modeling and studying these systems. At an international level, there are incentives to move towards electric vehicles and buildings by 2040. [2] The operation of photovoltaic (PV) panels relies on the ambient working temperature". The majority of incident solar radiation is lost as heat accumulation on PV panels in tropical regions, which degrades PV performance by high temperatures. PV modules must be cooled effectively so that their performance is maintained at a decent level. Also, many nations have set various energy policies aimed at reducing carbon emissions to net-zero by 2060. [3] Experimental studies of various cooling techniques employed for photovoltaic (PV) panels as the impact of fossil fuel use reaches communities, governments are making efforts to enact ambitious plans aimed at energy efficiency, decarbonization, and energy storage, all of which are critical to the growing energy economy. [1] The output efficiency of wafer-based crystalline as well as Thin- film Solar photovoltaic cells decrease with rise in panel temperature. It has been observed that the efficiency declines by approximately 0.5% for the rise of 1°C in panel temperature. As different communities have different energy requirements, combined systems that supply multiple outputs are crucial for optimum utilization of renewable resources. Due to this reason, much emphasis has been given to modeling and studying these systems. At an international level, there are incentives to move towards electric vehicles and buildings by 2040. [2] The operation of photovoltaic (PV) panels relies on the ambient working temperature". The majority of incident solar radiation is lost as heat accumulation on PV panels in tropical regions, which degrades PV performance by high temperatures. PV modules must be cooled effectively so that their performance is maintained at a decent level. Also, many nations have set various energy policies aimed at reducing carbon emissions to net-zero by 2060. [3] Experimental studies of various cooling techniques employed for photovoltaic (PV) panels

METHODOLOGY

Water electrolysis is a process based on electrical power to decompose water (H_2O) into its simplest elements: hydrogen (H_2) and oxygen (O_2). This is done in an electrolyzer, which comprises two electrodes the anode and cathode in water. Hydrogen gas is produced at the cathode when an electric current is applied to the water, while oxygen gas is generated at the anode. Electrolysis is a significant process for the generation of hydrogen, which can be utilized as a clean fuel. Pure water and an electrolyte are needed for the process to enhance conductivity and efficiency.

EXPERIMENTAL SETUP

Experimental design for water electrolysis production of hydrogen requires various crucial apparatus components which coordinate in disassembling water (H_2O) into the elements which it comprises—hydrogen (H_2) and oxygen (O_2). It runs on electric energy and is assisted through water electrolysis that can usually take place within a well-established lab or a miniature industrial arrangement. The major parts are the electrolyzer, power source, electrodes, electrolyte, gas collection device, water reservoir, and monitoring devices. The following is a brief explanation of every component used in the experimental design. The electrolyzer is the core part of the setup where electrolysis takes place. It is a chamber that contains the electrolyte solution and has the electrodes. The electrodes-ordinarily made of conductive materials such as platinum, stainless steel, or graphite are placed strategically within the electrolyte solution. Flow chat presented in figure 1. The electrolyzer is constructed to keep the electrodes submerged in the solution to allow efficient electrolysis. The electrodes are wired to an external circuit that delivers the required electrical current to enable the reaction.

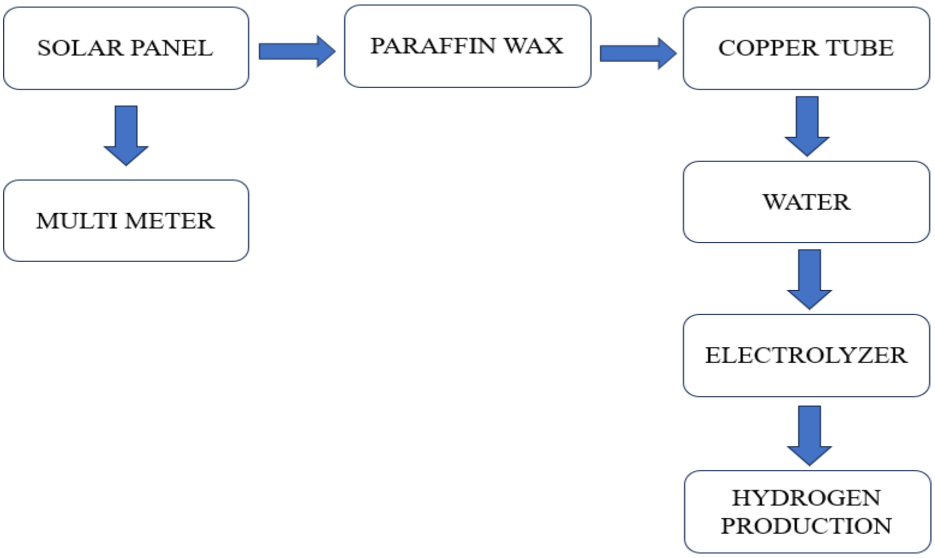

Figure. 1 Flow Chat

There are two electrodes in the electrolyzer: the anode (positive electrode) and the cathode (negative electrode). Oxygen (O_2) is generated at the anode, and hydrogen (H_2) is generated at the cathode. The electrode materials are selected for their good electrical conductivity and resistance to corrosion under the electrolytic conditions. Platinum is usually employed because of its durability and high efficiency, but less costly materials such as stainless steel are also typically used in experimental arrangements. There should be a continuous DC (direct current) power supply for water electrolysis. The power supply gives the voltage and current required to separate the hydrogen and oxygen atom bonds in the water molecules. The voltage employed for water electrolysis is generally between 1.8 and 2.2 volts, but the actual voltage could depend on the concentration of the electrolyte and the material of the electrodes. It is regulated to manage the amount of electrolysis and thus the quantities of hydrogen and oxygen gases evolved that flow through the circuit. It is a solution that improves the conductivity of water so that the electric current can pass through with greater efficiency. Power reading depicted in the figure 2. Pure water conducts poorly, therefore a trace amount of an electrolyte like potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to enhance the ionization of water. The electrolyte enables the breakdown of water molecules into hydrogen and oxygen gases at the electrodes. Two electrodes exist in the electrolyzer: the anode (positive) and the cathode (negative). The oxygen (O_2) is created at the anode, while the hydrogen (H_2) is created at the cathode. The electrodes are made from materials that have good electrical conductance and withstand corrosion under electrolytic conditions. Platinum is frequently employed for its high efficacy and longevity, though cheaper substances such as stainless steel are used in experimental conditions as well. There must be a steady DC (direct current) power supply for water electrolysis. The power supply supplies the voltage and current required to dissociate the hydrogen-oxygen bonds between the hydrogen and oxygen atoms in the water molecules. The voltage employed for water electrolysis is usually between 1.8 and 2.2 volts, but the actual voltage could be different based on the concentration of the electrolyte and electrode material. The current is regulated to manage the rate of electrolysis and, in turn, the amount of hydrogen and oxygen gases formed. The electrolyte is a liquid that increases the conductivity of water so that the electric current can flow better. Power reading indicated in the figure 2. Pure water is not conductive, therefore a little amount of an electrolyte like potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to enhance the ionization of water. The electrolyte facilitates the decomposition of water molecules into hydrogen and oxygen gases at the electrodes. The electrolyzer contains two electrodes: the anode (positive) and the cathode (negative). The anode is where oxygen is formed, and the cathode is where hydrogen is formed. The electrode materials are selected for their effectiveness in conducting electricity and for resisting corrosion under the electrolytic conditions. Platinum is frequently employed because of its high reliability and longevity, though cheaper materials such as stainless steel are also prevalent in experimental environments. There should be a constant DC power supply for water electrolysis. The power supply gives the power needed to fracture the hydrogen and oxygen atoms bonds in the molecules of water. The voltage between 1.8 and 2.2 volts is most commonly used to carry out water electrolysis, though the required voltage may depend on the material used for electrodes and the electrolyte concentration. The current is regulated to manage the speed of electrolysis and, in turn, the quantity of hydrogen and oxygen gases formed. The electrolyte is a liquid that increases the conductivity of water so that the electric current can pass through more effectively. Power reading depicted in the figure 2. Pure water is of low conductivity, and therefore a trace amount of an electrolyte like potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to enhance the ionization of water. The electrolyte facilitates the breaking of water molecules into hydrogen and oxygen gases at the electrodes. There are two electrodes in the electrolyzer: the cathode (negative electrode) and the anode (positive electrode). Oxygen (O_2) is generated at the anode, while hydrogen (H_2) is generated at the cathode. The electrode materials are selected for their good ability to conduct electricity and resist corrosion under the conditions of electrolysis. Platinum is frequently utilized due to its high efficiency and longevity, but cheaper materials such as stainless steel are also popular in experimental apparatus. There should be a constant DC power supply for water electrolysis. The power supply gives the voltage and current to disrupt the bonds of hydrogen and oxygen atoms within the water molecules. The voltage to be applied for water electrolysis is generally 1.8 to 2.2 volts, though the actual voltage might be different depending on the concentration of the electrolyte and electrode material. The flow of current is regulated to regulate the rate of electrolysis and, in turn, the quantity of hydrogen and oxygen gases that are formed. The electrolyte is a medium that increases the conductivity of water so that the electric current will flow more readily. Power reading indicated in the figure 2. Pure water is weakly conductive, and thus a trace amount of an electrolyte like potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to enhance the ionization of water. The electrolyte facilitates the breaking of water molecules into hydrogen and oxygen gases at the electrodes. There are two electrodes in the electrolyzer: the anode (positive electrode) and the cathode (negative electrode). The anode is where oxygen (O_2) is generated, and the cathode is where hydrogen (H_2) is produced. The electrode materials are selected for their good electrical conductivity and resistance to corrosion under the electrolytic conditions. Platinum is often used for its high efficiency and durability, although less expensive materials like stainless steel are also common in experimental setups. A steady DC power supply is needed for water electrolysis. The power supply delivers the voltage and current required to dissociate hydrogen and oxygen atoms' bonds in the water molecules. The common voltage applied in water electrolysis ranges from 1.8 to 2.2 volts, but the actual voltage might be different depending on the electrolyte concentration and electrode material. The current is regulated to manage the rate of electrolysis and, in turn, the amount of hydrogen and oxygen gases evolved. The electrolyte is a liquid that increases the conductivity of water so that the electric current can travel more effectively. Power reading illustrated in the figure 2. Pure water is not very conductive, so a little of an electrolyte like potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to enhance the ionization of water. The electrolyte aids in the dissociation of water molecules into hydrogen and oxygen gases at the electrodes. There are two electrodes in the electrolyzer: the anode (positive electrode) and the cathode (negative electrode). The anode is where oxygen (O_2) is formed, and the cathode is where hydrogen (H_2) is formed. The electrode materials are selected for their good electrical conductivity and resistance to corrosion under the electrolytic conditions. Platinum is often used because it is efficient and lasts long, but less expensive materials like stainless steel are also common in experimental setup. A constant DC (direct current) power supply is needed for water electrolysis. The power supply provides the voltage and current needed to break the hydrogen-oxygen atom bonds in the water molecules. The typical voltage used in water electrolysis is between 1.8 and 2.2 volts, although the real voltage is otherwise depending on the concentration of the electrolyte and electrode material. The current is controlled to govern the rate of electrolysis and consequently the volume of hydrogen and oxygen gases evolved. The electrolyte is a substance that enhances water conductivity so the electric current passes easily. Power reading as noted in the figure 2. Pure water conducts low, and therefore a very small quantity of an electrolyte such as potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to further ionize the water. The electrolyte facilitates the breakdown of the water molecules into oxygen and hydrogen gases at the electrodes. The anode (positive) and the cathode (negative) are two electrodes used in the electrolyzer. Oxygen (O_2) is evolved at the anode, whereas hydrogen (H_2) is evolved at the cathode. The electrodes are constructed from materials that efficiently conduct electricity and also resist corrosion under electrolytic conditions. Platinum is often used because it has high efficiency and durability, but less expensive materials like stainless steel are also used in experimental arrangements. A constant DC power supply is required for water electrolysis. The power supply provides the voltage and current necessary to break the hydrogen-oxygen atom bonds in the water molecules. The voltage that is generally used for water electrolysis is between 1.8 and 2.2 volts, but the actual voltage will vary with the concentration of the electrolyte and the electrode material. The current is controlled to control the rate of electrolysis and consequently the quantity of hydrogen and oxygen gases evolved. The electrolyte is a solution that enhances the conductivity of water so that the electric current travels smoothly through it. Power reading depicted in figure 2. Pure water has low conductivity, and hence a very small quantity of an electrolyte such as potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to boost the ionization of water. The electrolyte also allows for water molecules to break down into oxygen and hydrogen gases at the electrodes. The two electrodes in the electrolyzer include the anode (positive) and the cathode (negative). Oxygen (O_2) is generated at the anode, while hydrogen (H_2) is generated at the cathode. The electrode materials are selected for their capacity to conduct electricity good and resist corrosion under the conditions of electrolysis. Platinum is often used because of its toughness and efficiency but more expensive alternatives like stainless steel can also be employed in laboratory setups. An uninterrupted DC (direct current) power supply must be used to carry out water electrolysis. The power supply provides the current and voltage that is needed in order to split the bonds among hydrogen and oxygen atoms in water molecules. The applied voltage in the case of water electrolysis is typically 1.8 to 2.2 volts, although the voltage can vary with the electrolyte concentration and electrode material. Current is controlled in order to control the rate of electrolysis as well as the evolved amount of hydrogen and oxygen gases. The electrolyte is a fluid that makes water more conductive so that the electric current will flow easily. Power reading as shown in the figure 2. Pure water is non-conductive, and hence, a very small amount of an electrolyte such as potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to increase the ionization of water. The electrolyte promotes the water molecule breaking into oxygen and hydrogen gases on the electrodes.

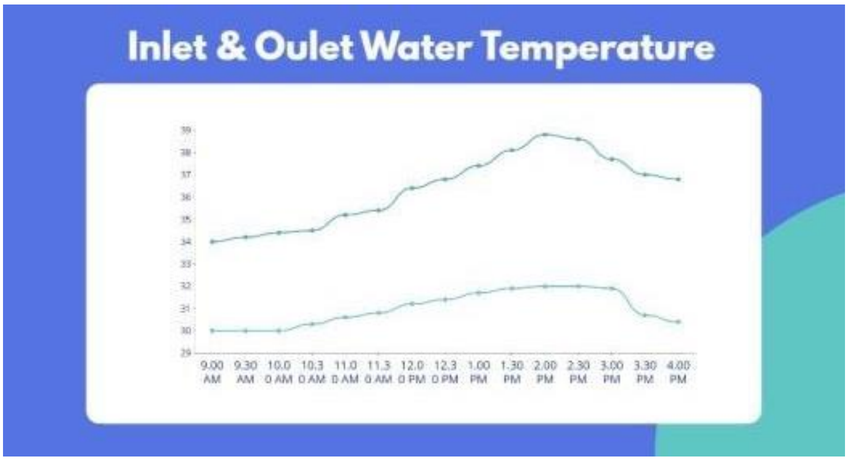

Figure. 2 Temperature Reading

The electrolyte concentration influences the efficiency of the electrolysis, and its temperature may also influence the rate of reaction. The gases evolved at electrolysis hydrogen at the cathode and oxygen at the anode need to be collected and stored separately. This is done through a system of gas collection that is commonly made up of inverted graduated cylinders or gas burettes connected to the electrodes. The gases are trapped in these vessels as they rise from the electrodes, and the amount of gas evolved can be quantified. The system prevents the hydrogen and oxygen gases from mixing, ensuring safety and enabling the gases to be quantified accurately. The water tank contains the electrolyte solution and serves as the medium for electrolysis to take place. It is usually a vessel with purified or distilled water to prevent impurities that may disrupt the process of electrolysis. The tank should be big enough to submerge the electrodes completely and provide a constant source of water for electrolysis. The water needs to be replaced from time to time, depending on the size of the experiment. Hydrogen is highly inflammable gas, and therefore a pressure regulator is an essential safety device in the setup The regulator safeguards the stored gases from being at unsafe pressures, especially in the case of hydrogen handling. The efficiency of the electrolysis process is monitored by measuring the volume of gas produced through the use of flow meters. These devices provide instantaneous feedback for the amount of hydrogen and oxygen that is formed, allowing the scientists to quantify the efficiency of the system. Thermometers for reading the electrolyte temperature, voltmeters for ensuring proper voltage is inputted, and ammeters for measuring how much current flows through the system are some additional measurement devices that may be employed. Hydrogen gas is highly flammable and explosive when combined with oxygen, so safety gear is a necessity in the experimental setup. Apart from the pressure regulator, the equipment should be installed in a well-ventilated area to allow safe release of the gases. Additionally, non-sparking equipment must be used in the handling or servicing of the equipment, and fire extinguishers must be within reach.

CONCLUSION

Commercialization process of hydrogen manufacturing through renewable resources, market emergence, and network building needs greater research. When there is limited access to a grid in isolated areas, one can use solar photovoltaics or wind- operated water electrolysis systems in the off-grid mode. Hydrogen can serve a crucial function in the transportation sector's de-carbonizing by utilizing coastal wind power in the production of clean fuel. Blue hydrogen can be shipped worldwide in the form of ammonia, which is easily converted to hydrogen on-site. Commercial deployment of CO_2 removal technologies can also support the achievement of net-zero CO_2 emissions and avoid 1.5 °C global warming. Besides being a traditional industrial feedstock for the production of ammonia and methanol, hydrogen is now also proposed as an emerging energy carrier. This study addresses the technologies to produce hydrogen from fossil as well as renewable energy sources and the chief issues concerning the practical application of these systems. Various renewable sources of energy, including solar, wind, geothermal, hydro, and biomass, are considered for producing hydrogen. Because intermittent renewable energy sources like solar and wind are among the most promising, hydrogen is the optimal choice for fuel, energy transport, and storage. Due to its advantages and the availability of carbon-free alternatives, hydrogen is increasingly becoming a viable fuel and an exceptional energy carrier globally.

This review article gives a concise overview of different hydrogen production methods from conventional and renewable energy sources, explaining each of them while detailing the progress made to date. The use of hydrogen energy for different purposes can be advantageous since it is low in emissions.

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