APA Style: An Action Research Proposal

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Renewable energy engineering

PEM Hydrogen Fuel Cells

Abstract

For centuries the Energy crisis has been a curse that made Egypt and the world suffer in various ways. Energy is the backbone of many aspects of life; yet depending on fossil fuel as the main source of energy has numerous drawbacks like the high price, transportation, unavailability and pollution to the environment. This has led us to assign the design requirement of having a cheap, available rather than green fuel for cars. As a result, our PEM hydrogen fuel cells are the solution to the problem after making essential changes in order to increase its efficiency while decreasing the price, through using nickel as a catalyst, instead of platinum. Finally the test plan has assured that it meets the design requirements mentioned before, and unquestionably proved that our PEM fuel cells are the right and suitable solution for running vehicles.

Introduction

Energy is an essential need for our life. It is the essential part of industry, transportation means and domestic uses which connects it to all other grand challenges. However, the energy production worldwide faces many issues, as about 81% of its production is from fossil fuel. Despite its high efficiency, it has many obstacles such as the increasing in prices, the possibility of running out in the near future, polluting the environment and the growing population demand. These problems have a considerable effect on Egypt because Egypt depends on fossil fuel in producing electricity, and this causes a shortage of27, 700 megawatts (20%) resulting in regular blackouts, especially, in summer. Egypt also suffer from gas and oil shortage used in domestic uses and vehicles. As a result, Egypt seeks to get energy from alternative resources like: hydro power in the high dam, solar energy stations in the western desert and using gasoline instead of oil in cars. Admittedly, each of the previous resources couldn’t stand alone for the highly

increasing population, so all of them were needed to complete each other and also have a sustainable future.

In our research, we have an objective which is achieving less pollutant rather than cheap car fuel by using the PEM hydrogen fuel cells. To reach this goal, we have to achieve some requirements such as being affordable by the public, dependable as the main energy source, and non-polluting to the environment. We modified the fuel cell prototype by using stainless-steel and nickel, instead of platinum, as catalyst which reduced the price significantly. And after testing the prototype, we found that it achieves these requirements and leads directly to make hydrogen "the fuel of the future".

Review of Literature

Fuel cells were first invented in the year 1839 by William grove which was called by him 'the gas battery'. Its idea of working was based on reversing the process of water electrolysis where the reaction of oxygen and hydrogen together form water and electricity these principles were demonstrated by Humphry Davy in 1801. In the 1970s the energy crisis arose and fossil fuel was threatened run out at any time. Moreover the awareness of how important was it to protect the environment from pollution increased which consequently increased the researches on alternative fuel resources which included the fuel cells. Then in1980s the researchers developed the production of electricity of the fuel cell until it reached 100MW. In the 1990s attention was given to fuel cells due to its low cost and high production which lead to the developing of its usage in industrial and other fields specially solid oxide fuel cell(SOFC) and proton exchange membrane fuel cell (PEMFC) which lead into their use in vehicles (Jonathan Mathews, 2015).

Different types of fuel cells where made like: Proton Exchange Membrane Fuel Cell (PEM)**,** Alkaline Fuel Cell (AFC)**,** Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cells (SOFC), Regenerative Fuel Cells (RFCs)**,** Zinc Air Fuel Cells (ZAFCs), and Microbial Fuel Cells (MFCs), but PEM fuel cells where the most suitable one for cars and vehicles because it needed low operating temperatures. Consequently they were used by Honda in 2007 to make the first ever fuel cell car. However fuel cells had a significant problem which is the high price due to the use the expensive metal of platinum as a catalyst to separate the hydrogen atoms from each other as well as the oxygen atoms.so several researches where done to develop alternate catalysts these included the use of cobalt-graphene alloy and the use of nickel doped with manganese dioxide and the use of other metal oxides these researches lead us to use nickel presented in stainless alloy.

Methods

We have used special materials that we associated together for forming the Hydrogen Fuel Cell prototype. These materials were (2 pieces (8x4 cm^2) from Nickel used as a catalyst in the fuel cell, (5 gm of Gelatin, 38.5 gm of Potassium Chloride, 80 ml DI water) used for making the proton exchange membrane (PEM), 2 pieces (8x4 cm^2) from rubber are put in the prototype to prevent any hydrogen leakage, Arduino UNO used to program the hydrogen sensor, Hydrogen sensor used in the circuit to detect the presence of Hydrogen, 7 nuts with their bolts Used to fix pieces together, 4 jumpers Used to connect different parts of the circuit together, Bread board used as construction base for the sensor and other circuits parts, LED used in the circuit to light in the presence of hydrogen, and 2 Acrylic plastic sheets (12.5 x 9 cm^2) used to make the cover of the PEM fuel cell)

After the creation of our prototype we used it in two tests one of them was **the**

Cost test plan: Tools: multimeter –internet to determine costs of some materials

Objective: this requirement is to compare the price of our fuel cell and its power to those of the PEM fuel cell

Procedures: Determining the prices and powers of our fuel cell and PEM fuel cell with platinum, then setting a ratio between fuel cell price to its power, after that we set another ratio between the price of the PEM fuel cell to its power.

Success conditions: If the ratio in our fuel cell is less than the ratio in PEM fuel Cells then it succeeded; otherwise, our fuel cell didn't meet the requirement.

The other was **the Safety test plan: Tools**: balloon filled with hydrogen – Arduino–LED – hydrogen sensor – jumpers – ruler.

Objective: this test plan is to test the safety system in the prototype.

Procedures: Passing an amount of hydrogen on the sensor from different distances, and observing the distance that the led don't light in, then graphing the results of the effect of different distances on the hydrogen sensor.

Success conditions: If the led lit in the presence of hydrogen this indicates then the safety system is well operating, otherwise it needs some modifications.

Results

After doing the coast test plan we founded that the total cost of raw material used in prototype= (price of gelatin + price of stainless steel + price of rubber + price of nuts and bolts + price of potassium chloride + price of Distilled water + price of Acrylic sheets) = 8 Pounds and it produces 0.3 (±0.02) volts and 0.225 (±0.031) watts

An average fuel cell made of platinum costs about 700 L.E and produces 0.6 (±0.1) volts and 0.9 (0.32) watts

Cost to power ratio in our fuel cell = $x = \frac{cost}{power} = \frac{8}{0225}$ = 35.58 L.E/Watts

Cost to power ratio in PEM fuel cell (Using platinum) $= \frac{cost}{power} = \frac{700}{0.9}$ = 777.78 L.E/Watts.

When we finished the safety test plan we made sure that our prototype is safe, because it can measure the danger of hydrogen leak until 20cm (±0.03 cm) far from the hydrogen storage as shown in graph 5 so the distance between each sensor and the other will be 20cm.

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