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DEVELOPMENT OF A FUEL CELL

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Abstract. *The most commonly used energy sources are pollutants and are mostly non-renewable, fuel cells appear as a solution to these problems and are considered a source of clean and renewable energy. This work aims to develop a hydrogen fuel cell and analyze its production capacity. Obtaining at the end a satisfactory result, thus considering the advantages in the application of fuel cells over the disadvantages.*

Keywords: *Cell, Hydrogen, Energy, Renewable.*

1. INTRODUCTION

Hydrogen is considered an alternative to non-renewable fuels, when it is used to generate electricity using fuel cells, it does not produce pollutants and is a renewable source, at the end of the process only water remains. These are the main reasons to be considered fuel for the future, if it can replace the current sources of exhaustible energy, will be a great step toward a sustainable future in energy generation. "Recently, Villullas, *et. al*., 2002, the galvanic cell is an electrochemical system that can generate useful electrical energy by means of a chemical reaction that occurs spontaneously in its interior".

The cells are considered one of the trends for the future when the subject and sustainable energy in the means of transport. "Recently, Wendt, *et al*., 2000, the fuel cell principle was discovered by Sir Grove as early as 1835".

Fuel cells produce energy through the cold electrochemical combustion of a gaseous fuel, as well as a device to convert chemical energy into electricity, such as a battery, the difference and that in the cell the reactants are stored externally. Hydrogen is oxidized continuously in the anode, while oxygen is reduced on cathode, with a flow of electrons through the circuit and produces electrical work as shown in Fig. 1.1.

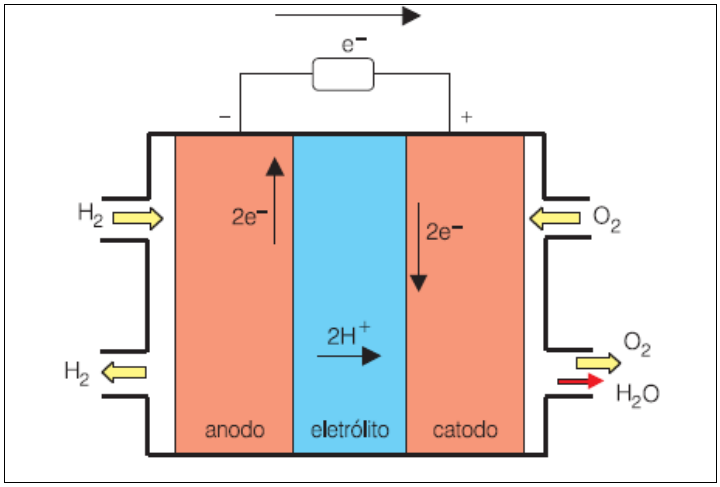


Figure 1.1. Schematic of a fuel cell.
Source: Villullas, (2002).

There are several types of galvanic cells. “Recently, Carrete, *et. al*., 2001, fuel cells are usually classified by the electrolyte employed in the cell”. Each cell is made with ideal components for your purposes like Fig 1.2 presents the cell types.

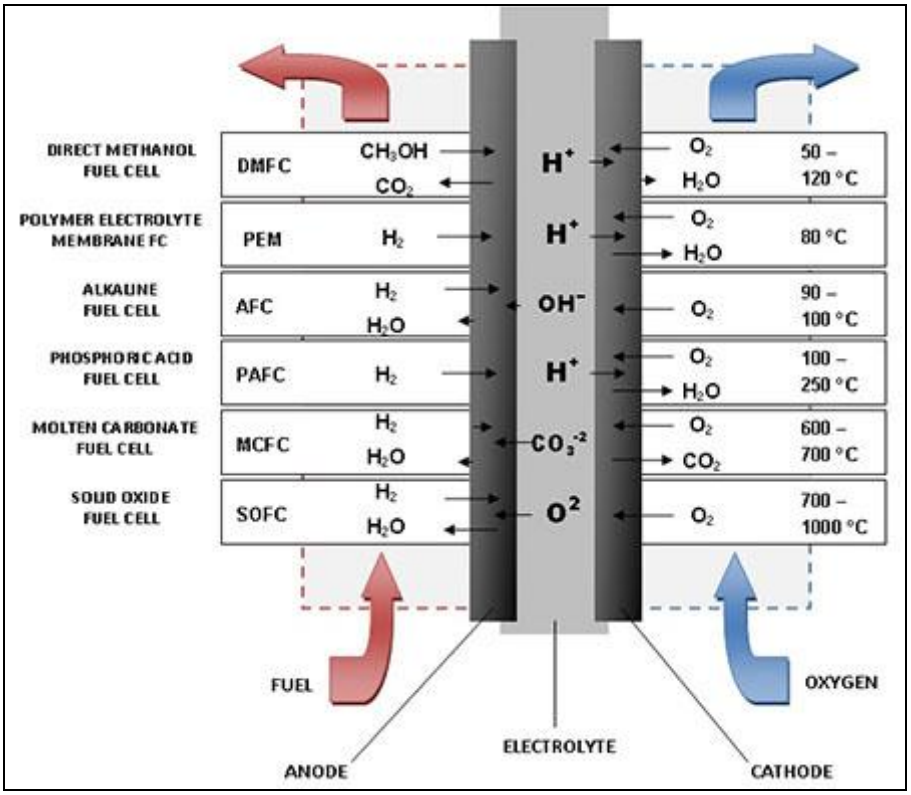


Figure 1.2. Types of fuel cells.
Source: <http://www.novocell.ind.br/pt/tecnologia> Accessed in 2017.

A cell is composition by electrodes that are electronic conductors, the materials used in its construction must present high electro catalytic activity, favoring a kinetic of the electrochemical reactions. Among the electrodes is the electrolyte that is an ionic conductor that can be a liquid or a polymer. All these components form a circuit capable of transforming chemical energy into electrical energy, the most commonly used fuel is hydrogen, because it has the highest energy per unit weight compared to others and is the lighter element because it does not have heavy carbon atoms the Tab 1.1 shows the calorific value of the main fuels.

Table 1.1. Heat power of fuels.
Source: Santos, (2005).

Combustível:	Valor do Poder Calorífico Superior (a 25°C e 1 atm)	Valor do Poder Calorífico Inferior (a 25°C e 1 atm)
Hidrogénio	141,86 KJ/g	119,93 KJ/g
Metano	55,53 KJ/g	50,02 KJ/g
Propano	50,36 KJ/g	45,6 KJ/g
Gasolina	47,5 KJ/g	44,5 KJ/g
Gasóleo	44,8 KJ/g	42,5 KJ/g
Metanol	19,96 KJ/g	18,05 KJ/g

Hydrogen is considered the ideal fuel for such cells, because of its very high reactivity in the electrochemical reaction of the anode and its oxidation produces water for the environment. “Recently, Santos-M and Santos-A (2005), hydrogen is the most abundant element in the Universe and the lightest, being also simpler of Mendeleev's periodic table”. Among the forms of production can be highlighted:

Water electrolysis

This method uses electrical energy to separate the atoms from the water (hydrogen and oxygen), with the general efficiency of the process of the order of 95%. Electrolysis has the advantage of being a clean way of producing hydrogen. But it also has negative aspects, because requiring large amounts of energy and, in general, the energy sources used are not renewable and polluting.

Steam reforming natural gas

This technique consists of exposing natural gas or other hydrocarbons on steam in high temperatures to produce hydrogen, carbon monoxide and carbon dioxide. However, this method has three drawbacks: The production of hydrogen with this method is more expensive per unit of energy, the second is that this method only applies to fossil fuels that are a non-renewable source of energy and the third is the carbon dioxide that is released into the environment.

Photobiological

Some photosynthetic microbes produce hydrogen in their metabolic activities using light energy. It has the advantage of being a clean production method and may eventually be cheap. The disadvantage is the process efficiency needs to be improved.

Other ways of producing hydrogen

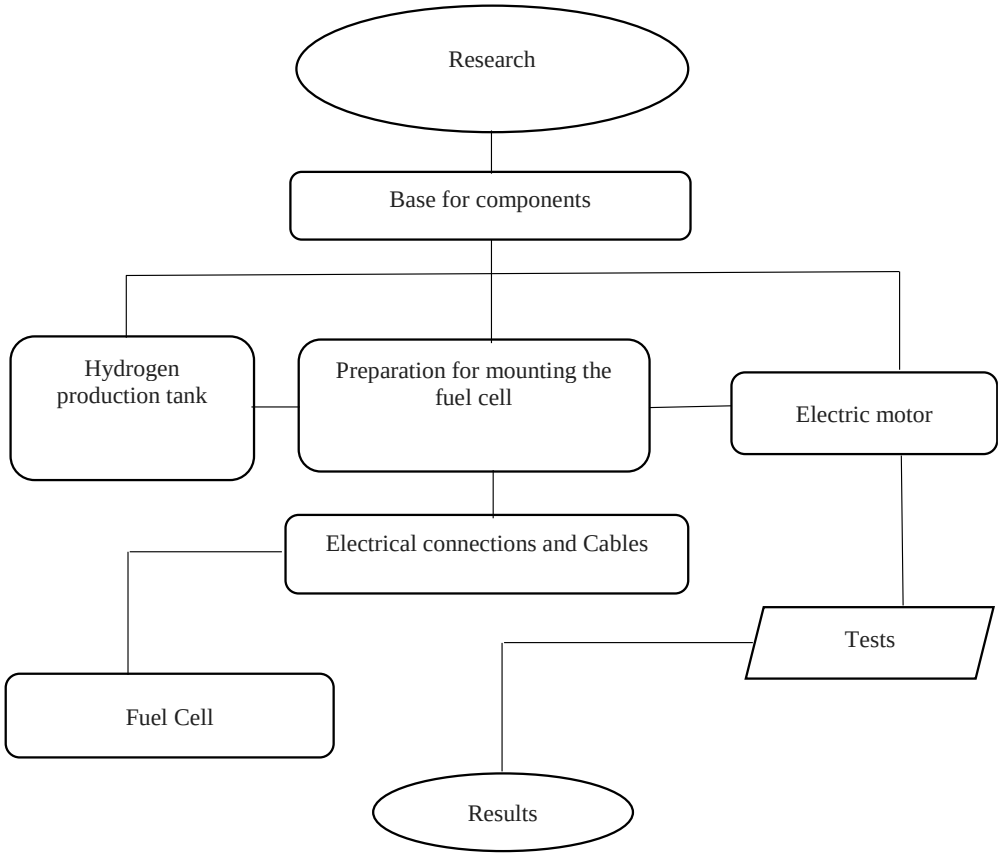
Hydrogen can be obtained by reaction of very reactive metals with water, or by the action of sulfuric or hydrochloric acids with moderately reactive metals such as iron or aluminum.

2. OBJECTIVE

The objective of this paper was to evaluate the advantages in the use of fuel cells in replacing the current sources of nonrenewable energy through the development of a prototype in which a cell feeds an electric motor and demonstrate the advantages in the end about the disadvantages.

3. MATERIALS AND METHODS

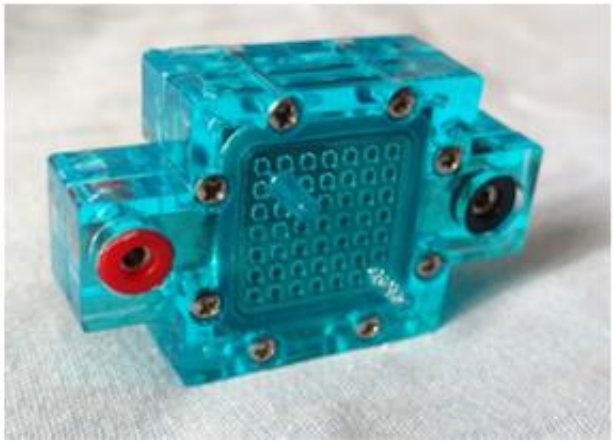
To perform hydrogen production tests and efficiency that the engine is fueled by the fuel cell, a small-scale prototype is built. The components and steps required for the construction are represented in Flowchart 3.1.



Flowchart 3.1. Stages of construction.

3.1 FUEL CELL

To construction of the cell, it is necessary, oxygen entry plate, hydrogen entry plate, diffusive layer (anode), diffusive layer (cathode) and ion exchange membrane, thus composing an alkaline type fuel cell according to Fig 3.1.1.



Cell Specification	
Dimensions	32mm x 32mm x 10mm
Total weight	27,3 Grams
Number of plates	3
Power rating	270 mW

Figure 3.1.1. Fuel cell.

To hydrogen production, a tank and a connection are used, the chosen method is the chemical reaction between the solution composed of H2O (distilled water) + NaOH (sodium hydroxide) + AL (aluminum). The concentration required for a satisfactory voltage is obtained through Eq 3.1.1. “Recently, Rocha-Filho and Da Silva (2017)”. After mixing occurs producing hydrogen, this method consists of filling the cylinder with water and positioning the same in a container with water, so that the inlet remains in contact with the recipient without loss of liquid, subsequently the gas flow hose and placed on the mouth of the cylinder, as the gas is produced the water is pushed to the recipient, obtaining thus the gas volume produced according to Fig. 3.1.2.

$$C = m / v \tag{3.1.1}$$

At where:

C = Concentration of solute m = Mass v = Volume of the soluble

Figure 3.1.2. Production of hydrogen.

3.2 TESTS

The multimeter is connected to the cables connecting the cell to the motor to check the current and voltage, according to Eq (3.2.1). To obtain the efficiency in which the mechanism works by the cell is used the Eq (3.2.2), "Recently, Tipler and Mosca (2009)".

$$P = VxI \quad (3.2.1)$$

$$I] = Pu / Pt \quad (3.2.2)$$

At where:

Pu = Power used *Pt* = Power received *V* = Voltage *I* = Current

4. RESULTS AND DISCUSSIONS

Figure 4.1 presents the final assembly of all components of the prototype.

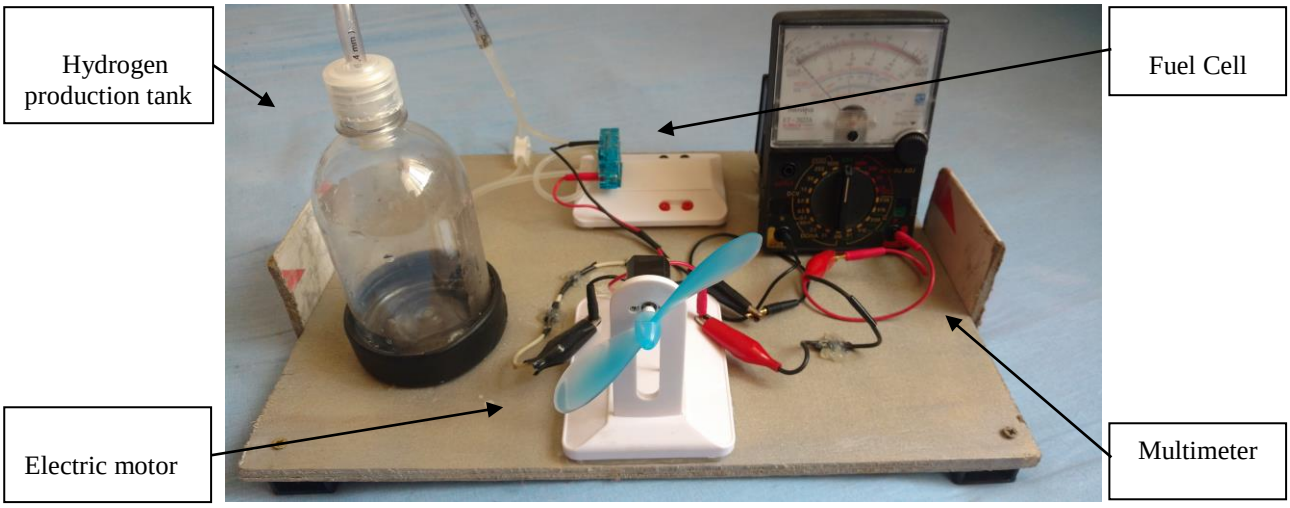


Figure 4.1. Final prototype.

The results of the hydrogen production tests using the method shown above whit 5% of NaOH concentration can be observed in Fig 4.2.

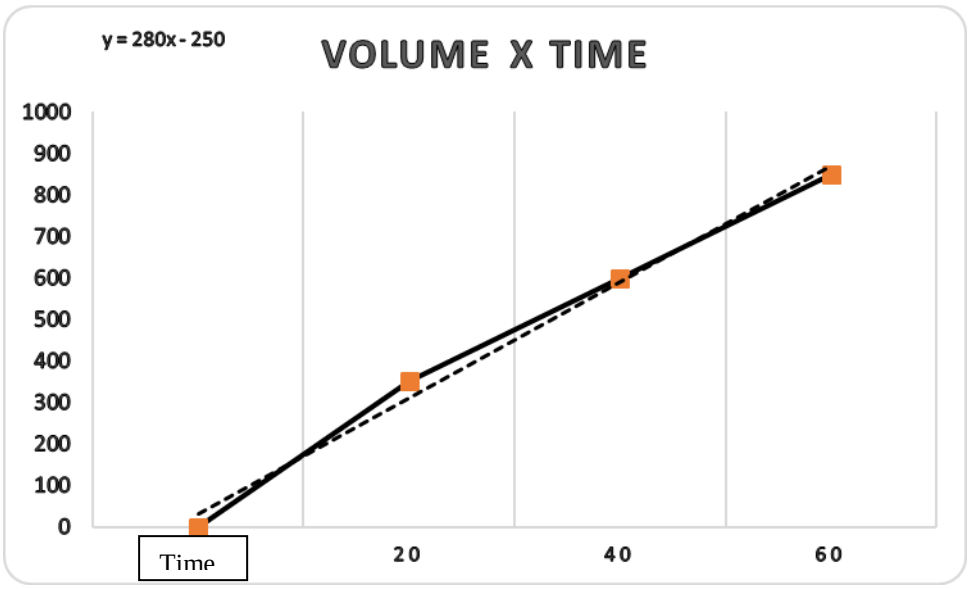


Figure 4.2. Volume x Time (NaOH concentration 5%).

Table 4.1. Final hydrogen production.

Solution NaOH		
Solution	Concentration	Hydrogen Volume
NaOH / L H_2O	5%	850 *ml/min*

The method chosen to produce hydrogen is the contact with the (NaOH) solution with the metal aluminum that forms a complex of Na and Al, and H2 gaseous expressed on Reaction 4.1.

$$2Al(s) + 2NaOH(aq) + 6H_2O \rightarrow 2Na[Al(OH)4](s) + 3H_2(g) \quad (4.1)$$

The prototype used presented the results expressed in Tab 4.2 for current, voltage, hydrogen consumption and efficiency in which the cell feeds the engine.

Table 4.2. Cell results.

Alkaline cell with 3 plates				
Tension	Current	Potency	Volume consumed	Efficiency
0,68 *V*	223,16 *mA*	151,75 *mW*	850 *ml/min*	56%

The delta cost to produce the prototype is shown in Tab 4.3.

Table 4.3. Delta cost.

Cell	280 *R$*	Total cost
Motor	20 *R$*	
Hydrogen Container	15 *R$*	
Gas Connections	20 *R$*	
Electrical connections	20 *R$*	355 *R$*

The disadvantage of cells is the high cost of using noble metals or polymers as electrical conductors. With the improvement of the technology, new materials can be adopted, because the cells have high efficiency, renewable energy production capacity and no emission of pollutants. The fuel cell at the end of the tests presented satisfactory efficiency, like other studies done in AFC cells that present efficiency between 45% and 60%.

5. CONCLUSION

A small alkaline fuel cell powered with hydrogen can power a 1.5 *V* electric motor with an efficiency of 56% and is considered a satisfactory result in relation to thermal machines for a larger power generation capacity. A cell with a higher number of plates and more efficient conductive materials such as solid polymer should be used. For the technology to be widely diffused, companies must create a hydrogen distribution chain and alternatives to high-cost materials, as the advantages outweigh the disadvantages.

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7. RESPONSIBILITY NOTICE

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