Hybrid Electric Vehicle (NAYAA II)

Batteries – Fuel Cell

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ABSTRACT

Worldwide, the trucking sector emits about 25% of all CO2 emissions and is projected to increase to 50% by 2030 and more than 80% by 2050, according to the International Energy Agency (IEA, info. 2009).

The use of hybrid vehicles can significantly reduce the amount of emission of polluting gases into the atmosphere. A hybrid electric vehicle (HEV) could have two or more power sources on board and depending on system configuration; two or more sources of energy are used to drive the vehicle. The interest in reducing the emission of pollutants in automobiles has created the need to develop and build a wide variety of systems and devices for this purpose.

This experimental work presents the design, construction and performance evaluation of a hybrid electric vehicle (Nayaa), powered by a generator with PEM fuel cell and / or rechargeable batteries. The generator design was done using AutoCAD software, construction of fuel cells using a CNC router and CNC laser cutter.

The characterization of the cell was performed by potentiostatic polarization tests.
The operation conditions of generator with fuel cell was: feeding the fuel (H2) and oxidant (air) at room temperature and a pressure of 0.1 atm (1.5psi), operating temperature of 20 º C at 70 º C.

Keywords: Design; Stack Fuel Cell; Electric Vehicle.

1. Introduction.

The use of fossil fuels in automobiles, produce large amounts of emissions, it affects climate change and leads to global warming and deteriorating health of living beings. In worldwide many laboratories and institutions have been developing prototypes and marketing, based on different technologies, such as hybrid vehicles (ie., different motor carriers), this will help to reduce energy dependence on fossil fuels and significantly reduce the amount of greenhouse gas emissions to the atmosphere.

PEM fuel cells are devices that produces direct current when fed with hydrogen (fuel) and oxygen (oxidant) through an electrochemical reaction. The end product of this reaction is water and heat, therefore, it does not produce any green house gases [1].

A hybrid electric vehicle can have two or more power sources, used to drive the vehicle depending on system configuration. For the first time in Mexican renewable energy scenario our group of researchers developed an improved prototype vehicle called as NAYAA. It utilizes the primary source of energy in reachable batteries as secondary source.

2. Experimental conditions.

2.1. Generator of electricity by PEM-FC.

The power generator consists of the PEM fuel cell stack with fuel system supply and power electronics. The generator provides electrical energy through the unregulated D.C. The weight of the generator is 13.5 kg.

The design of the fuel cell stack were carried out by AutoCAD software, taking into account of different designs proposed in the literature [2-3-4-5]. The construction of the monopolar, bipolar and end plates were used milling machine through CNC controller. Gaskets, membranes and acrylic pieces were cut by a laser cutter.

Fuel cells is constituted by plates of high density carbon with a thickness of 5mm, 150mm wide and 150mm long. The field design flow of gas to the anode and cathode is shaped cross straight channels.

Brass sheet act as current collector, acrylic plates channel input and output for hydrogen and air. Aluminum end plates, silicone gaskets and stainless steel studs were used. Between each current collector plate there is a membrane-electrode assembly (MEA), which is formed by membrane Nafion ® NRE-212, carbon cloth diffusers with catalyst loading of 20 wt% Pt / C loading of 0.5 mg / cm^2 in both the anode and cathode. The performance of fuel cells was determined by potentiostatic polarization in a test module.

Figure 1 shows a photo of the generator, contains the PEM-FC, and peripheral system.

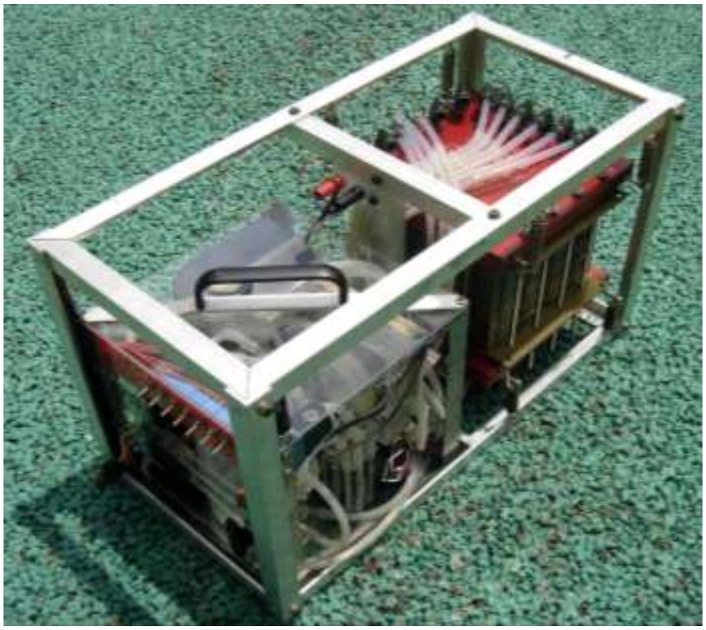

Fig 1. Power generator.

2.2. Rechargeable batteries.

Two rechargeable lead-acid batteries with an electrical capacity of 12V, 24 Ah (VISION CP12240) were used. They are connected in series to obtain a total voltage of 24 V.

The following table describes the specifications of the battery and the figure shows the component parts.

Table 1.General Specifications.

Component	Positive plate	Negative plate	Container	Cover	Safety valve	Terminal	Separator	Electrolyte
Raw material	Lead dioxide	Lead	ABS	ABS	Rubber	Copper	Fiberglass	Sulfuric acid

Fig 2. VISION CP12240 Battery.

2.3. Power electronics.

2.3.1. Power Electronics generator.

The 360W load control was use to be regulated electricity and take advantage of gaining the full power of the cell. The load control operates with input voltages from 12.7V to 14.4V and produces an output voltage of 12.7V with a variation of ± 1.5%. A 400W inverter was coupled to load control, which operates with an input voltage of 12.8V at 25A and produces an output voltage of 115V AC, 60Hz. Figure 3 shows a picture of the power electronics, DC / DC converter - DC / AC 100W.

Fig 3. Power Electronics, DC / DC converter and inverter DC / AC.

2.3.2. Power Electronics for rechargeable Vehicle batteries.

A 500W power converter was designed and built for conditioning the electrical energy and voltage boost from the PEM-FC. The DC-DC converter uses a digital control to adjust the output voltage. The Spain of the input voltage is 9 to 18 volts. The output voltage varies between 28 and 29 volts. A 480W load control was coupled to boost converter for recharge the batteries of the vehicle. The load control operates with input voltages from 26.2V to 29V and produces an output voltage of 26.2V with a variation of ± 1.5%.

Fig 4. Power Electronics DC / DC converter-load control

2.4. Diagrams of energy systems.

2.4.1. Diagram of the fuel cell generator.

Figure 5 shows the diagram of the components that make up the autonomous system: pressurized tank with hydrogen at 136 atm, auxiliary systems recirculation of hydrogen pressurized to 0.1 atm with humidification [6], feeding of the oxidant (atmospheric oxygen), fuel cells, DC / DC load control and inverter DC / AC. The lines show the flow of the different states of electricity and fuel.

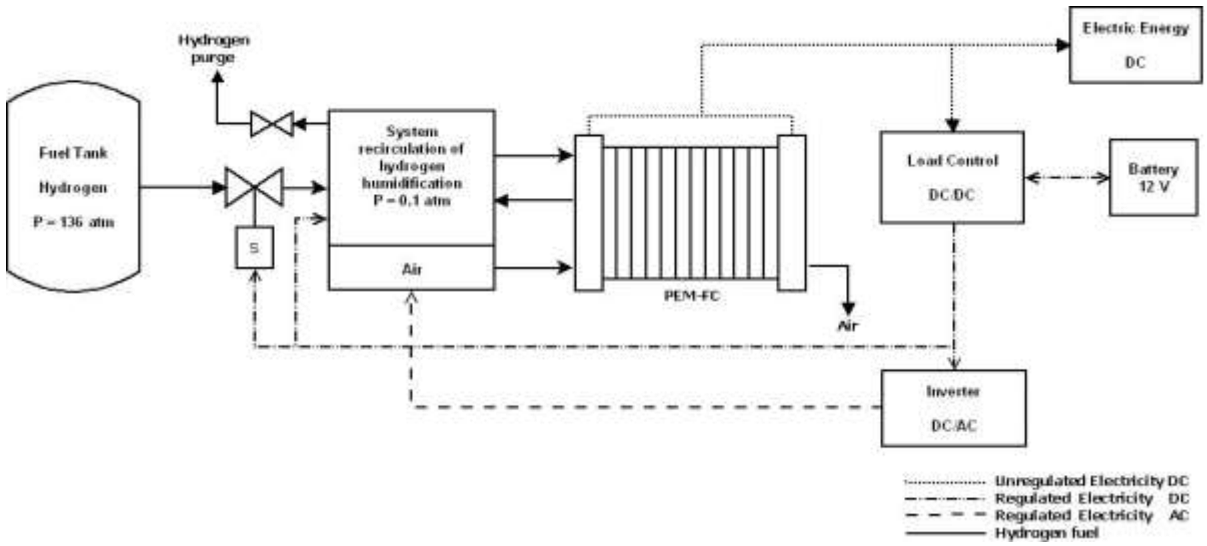

Fig 5. Diagram of the autonomous system based on fuel cells.

2.4.2. Diagram of the installation of energy sources.

Figure 6 shows the two power sources that are on board the vehicle and also the main components that make up for its operation.

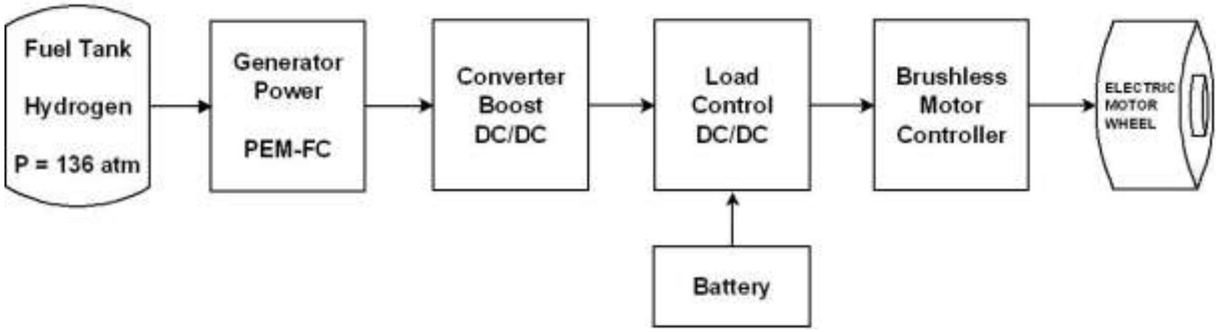

Fig 6. Diagram of energy sources (Battery, PEM-FC).

2.5. Hybrid Electric Vehicle.

The hybrid electric vehicle (HEV) has two power sources (PEM and rechargeable battery) board for propulsion [6].

It consists of four wheels, two rear-wheel drive for progress and two front for steering, were used aluminum for the chassis and bodywork fiberglass, which has a total weight of 180kg.

The displacement front is provided by two electric motors with maximum power of 500W each one, the brake system of the vehicle is made up of magnetic brake motors and mechanical disc brakes on the front wheels.

Figure 7 shows a photo of the HEV (Nayaa II), powered by rechargeable batteries and PEM-FC and all peripheral systems.

Fig 7. Hybrid electric vehicle (Nayaa II).

3. Results and discussion.

3.1. Performance of PEM-FC power generator.

The pressurized hydrogen in tanks 136atm is fed to the cell by auxiliary recirculation system and humidification of hydrogen at 0.1atm, using 5 diaphragm pumps.

The hydrogen consumption is variable to times, depend on the load demand will range cells, whereas the cell operating at its maximum power consumption of total hydrogen is approximately 6 l / min.

Figure 8 shows the voltage-current response of the power fuel cell.

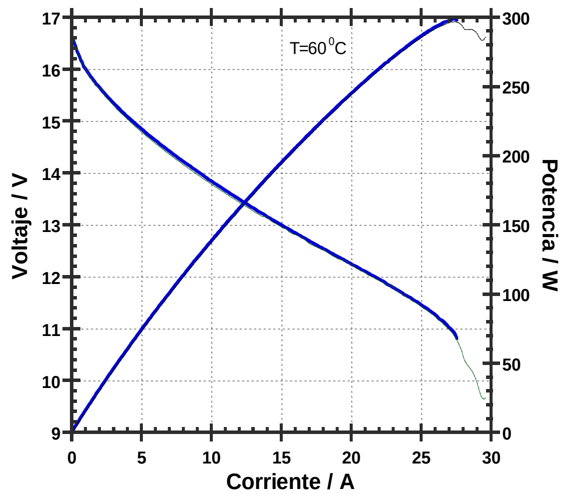

Fig 8. PEM-FC Performance.

3.2. Performance of Rechargeable Lead-Acid battery.

This battery is typically used for UPS that provides constant power. Figure 9 shows the typical behavior of discharge to the ambient temperature of 25 ° C.

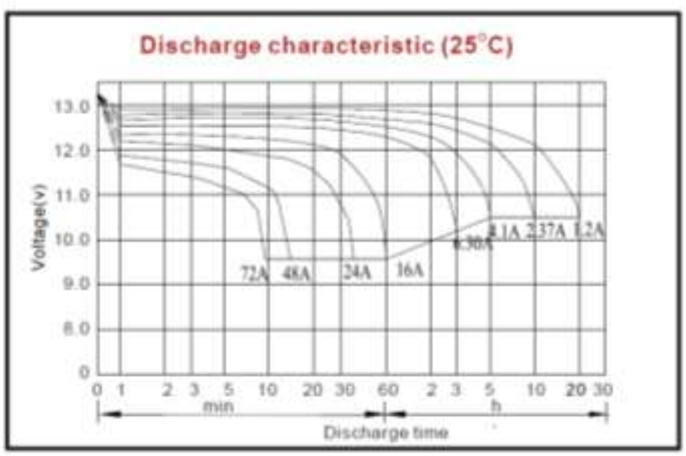

Fig 9. Discharge curve.

3.3. Strategy and distribution of energy to the vehicle.

The vehicle progress is achieved by two brushless electric motors that are powered by two speed controllers, the speed controllers operate by electricity (DC) regulated from battery load control, the batteries are recharged by the fuel cell and the boost converter (DC / DC)

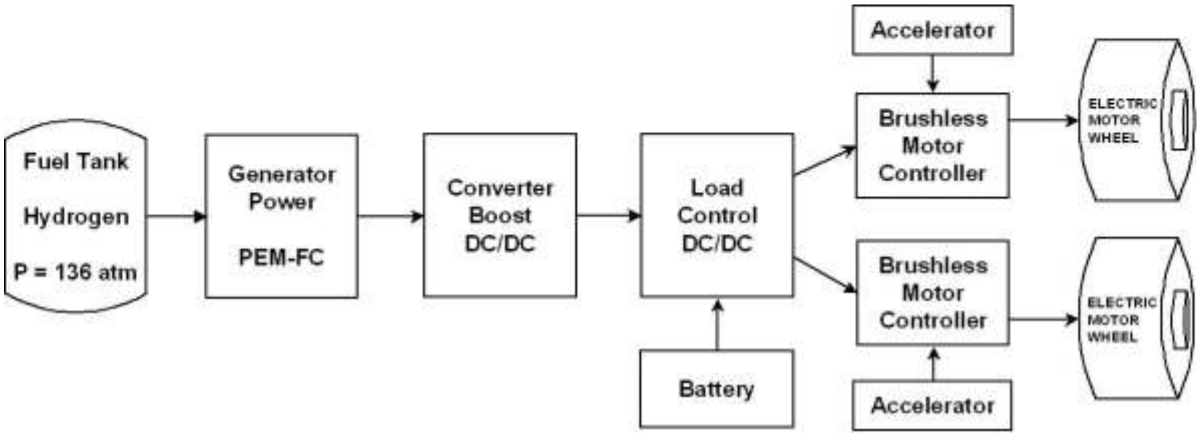

Fig 10. Strategy and distribution of energy.

Figure 11 shows a photo of the different electrical systems, generator and batteries of the vehicle.

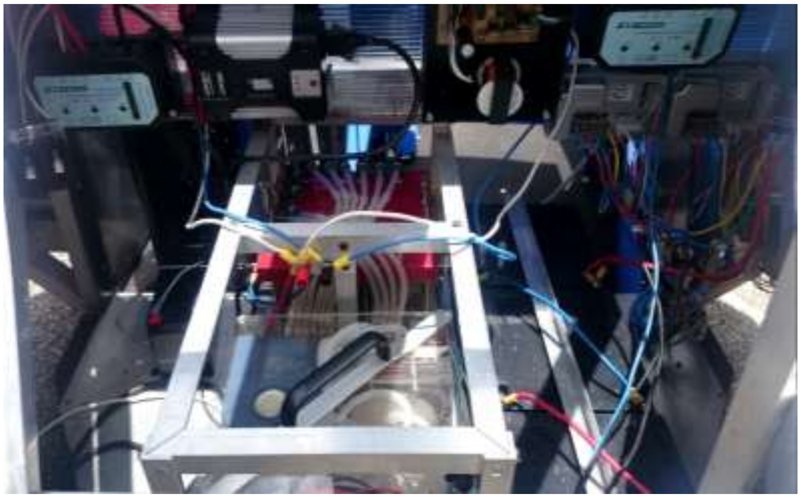

Fig 11.PEM-FC Generator and power electronics.

4. Conclusions.

This hybrid solution (battery, fuel cell) for vehicle could be profitable and eco friendly.

Power generator PEM-FC provides maximum power of 300 W @ 11 V and 27 A with a maximum consumption of 6 l / min of hydrogen.

In our laboratory for the first time in Mexican renewable energy scenario, we achieved to build a hybrid electric vehicle and to analyze the possibility to wards the automobiles application.

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