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Hydrogen generator, an application with internal combustion engines

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***Abstract*— *This Paper present the steps to build an hydrogen cell emphasizing the need to use as a renewable energy source, being applied with internal combustion engines, as an efficient result obtained through electrolysis. Data presented in tables and graphs were collected and analyzed, both for urban streets and for highways. The tests in urban streets the vehicle presented 15.5 kilometers per liter of fuel (km/l), with efficiency of 38% compared to ordinary fuel, as well as on highways, made 18.9 km/l, with 33%, respectively acting at 60.5 kilometers per hour (km/h), the gain is due the fact that the system, which is directly linked to the generator currents and voltages consumption, implying that the higher current consumption, greater will be the gas generation. The results of the project show the veracity of achieving economy, yield and efficiency through hydrogen, allowing the possibility of implementation not only in vehicles but, in all varieties of engines available on the market today, and the substitution for other sources.*
***Keywords*— Electrolysis, Fuel, Efficiency, Cars.**

I. INTRODUCTION

Currently, new ways to obtain a clean and renewable energy source are being sought, as the environmental crisis intensifies each year. Therefore, one of the most questioned cases is car pollution, since they emit tons of carbon monoxide (CO) every day contributing to global warming and the greenhouse effect.

In this condition according to [16], some companies present solutions to reduce or eliminate the emission of pollutant gases, notably Tesla company, with the production of fully electric vehicles, with zero air pollution, and with support for large storage capacity and generation of energy.

Many companies are still using fossil fuels to produce energy, and some of them are not care about environmental degradation or the fact that their materials are depleted, 75% of companies do not seek improvements to eliminate pollutant gases from their cars, or even investing in hybrid cars, to generate savings and less consumption of exhaustible sources [7].

According to [4], the principle of operation of engines is becoming archaic, because the method used still emits many gases in the atmosphere and uses a lot of energy to produce movement, basically the engine works as follows: intake, explosion and exhaust, the energy is released to make movement of the pistons, however, the current way of energy generation is more efficiently when compared to past times.

Hydrogen is a pure and non-polluting element, can be applied in many sectors of the industry, among them, electric power generation, raw materials to heat generation, are also used in the chemical, petrochemical, steel companies and food sectors. There are several ways to obtain hydrogen through electrolysis, solar panels, wind energy and biomass generation [14].

In the mechanical sector, hydrogen can also be applied to diesel engines used for power generation, including river and automobile sectors for fuel production. Studies show that only hydrogen could be used as a single source of energy, receiving power from a renewable source [1].

Consisting of a simple architecture, the cost of production is viable when compared to the amount the consumer would spend in five years using fuel. However, with market competition and scarce raw material, the price of a barrel of oil has been rising each year, causing variation in the final value of fuels and derivatives, pointing to need for robust products that generate more economy [17].

Hydrogen is clean, and do not damage the combustion chamber, its heat level is higher compared to ordinary fuels. Therefore, hydrogen results in a much higher explosion power, reaching up to 80% efficiency and 50% more of yield, with values that vary for each type of implementation, and the type of construction [15].

The hydrogen generator is made up of positive and negative cells, and depends on the power supply of a

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battery to make the electrolysis, which is submerged by water. However as it is a natural agent, environmental impacts are reduced by mixing hydrogen and fuel. One of the important point to be mentioned is the formation of electrolysis like the main basis for obtaining hydrogen [18].

The objective of this study is to describe the benefits of implementing the hydrogen generator in engines, seeking economy, durability and performance, without the need to generate impacts for the environment, because it can reproduces itself naturally.

II. MATERIAL AND METHODS

The research method used was the explanatory and quantitative type relying on data collection. According to [8], explanatory research seeks to record the facts, analyze, interpret and identify their causes, being able to raise theories, logical deductions and define broader laws.

However quantitative analysis is related to numerical data collection, predictable estimates with results able to represent the data collection.

2.1 Data collection

The car that has used to this data collection is owned by the manufacturer Renault, with 1.6 and 16-valve engine, acting on 4 cylinders with a power of 110 Horse Power (HP), its fuel consumption is according to the type of road, for which it was developed. The vehicle has autonomy of 8 km/l on urban roads and 10 km/l on highways, using gasoline as fuel.

The prototype was made from 316 L stainless steel plates, measuring 11 x 11 x 0.1 centimeters (cm), with access to two holes in the middle that will be available for water and gas with a diameter of 2 millimeters (mm) (Fig1). The model has 3 plates in total, adhering to 2 positive and 1 negative poles, and the plates are mounted in parallel and separated by seals, so that the liquid does not leak. For generator protection two acrylic sheets are used which measure 120 x 120 x 10 mm.

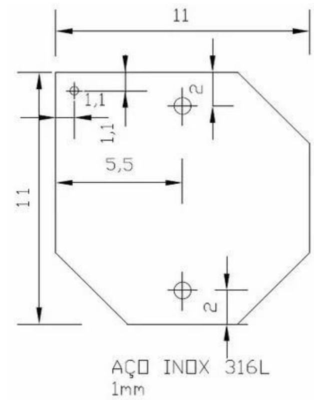

Fig.1: Inox 316l plate measurements.

The explosion system consists of two valves and the spark plug, one open for fuel injection and the other to the oxygen inlet, the valves opening must be at the right time to provide the right operation, oxygen inlet is admitted by the Throttle Body Injection (TBI), where there are a measure of air purity is also made so that the gasoline dosage is appropriate for the mixture.

Therefore, hydrogen is injected through the tube that goes into the TBI, reducing the gasoline dosage as oxygen enters the system, informing to the on-board computer to calculate the new range of kilometers traveled per liter[6].

Fig.2: Hydrogen generator installed.

The drive system is made by a relay, whose operation is linked to the ignition signal, when received by the system, releases the generator access to battery power through the electromechanical process of switching terminals, allowing the generator start and inform the signals [2] (Fig3).

Fig.3: Relay drive system

The digital panel inform the current consumption in the full system and the working voltage value for analysis in relation to the trip data. The test starts when the car tank is empty, the fuel is supplied for route data collection, on the road and in urban places, with the generator running, in the panel is informed the amount of fuel consumption in the engine, providing the correct measures for a quantitative analysis [11].

The prototype is related to a digital fuel control concept, where the control unit (UC) receives the data collected by the sensors in the vehicle, and it is calculated to show in the onboard computer. [9] points out that with the advent of electronic injection, improvements in (UC) have enabled more advanced features so that the driver

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has more control over his vehicle, obtaining more information about what happens in operation.

The car tunes to km/h averages, where (UC) calculates tire tread to provide information on the digital dashboard, as well as providing km/l, indicating the basis of kilometers driven by fuel consumption [3] (Figure 4).

Fig.4: Digital dashboard showing the consumption

III. RESULTS AND DISCUSSIONS

The way the TBI absorbs the gas to make the combustion inside of chamber, resulted in small losses due to the isolation of the throttle body, however the obtained data still favors the fuel economy,

The chemical reagent used proposed a great efficiency in the generation of hydrogen dissolved in the solution KOH (Potassium Hydroxide), proving to be effective and harmless in the reaction process. [10], state that there is only efficiency in hydrogen generation in formic acid solution (CH2O2), able to remedy the oxidation of steel, on the other hands it is stated that by facilitating the release of the acid faster, the material tends to prolong the use time.

The test presented data on mileage gains, and the hydrogen gas mixed with fuel resulted in a reduction in CO_2 emissions into the atmosphere, so was used less fuel in the engine to achieve the goal. [5] claim that the hydrogen cell is much more operative compared to internal combustion, and reduces about 50% of carbon dioxide emissions into the atmosphere (Tab1).

Table. 1: Route data for kilometers driven, with generator and fuel.

Fuel	Street (Km/l)	Highway (Km/l)	Speed(Km/h)
Hydrogen Gas and Gasoline	15,5	18,9	60,5
Gasoline	9,7	12,6	60,5

According to the data obtained, it is easy to see the increase of the path performed per liter, both on the highway and in urban centers streets, the path performed on the urban road with hydrogen and fuel has a 38% increase compared to the use just the standard fuel, while on the highway 33% are obtained, the gain variation becomes high with a difference of 5%, because are factors that link losses in urban centers in relation to environmental variables, while on the highway the result indicates that the disturbances that influence the system are smaller.

Being self-sufficient in its own generation of complementary fuel, the vehicle has a higher torque, according to [19], the hydrogen in the act of ignition reaches up to 585 ºC, being higher than the point which gasoline burns, which default is 257 ºC. Analyzing the data, the mixture can reach approximately 842 ° C.

The prototype acts in the generation of hydrogen, through the applied voltages and currents, resulting in the temperature variation of the plates, presenting standard ambient temperature at the moment of actuation. The indicated data refer to the energy consumption that the generator needs to supply the engine fuel demand (Tab2).

Table. 1: Current consumption and working voltage in the prototype.

Plate 316L	Current (A)	Voltage (V)	Speed (Km/h)
1 Pole	0,75	12,1	60,5
2 Poles	1,5	6,05	60,5

Current and voltage are directly related to hydrogen generation, resulting in a set of factors related to the mileage gain rate, so when diversifying the number of plates the current will vary because current consumption does not depend on the need of the engine but the number of plates to each type of engine.

If each plate consumes 0.75 amperes totaling 1,5 amperes on average 52% efficiency, it should be noted that gas generation must be attributed to total current consumption. Thus the choice of plate quantity varies according to the diameter of each engine cylinder.

The hydrogen prototype with low current and voltage consumption in the system indicates that if the car were fully hybrid, it would not use the alternator as a secondary source to provide battery power. However it could be replaced, both by a solar panel and [12] states that solar panels are very important for more efficient power generation, calling a direct generation called photo electrochemistry, resulting in prototype and panel interaction, directly feeding the generator with continuous loads.

Due to the production process, when analyzing the gas production management in the reservoir, there was hydrogen accumulation, consequently after removing the high pressure cap of the reservoir, with engine turned off, an accumulated gas content was observed. According to

[20], hydrogen storage is still a factor to be analyzed, this due to temperatures and pressure variables, however it points out that the simplest forms of storing hydrogen are liquid and gaseous forms, where the gaseous form requires that the environment is at high pressures and low temperatures.

Alkaline water was indicated for the use of electrochemistry, as a result of its purity factor, neither contaminating nor allowing the reduction of generator efficiency to decrease. Therefore water from rivers, taps and rain are not suitable for the use of the generator, resulting in contamination and low hydrogen yield. According to [13], the diluting agent KOH, in alkaline water whose temperature occurs between 60 to 90 Celsius degrees (ºC), is capable of maintaining the water purity level, allowing to lower, with lower speed, the aqueous solution of the system. Figure 5 presents effective factors in the water yield in the obtained system.

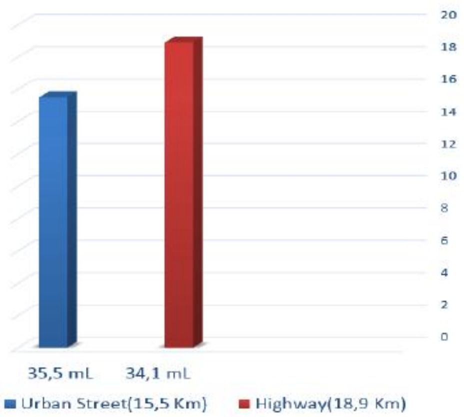

Fig.5: Yield from alkaline water in composition with potassium hydroxide.

Thus the variation and tests made in both situations promoted minimal differences in relation to the total liquid storage, enabling the generator to offer up to 873.23 km in VU and 1108.50 km in RO. With two liters of water, the limit of all consumption of the stored liquid is indicated. Equation (1) urban streets (VU), and (2) to highways (RO).

$$0{,}0355l - 15{,}5km \ (1)\ VU \quad (1)$$

$$0{,}0341l - 18{,}9km \ (2)\ RO \quad (2)$$

Through the rule of three, relating kilometers (km) with water consumption, obtaining the total result (3; 4).

$$x = 2l * \frac{15{,}5km}{0{,}0355l} = 873{,}23\ km \quad (3)$$

(4)

$$x = 2l * \frac{18{,}9km}{0{,}0341l} = 1108{,}50\ km \quad (4)$$

The generator presented a total of 71% efficiency and 25% yield, indicating factors that point to a good performance, but the data also reflect on the vehicle power where there was shorter starting time and better track fluidity.

IV. CONCLUSION

The prototype model resulted in improvements in the engine system, indicating factors of fuel efficiency, power and reduction of pollutant emissions into the atmosphere. It was realized that for each type of system must have a suitable design, to be implemented in different types of engines.

Noting the difference in water consumption compared to ordinary fuel, it is clear that the need to obtain energy efficiency is totally linked to the economic factor, due to the price of fuel in relation to water, where it is important to emphasize the performance generated by aqueous solution, making it more feasible than gasoline.

The results show that hydrogen has a very high explosion factor, makes it feasible for implementation in engines, creating possibilities to build a hybrid vehicle or totally free of fossil fuel. As an electrolytic generator, it is possible to implement together with solar panels, wind power, and biomass generation, due to direct current operation can also meet the needs of people living in isolated areas using electricity generators.

Finally, this hydrogen generator study presents the importance of efficient and renewable energy generation, aiming at the creation of products with new technologies, considering the environmental factors and reducing the consumption of fossil fuels to ensure future sustainability.

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