Reduction of CO_2 emissions using HHO mounted in a car's motor & its economic

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1 Abstract

The HHO cell has been proved itself as most important hybrid fuel, that, it can reduce the fuel consumption and reduce of the CO_2 emission, the objective of this research is reduce of pollution that result from the internal combustion engine that use the gasoline as fuel by using the HHO dry cell. Also using hydrogen cell technology as a way to reduce fuel consumption in vehicles and to reduce harmful emissions to the environment by design hydrogen cell that is inexpensive and with high performance for helping consumers and encourage them to purchase it. Results show that the CO_2 emissions in Libya is reduced from 12.24 Mt to 8.39 Mt through driving inside cities and decreasing carbon emissions from 8.55 Mt to 6.53 Mt in combined drive. Also it was reduced fuel consumption for a motor vehicle in the city up to 31.4 %, and 32.9 % between city and combined drive. The benefit of installing HHO cell for all cars in Libya is about 1.26 billion dollar yearly.

Keywords: HHO cell, catalyser, reduction fuel consumption, reduction of CO_2 emissions

2 Introduction

Fossil fuels remain one of the most prominent influences on environmental pollution, and it is prominent in the uses of fuel special automobile fuel, whose number is growing day by day. Statistics have shown the number of vehicles on roads in Libya has increased from 465,000 in 1983 to 2,680,000 in 2014[1-2].

In line with the above, the transportation wastes and emissions are considered one of the main drivers of air pollution in Libya. Between 1990 - 2012, emissions from transportation have increased drastically within the energy sector. Total transportation emissions rose from 6.12 $MtCO_2e$ in 1990 to 16.59 $MtCO_2e$ in 2012 .Also, the CO_2 emissions from transportation have increased from 1 metric ton in 1970 to 18 metric tons in 2019 by growing at an average annual rate of 7.79% [3]. This is due to the fact that the number of vehicles has become the equivalent of 2,500,000 gasoline-fuel vehicles for passenger cars carrying 2,566,465 passengers per year, that huge number is the result of imports for their cheap prices[4]. Actually , the non-compliance with the

environmental measures and conditions, where the most important element for environmental conditions is a lack of catalyser exhaust in the imported vehicles from abroad, are dispensed with them as a result of their malfunctions and irreplaceable due to their high price and the lack of environmental knowledge. This is the main factor behind damages caused by not installing them. This led to a public health crisis and lung diseases diagnosis amongst many Libyans [5]. Emissions, fuel and cost savings in the internal combustion engine (ICE) are reduced by adding hydroxyl gas into the combustion chamber for the accomplishment of more complete combustion Chinguwa, Simon, et al [6]. Also, Prasetya, Hendrik Elvian Gayuh, et al [7] increased the performance and reduce the exhaust emissions on 120 cc engines with four strokes that also worked on by using a catalyst in the HHO generator integrated into the engine. Salek, Farhad, Mohammad Zamen, et al. [8] used (HHO) dry cell which is coupled to a gasoline engine to show the effects of electrodes, shape, distances, and the influences of ultrasonic waves, the ultrasonic waves improves the HHO dry cell production rate from about 6.4% to 52.4%. Basori, [9] studied the effect of HHO dry cell of reducing air pollution by measuring emission level of exhaust gas. the results of NaOH solution is decrease 81.74% of CO gas concentration and the use of NaOH solution to get an average concentration of hydrocarbon gas are decrease by 69.62% when compared operating without HHO generator. Brown gas (HHO) was produced by using the electrolysis process in 4 stroke engine with KOH (aq) as a catalyst. It indicated that the engine's brake power, thermal efficiency, and mechanical efficiency are increased 22%, 47% 24%, respectively, Gohar, Ghulam Abbas et al [10]. Rusdianasari, Bow Y, et al [11] Show that the best setup was electrolyte concentration of sodium hydroxyl was 0.05 M and the applied current was 15 A to produce 0.1028 LPM HHO gas with the electric current efficiency of the hydrogen generator 89.13%.

This project focuses on the possibility of reducing fuel and emissions caused by vehicles currently on the road, as well as vehicles that will be imported in the future. Another important aspect is reducing emissions from exhaust without imposing any restrictions on citizens, but rather by encouraging them to obtain the advantages of this technology. Hydrogen cells can make car exhausts containing catalyser have a longer life because of their ability to clean them of combustion deposits.

3 3. The first experiment on car's motor

Installing HHO cell as shown in Figure 1. It can be used with graduated cylinder or directly into the gasoline motor. It needs only the electrical current stabilizer as Cut-Out. It is important to reduce the temperature of the cell and save the battery and dynamo from damage.

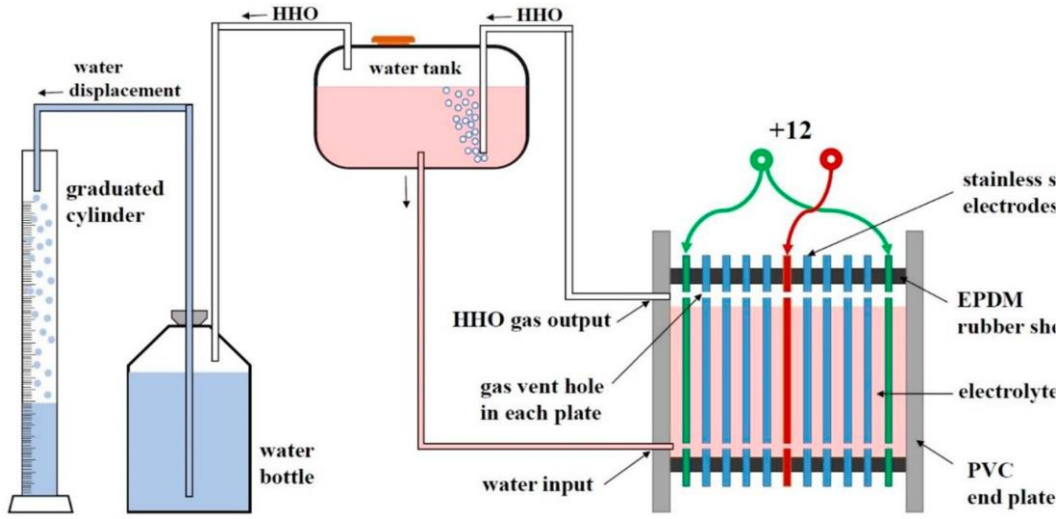

Figure 1: *Schematic drawing of modern gasoline car' motor with HHO cell generator [12].*

4 **4. The effect of HHO cell on catalyzer**

This work is a part of continues work on HHO dry cell [13], [14]. As shown in Figure 2, the catalyser is improved and it is more clear after using the HHO dry cell, it is clearly shown that the HHO dry cell effect not only reduces the fuel consumption but also clean the catalyser.

Figure 2 *the picture of catalyzer after using HHO dry cell*

5. Determining CO_2 emissions for vehicle exhaust

By converting the energy stored in the fuel into mechanical energy for an internal combustion engine, the vehicle will move down the road, these processes produce an amount of carbon dioxide CO_2 emission which is contained atoms of hydrogen (H) and carbon (C) to produce fuel with hydrocarbon molecules (C_xH_Y). A simplified equation for the combustion of a hydrocarbon fuel is expressed as follows:

Fuel (C_xH_Y) + oxygen (O_2) + spark g water (H_2O) + carbon dioxide (CO_2) + heat (1)

In this combustion reaction, hydrogen combines with oxygen to produce water (H_2O).

Similarly, oxygen combines with the carbon to make carbon dioxide (CO_2). In fact, this reaction can be expressed as follows:

$$C + O_2 \longrightarrow CO_2 \qquad (2)$$

Carbon has an atomic weight of 12, and oxygen has an atomic weight of 16 those results of a molecular weight equals 44 for CO_2, it can be determined as following expression :

1 carbon atom (12) + 2 oxygen atoms x an atomic weight of oxygen (16) molecular weight CO_2 (3)

Hence, CO_2 is 3.67 times heavier than carbon. One Litre of petrol fuel (gasoline), includes about 0.63 kg of carbon, it produces about 2.39 kg. In other words, burning a litre of petrol fuel produces around 2.39 kg of carbon dioxide.

6. Vehicle CO_2 Emissions Footprint Calculator online Software

Online Software is used to calculate CO_2 emissions (kg) that are produced by the exhaust in a car. Just add fuel consumption (L/100 km) with travelled distance as input data to know how much CO_2 emission has produced [15]. In the experiment, using the fuel cell and without it on the same pattern and data, through driving the car normally for a distance equal to 200 km by the determined pattern of driving inside the city, or combine (city, highway). By determining the number of litres used in the tank with travel distance, the fuel consumption rate in the car is determined.

6.1 Determination of Fuel consumption

Fuel consumption gives consumers reliable information about the relative fuel efficiency of vehicles and it can be determined by the following formula;

$$FC = \frac{L.S \times 100}{T.s} \qquad (1)$$

6.2 Determination of reduction ratio for fuel consumption

$$R_{FC}\ (\%) = \frac{\text{Fc\_without fuel cell} - \text{Fc\_with fuel cell}}{\text{Fc\_without fuel cel}} \times 100 \qquad (2)$$

$$R_{Co_2}\ (\%) = \frac{CO_{2\text{emission}} - CO_{2\text{emission}}\text{fuel cell}}{CO_{2\text{emission}}} \times 100 \qquad (3)$$

6.3 Reduction ratio for CO_2 emission

Determine Present decrease in saving fuel consumption

$$R_{\_FC}\ (\%) = \frac{\text{Save}_{f/\text{ case}} - \text{Save}_{f/case}\ with\ fuel\ cell}{\text{Save}_{f/case}} \times 100 \qquad (4)$$

7. Results and Discussions

7.1 Results of the first experiment on car's motor

The results from [13] and [14] experiments are shown in Table 1. The hydrogen cell had a clear effect in reducing fuel consumption within the combustion engines and reducing environmental pollution.

Table 1: CO_2 *emission reduction rates for experiment car's motor*

Case	Inside city		Combine		
Data	Integrated without fuel cell	Integrated with fuel cell	Integrated without fuel cell	Integrated with fuel cell	Unit
Travelled distance	200	200	200	200	km
Fuel consumption	9.55	6.55	7.60	5.10	L/100 km
CO_2 emission (kg)	45.66	31.31	36.33	24.38	kg
CO_2 emission (kg/km)	0.23	0.16	0.18	0.12	kg/km
	Inside city		Combine		
Total Emission in Libya by 2,680,000 vehicle on roads	12.24	8.39	9.47	6.53	$MtCo_2e$
Reduction ratio fuel consumption & CO_2	31.4 %		32.9%		

Fuel consumption is decreased by using a fuel cell on the car as shown in Table 3, and Figure 4. values are decreased by installing fuel cells in a car from 9.55 L/100 km to 6.55 L/100 km inside the city driving, and from 7.60 L/100 km to 5.10 L/100 km during combine driving. In addition, by multiplying the total number of vehicles, which was equal to 2,680,000 vehicles to CO_2 emission (kg) for a vehicle, the total Emission $MtCo_2e$ in Libya by vehicles on roads is evaluated. The results in Table 1 show the reduction in total emissions for vehicles in Libya when installed a fuel cell on the engines.

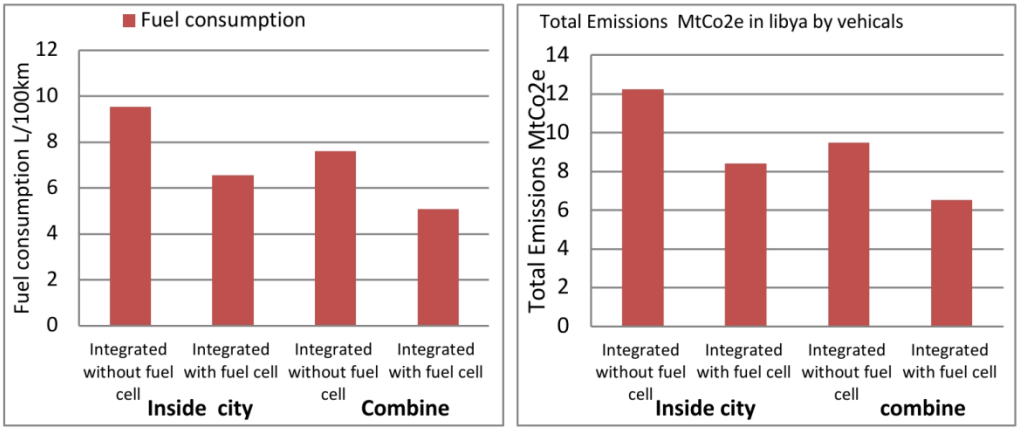

Figure 3. *Fuel consumption and the total Emission $MtCO_2e$ by using a fuel cell on the vehicles*

A decrease in the rates of carbon emissions by using a fuel cell on the cars, helps in preserving the environment, as shown in Table 1 and explained in Figure 3&4, the CO_2 emissions are dropped by installing fuel cells in a car from 45.66 $kgCO_2e$ to 31.31 $kgCO_2e$ through city driving, and from 36.3366 $kgCO_2e$ to 24.38 $kgCO_2e$ during combine driving.

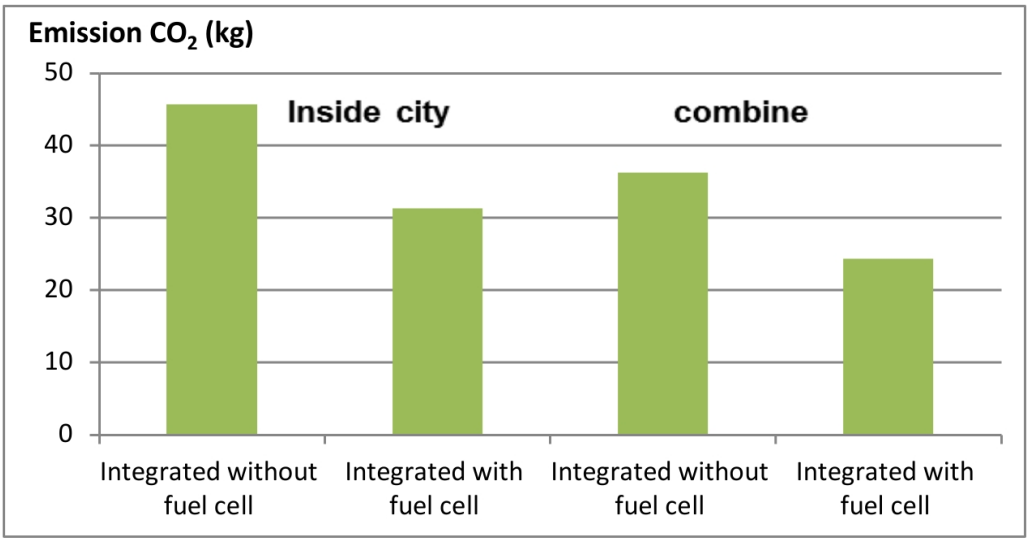

Figure 4. *CO_2 Emissions results by kg for car motor experiment*

From the results and as shown in Figure 5 , the reduction ratio of fuel consumption is 31.4% during driving inside the city, and the reduction in fuel consumption is 32.9% when driving through highway and city (combine drive),

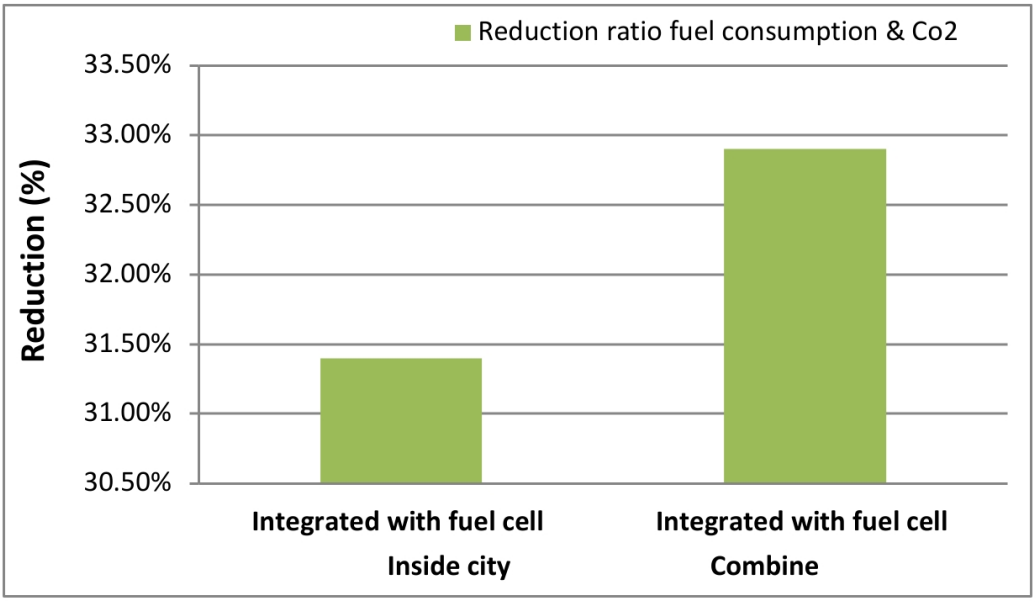

Figure 5. A *ratio reduction of fuel consumption as same as CO_2 emissions by a car motor experiment*

Clearly, the difference between these ratios is attributed to the effect of the high number of cars inside the city when compared to one outside the cities. The number of cars inside cities cause jam resulting in increasing fuel consumption when compared to driving through a highway outside cities. Also, there are many reasons affects the increase in emissions such as the high mileage of a car, and the presence of problems in the catalysed causing a decrease in the car's torque resulting in the consumption of a greater amount of fuel.

In addition, the huge number of cars in Libya when compared to the population leads to a rise in exhaust emissions, which leads to an increase in the risk of chest and cancer diseases. Finally, the presence of fuel cells is a helpful and effective factor in rising health care and reducing treatment and insurance costs.

7.2 Economic or reduction fuel consumption

The economy for Libya can be obtained by calculating the overall fuel consumption by the cars. If it is assumed that the fuel consumption is reduced by using HHO to about 31.5% as shown in Figure 5. Assuming that, all cars in Libya use this device that decreasing the overall fuel consumption in Libya. In fact, the population of Libya is about 6.5 million and the support from the state reached to 4 billion dollar [1][16][17][18]. If the state support covers this device to be installed in all cars, it can reduce the fuel consumption and benefit by 1.26 billion dollar without calculation of smuggling.

8. Conclusions

According to the results, the emission of CO_2 can be reduced by about 31.4% minimum. It reduces the emissions to about 3.85 $MtCO_2e$. The benefit of the reduction of the fuel consumption are 1.26 billion dollar in Libya yearly. It increases or decreases as fuel price value.

Nomenclature	Name of symbols	Unit
FC	Fuel Consumption	L/100 km
L.s	Amount of litres used for driving	L
T.S	Travel distance drive	Km
FC_ without fuel cell	Fuel Consumption without fuel cell	L/100 km
FC _with fuel cell	Fuel Consumption with fuel cell	L/100 km
R_{CO_2}	Reduction ration for CO_2 emission	%
$CO_{2_{emission}} fuel$ cell	CO_2 emission with fuel cell	kg/km
$CO_{2_{emission}}$	CO_2 emission without fuel cell	kg/km
R_{FC}	Reduction ration for fuel consumption	%
$R_{\_FC}$	Reduction ratio for fuel consumption in	%

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