FUEL CELLS IN AUTOMOBILES

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1. INTRODUCTION

1.1 FUEL CELLS

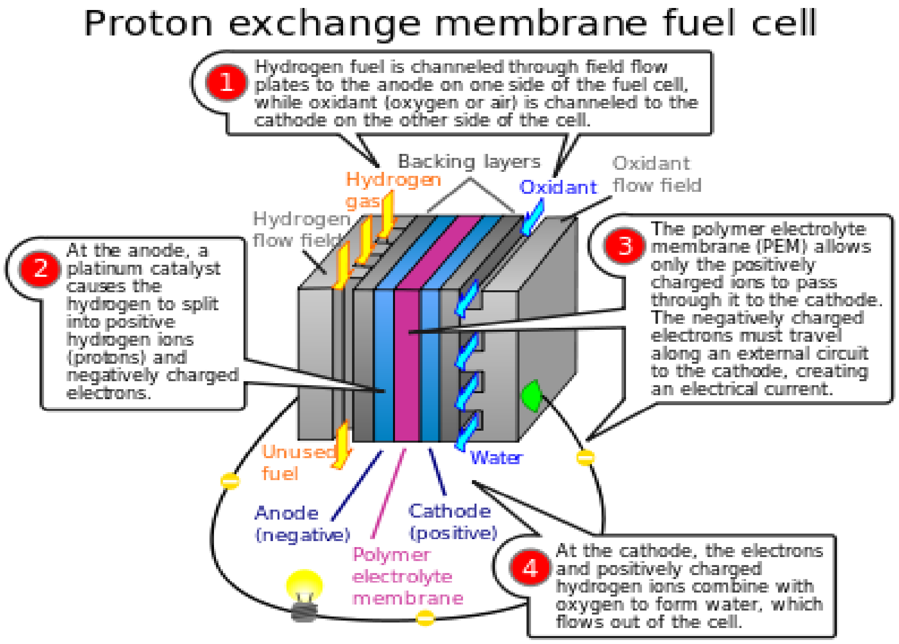
A fuel cell is an electrochemical cell that change the form of chemical energy from a fuel into electricity through an electrochemical reaction of hydrogen-containing fuel(water) with oxygen or another oxidizing agent. Produced energy is stored in batteries. And then used for external applications. They are different from batteries in requiring a continuous source of fuel and oxygen usually from air to sustain the chemical reaction, whereas in a battery the chemical energy comes from chemicals already present in the battery. FCs can produce energy continuously without any intervals, for as long as fuel and oxygen are supplied. They are used for backup power for commercial, industrial and residential buildings and in remote or inaccessible areas. They are also used as a fuel source in vehicles, including automobiles, boats, and submarines.

2. TYPES

- Proton exchange membrane fuel cells (PEMFC)
- Phosphoric acid fuel cell (PAFC)
- Solid acid fuel cell (SAFC)
- Alkaline fuel cell (AFC)
- Molten carbonate fuel cell (MCFC)

2.1 PROTON EXCHANGE MEMBRANE FUEL CELLS (PEMFC)

Proton exchange membrane fuel cell is a type of fuel cell, a proton-conducting polymer membrane which contains the electrolyte solution that separates the anode and cathode sides. On the anode side, hydrogen breaks to the anode catalyst where it later dislocates into protons and electrons. So protons react with oxidants causing them to become what are commonly referred to as multi-operated proton membranes. These protons are arranged through the membrane to the positive cathode, but the electrons are made to flow in a circuit due to the membrane is electrically insulated.



2.2 PHOSPHORIC ACID FUEL CELL (PAFC)

Phosphoric acid fuel cells are the type of fuel cells in which phosphoric acid is used as a non-conductive electrolyte to pass positive hydrogen from the anode to the cathode. These cells actually made to work in temperatures of 150 to 200 degrees. Due to this high temperature will cause heat loss and energy loss if the heat is not removed and used properly. This heat can be used to produce steam for air conditioning systems or any other thermal systems. Phosphoric acid, the electrolyte used in PAFC, is a non-conductive liquid acid which made electrons to travel from positive anode to negative cathode through an external electrical circuit. Though the hydrogen energy production rate on the anode is small, platinum is used as catalyst to increase this production rate.

2.3 SOLID ACID FUEL CELL (SAFC)

Solid acid fuel cells are the types of fuel cells characterized by the use of a solid acid material as the electrolyte. In order to undergo electrolysis reaction, at low temperatures, solid acids have an ordered molecular structure like most salts. At warmer temperatures some solid acids undergo a phase transition to become highly disordered structures, which increases conductivity by several orders of magnitude. The only proof of concept SAFCs were initiated in 2000 using hydrogen sulfate. Recent SAFC systems use cesium dihydrogen phosphate and have demonstrated lifetimes in the thousands of hours.

2.4 ALKALINE FUEL CELL (AFC)

The alkaline fuel cell are one of the type of fuel cells hydrogen-oxygen fuel cell. The cell consists of two carbon electrodes impregnated with a suitable catalyst such as Pt, Ag, CoO, etc. The spacing between the two electrodes is filled with a non-diluted solution of KOH or NaOH which serves as an electrolyte. Hydrogen gas and Oxygen gas are bubbled into the electrolyte through the carbon electrodes. Then the overall reaction involves the combination of hydrogen gas and oxygen gas to form water. It runs continuously until the reactant supply is made to cutoff. This cell operates more efficiently in the temperature range 343 K to 413 K and provides a potential of about 0.9 V is a type of AFC which employs a solid polymer electrolyte instead of aqueous potassium hydroxide (KOH) and it is superior to aqueous AFC.

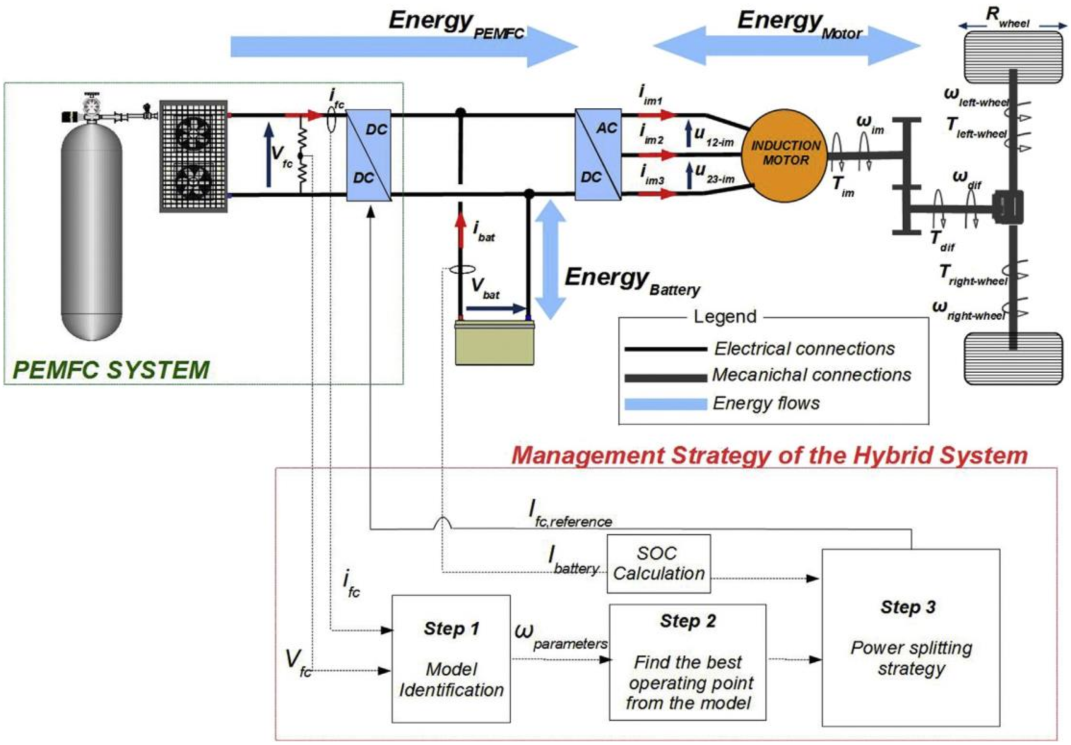
2.5 MOLTEN CARBONATE FUEL CELLS (MCFC)

Molten carbonate fuel cells (MCFCs) are the type of fuel cells, which require a high operating temperature, 650 °C MCFCs use lithium potassium carbonate salt as an electrolyte, and this salt changes its phase at high temperatures, making for the movement of charge within the cell in this component, and negative anode carbonate particles. MCFC- fuels include natural gas, biogas and gas produced from coal. The H_2 gas reacts with carbonate ions from the electrolyte to produce water, CO_2, electrons and small amounts of other chemicals ions. The ions travel through a circuit creating electricity and return to the cathode. O_2 in the air and CO_2 already from the anode react with the electrons to form carbonate ions that reproduces the electrolyte, completing the circuit.

3. FUELCELLS IN AUTOMOBILES

Fuel cells are widely used in automobiles around the world in order to avoid fossil fuels to control emissions. The type of hybrid vehicles use H2 gas to drive an electric motor. Mostly vehicles which run on petrol or diesel, fuel cell cars and trucks hydrogen and mostly combine the both oxygen to produce electricity, which drives a motor. They are driven entirely by electricity, fuel cell vehicles are said to be electric vehicles but like other electric vehicles, their range and refueling processes are comparable to conventional cars and trucks. Production of the hydrogen can lead to pollution, including greenhouse gas emissions, but even when the fuel comes from one of the sources of hydrogen, natural gas, today's early fuel cell cars and trucks can cut emissions by over 25 percent when compared with their gasoline-powered counterparts.

An interesting solution to produce near zero local emission electricity in an embedded system is the fuel cell system (FCS). The most practical FCS for fuel cell hybrid electric vehicles is the proton exchange membrane fuel cell (PEM-FC) to its low operating temperature and pressure, tolerance to carbon dioxide and solid membrane, hydrogen with high purity can be produced with renewable energies, such as electrolysis and biomass processes to produce near zero global emission electricity. A good durability is ensured for the PEM-FC when slow load dynamics are applied in practice. Consequently, an energetic buffer such as battery, super capacitor, and flywheel should be used with the PEM-FC to satisfy the fast dynamic.

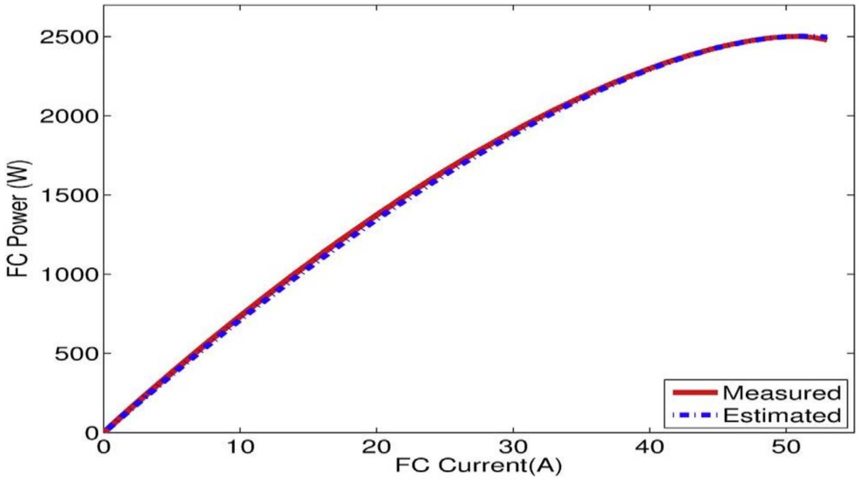


Fig– 1 FUEL CELL IMPLEMENTATION

3.1 EXTREME SEEKING PROCESS

In this section the ESP is described and is a key step of the adaptive EMSs. The performance criteria needed for the global EMS are the ME and the MP. The calculus of these criteria is performed with the PEM-FC voltage, the PEM-FC current and the PEM-FC hydrogen molar flow. The PEM-FC current is the control variable but an estimation of the voltage and of the molar flow is needed to deduce the MP and the ME. Then the first step is the online identification of the PEM-FC voltage and the hydrogen molar flow using the square root unscented filter algorithm. The SR-UKF algorithm is used to identify the PEM-FC models and it is based on the successive update of the model parameters. The extreme-seeking control is the step in which the optimum PEM-FC power and efficiency are tracked at the same time. So, two optimization problems are formulated each with an objective function (power and efficiency). The sequential quadratic programming (SQP) algorithm is one of the most popular methods for solving optimization,

3.2 HYSTERISIS POWER SPLITTING



The aim is to highlight that Hysteresis EMS helps to maintain the *SOC* level around the reference while meeting the power demand. The hysteresis EMS is based on a hysteresis algorithm. In this strategy thresholds of SOC are determined. The thresholds intends to active and disable high power mode to track or not the maximum power (MP). The levels switch on and off the low power mode to track the maximum efficiency (ME) point

This step allows an online power distribution between the battery pack and the PEM-FC. Moreover, it takes into account the real-time variations of the power and efficiency curves of the FCS. The optimization of hybrid system aims to determine an optimal trajectory of the control variable in order to minimize a criterion under constraints. Note that in the formulation of the optimization problem, the power of the described before are applied and the results shows that the SOC is sustained during the test. The PEM-FC power switch between ME mode to MP mode to sustain the SOC and help the battery pack to give power to the load. During the ME mode the ESP seeks the maximum efficiency and as defined in the ME is near 900 W.

3.3 LITERATURE SURVEY ABOUT U.S AND EUROPEAN STANDARDS

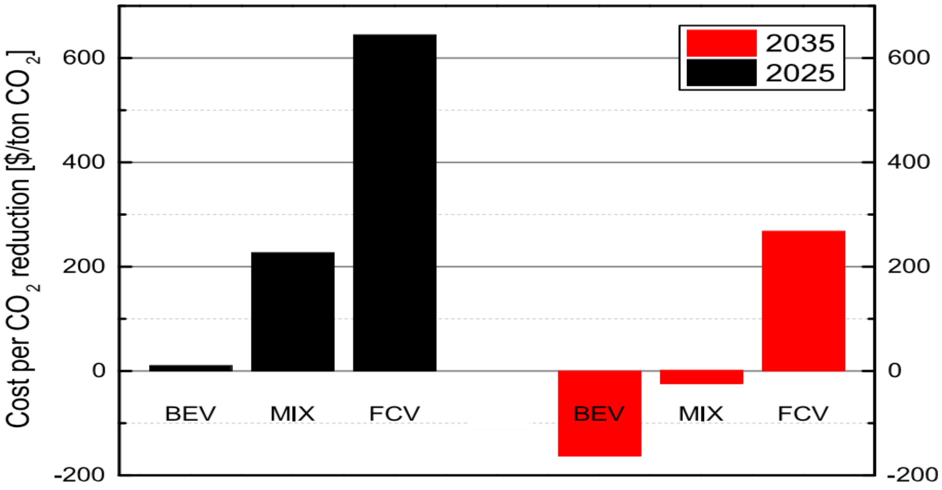
We summarize the European standards and discuss the empirical implications of the contrasts between the two regions' policies. The standards were first phased in by the mid-1980s and set standards of 27.5 mpg for cars and 20.7 mpg for light trucks. In 2003 finalized new, tighter, standards for light trucks that increased fuel economy to 24.1 mpg by 2011. The 2007 Energy Independence and Security Act set standards for 2020 that would require a combined 35 mpg for cars and light trucks; in 2009 the compliance deadline for these new standards was moved to 2016. Thus, tighter standards were announced in 2003, 2007 and 2009 .In those three cases the new standards are based on the footprint of the vehicle, which is roughly the vehicle's width multiplied by the distance between the two axles.

Europe has traditionally taxed fuels at much higher rates. European cars also tend to be much smaller and have higher fuel economy than cars. In 1998 and 1999 manufacturers agreed to increase fuel economy to about 39 mpg within 10 years. However, they did not increase fuel economy quickly enough to meet the targets and in 2007 the European Commission issued requirements for about 42 mpg by 2015. Whereas the initial agreement was purely voluntary, compliance with the 2015 standards is backed by fines. The standard is weight-based, depending on the difference between a specific car's weight and a benchmark weight.

The U.S. and European standards thus differ in several important ways. First, the European standards are more stringent, which may make it more challenging for manufacturers to increase the rate of technology adoption. Second, one of the reasons for adopting footprint rather than weight-based standards in the United States was to provide stronger incentives for weight reduction. For that reason the tighter standards might cause more weight reduction in the United States than in Europe. Third, high fuel prices in Europe incentivize manufacturers to raise fuel economy when they adopt fuel-saving technology, even in the absence of tighter standards.

3.4 CO_2 EMISSIONS REDUCTIONS AND ANNUALIZED SYSTEM COST

The model projects that in the all-ICV reference case, the community's overall costs for electricity, heating and transportation in 2025 and 2035 are similar to the 2015 level. The all-ICV reference case assumes exclusive use of conventional vehicles and no electric vehicles in the vehicle fleet. CO_2 emissions in the all-ICV reference case decrease by 33% by 2035 due to efficiency improvements in the ICVs. The deployment of electric vehicles will decrease CO_2 emissions by 40% (BEVs) and 41% (FCVs) compared to 2015. In the BEV case, this can be achieved at almost no additional cost from 2025 onward. However, in both 2025 and 2035, the FCV case is significantly more expensive than the all-ICV reference case, and provides almost no co-benefits.



Cases that achieve both lower CO $_2$ emissions and lower costs by 2035. The FCV case achieves slightly lower overall CO $_2$ emissions than the BEV case, but at significantly higher costs.

4. CONCLUSION

This study briefly explains the use of fuel cells in automobiles and its benefits and also explains about the emission reduction towards pollution and so on. Also quantifies the reductions in transport sector CO_2 emissions that would result from market penetration of BEVs and or FCVs into the light-duty vehicle fleet. The results of our study provide three key insights First, BEVs are a cost-competitive alternative to conventional vehicles from 2025 onwards, mainly because of decreasing BEV costs and increasing ICV and fuel costs. BEVs therefore offer an opportunity for reduced CO_2 emissions accompanied by lower costs.

This paper also give a study of two EMSs coupled with an adaptive layer to identify online the maximum efficiency and the maximum power. A Hysteresis EMS is design to highlight the capability of seeking the PEM-FC maximums. Then a constrained optimization problem based on principle is formulated in order to allocate the power optimally. The online identification layer is added to the PMP EMS in order to take into account the operating point drift in real time. It has been shown that the developed adaptive management A-PMP could meet the power demand, sustain the SOC. Furthermore, the APMP EMS gives better result than Hysteresis EMS since the hydrogen consumption is reduced with the first one.

This work opens perspectives for future work and should now converge to a multi-perspective. Indeed, the work of the paper deal with a single parameter: the current of the fuel cell. A next step will be multipara metric optimization. In the case of semi-empirical models including physical phenomena such as temperature, pressure and humidity.

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