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Fuel Cell in Electric Vehicles

Basil K Thomas[1], Liya Antony[2]

UG Scholar, Dept. of EEE, MGM College Of Engineering and Technology, Kerala, India[1]

Assistant professor, Dept. of EEE, MGM College Of Engineering and Technology, Kerala, India[2]

ABSTRACT: One of the major goals of the automotive industry is to improve vehicular fuel. Efficiency and performance with much lesser percentages of harmful tailpipe emissions. One of the major technologies includes fuel cell vehicles(FCV). Various advantages of Fuel cells including reliability, simplicity, quietness of operation,and low pollution have Made them an attractive potential candidate for providing automotive power. This paper aims at dis cussing the basic possible topologies of fuel cell vehicles and the major issues that need to be overcome in order to make them practically viable. Several alternative vehicle and fuel options are under consideration to alleviate the triple. Threats of climate change, urban air pollution and foreign oil dependence caused by motor vehicles.

KEYWORDS: Fuel cell, Hybrid electric vehicle, Series HEV drive train, Parallel HEV drive train.

I.INTRODUCTION

Economic development is reflected in all countries by increasing the consumption of energy. Economic signs of progress have been marked by the consumption of different types of energy like biomass, solar, wind, hydro, etc. The main problem is that our economy has become very dependent and this resource is very poorly distributed in the world. One of the major goals of the automotive industry is to improve vehicular fuel Efficiency and performance with much lesser percentages of harmful tailpipe emissions. One of the major technologies includes fuel cell vehicles(FCV)can be used to solve this problem. Various advantages of Fuel cells including reliability, simplicity, the quietness of operation, and low pollution have made them an attractive potential candidate for providing automotive power.

This paper aims at discussing the basic possible topologies of fuel cell vehicles And the major issues that need to be overcome to make them practically viable. Several alternative vehicle and fuel options are under consideration to alleviate the triple threats of climate change, urban air pollution, and foreign oil dependence caused by motor vehicles.This paper aims at discussing the basic possible typologies of fuel cell vehicles and also through this paper I tried to make a comparative study between the HEV and FCV with their currently available topologies and their various advantages disadvantages and the major issues that the FCV need to overcome.

Before we are going through the discussion about fuel cells in an electric vehicle we must know what is an electric vehicle.An electric vehicle (EV), also called electrics is a vehicle that uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources or may be self-contained with a battery, solar panels, fuel cells, or an electric generator to convert fuel to electricity. EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft, and electric spacecraft.

Types of electric vehicle as follows.

- Hybrid electric vehicle

The HEV is consists of an IC engine and an electric motor with a battery, the battery cannot be charged by external.

- Plug-In Hybrid Electric Vehicle

A PHEV is any motor vehicle that can be recharged from any external source of electricity, such as wall sockets, and the electricity stored in the Rechargeable battery packs drives or contributes to drive the wheels.

- All-Electric Vehicle

AEVs are powered by one or more electric motors. They receive electricity by plugging into the grid and store it in batteries. They consume no petroleum-based fuel and produce no tailpipe emissions.

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II. FUEL CELL IN ELECTRIC VEHICLE

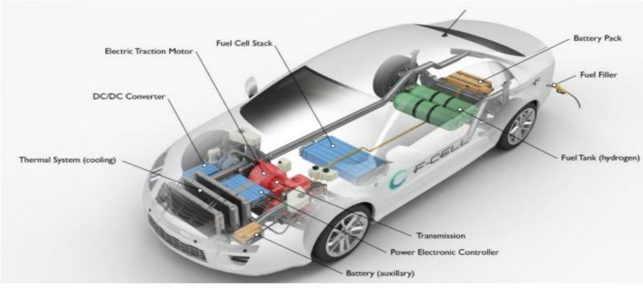

Fig 1. Parts of fuel cell vehicle

The above figure shows the major parts of a hydrogen based fuel cell electric vehicle. A fuel cell vehicle (FCV) or fuel cell electric vehicle (FCEV) is an electric vehicle that uses a fuel cell, sometimes in combination with a small battery or supercapacitor, to power its on-board electric motor. Fuel cells in vehicles generate electricity generally using oxygen from the air and compressed hydrogen.As compared with internal combustion vehicles, hydrogen vehicles centralize pollutants at the site of the hydrogen production, where hydrogen is typically derived from reformed natural gas. Transporting and storing hydrogen may also create pollutants.

A. ELECTRIC DRIVE

Although DC motor seems a logical choice for EV's propulsion, as it is powered from DC batteries, DC Motors are widely applied in EVs, because of the orthogonal disposition of field and armature. Simple control is the advantage of DC Motors. The permanent magnet DC Motors allow a significant reduction due to the efficient use of radial space. Due to the low permeability of the permanent magnet DC Motors, armature reaction decreases under normal circumstances, the commutation has been greatly improved. However, their commutator and brushes make operation not very reliable and maintenance is difficult. But today's solutions are based on AC motors. Induction or synchronous AC motors are used as traction motors, due to their lower weight and costs, higher reliability, and lower maintenance needs. For high power propulsion, an induction motor is used.

B. REDUCER

The reducer is a kind of transmission in that it serves to effectively convey the motor's power to the wheel. But it carries the special namereducerfor a reason: the motor has a far higher RPM than that of an internal combustion engine, so whereas transmissions change the engine RPM to match the driving circumstance, the reducer must always reduce the RPM to an appropriate level.

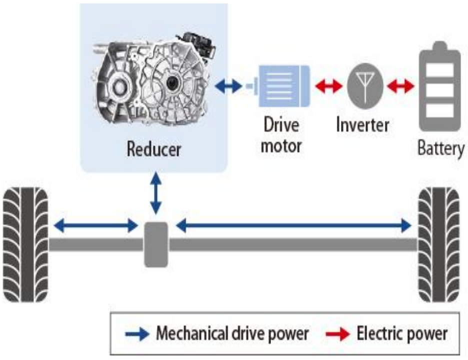

Fig 2. Concept of reducer

With the reduced RPM, the EV powertrain can take advantage of the resulting higher torque. A reducer adjusts the number of revolutions by the motor and conveys those revolutions to the tires (driveshaft). The function of the reducer is equivalent to a conventional transmission.

C.ELECTRIC POWER CONTROL UNIT

The Electric Power Control Unit(EPCU) is an efficient integration of nearly all devices that control the flow of the electric power in the vehicle. It consists of the inverter, the Low voltage DC-DC Converter(LDC), and the Vehicle Control Unit(VCU).

- **Inverter**

The inverter converts the battery's DC into AC, which then is used to control the motor speed. The device is responsible for executing acceleration and deceleration, so it serves a crucial part in maximizing the EV's drivability. To expand the motor speed and torque region, usually high modulated frequency and high output current are permitted for the motor controlled by the inverter for AFV applications. Inverters improve the voltage utilization, reduce current harmonic contents, and create modulated sinusoidal voltage by sinusoidal PWM (SPWM) or space vector PWM (SVPWM) control methods. Three-phase two-level inverter, known as six switches inverter, shown in Figure 3, is widely used. This topology has the merits of low cost, easy control, and high reliability.

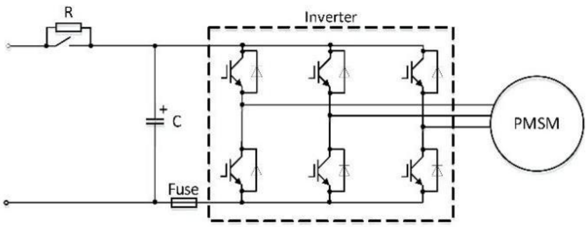

Fig 3. A common inverter topology

- **Low Voltage DC-DC Converter**

The LDC converts the high voltage electricity from the EV's high-voltage battery into low-voltage(12V) and supplies it to the vehicle's various electronic systems. All electronic systems in the EV use electricity in low voltage, so the high voltage in the battery must be converted first to be useful for these systems.Owing to the advent of intelligent vehicle systems, the demand of DC power for automotive electronic equipment is continuously increasing.A DC-DC converter possesses the function of converting the input DC voltage to another output DC voltage with different levels. A high conversion efficiency can be usually guaranteed. Normally, DC-DC converters are switching regulators with operations at high frequency. MOSFETs and IGBTs are used as switches. The size of the MOSFETs or IGBTs is drastically reduced at high-frequency operation. The switches are turned ON and OFF by the pulse-width modulation (PWM) technique.The applications of DC-DC converters have been implemented in AFVs. Bidirectional DC-DC converters are applied for battery charging, regenerative braking, and backup power. Unidirectional DC-DC converters are also used in DC motor drives and electric traction.

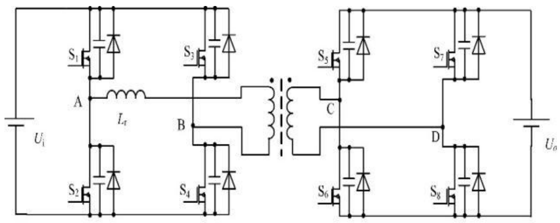

Fig 4. Full-bridge bidirectional DC-DC converter

A bidirectional DC-DC converter as seen in Figure4 can be divided into three main blocks. The primary side (low-voltage side) usually consists of a buck or boost-type converter and the secondary side is usually a half or full-bridge arrangement.

- **Vehicle Control Unit**

As the control tower of all-electric power control systems in the vehicle, The VCU is arguably the most important component of the EPCU.

D. BATTERY STORAGE SYSTEM

The battery stores electrical energy and is the equivalent of a fuel tank in an internal combustion engine. The maximum driving distance of an EV is often determined by the battery capacitythe higher the capacity, the higher the

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driving distance. In that light, increasing the capacity may seem an obvious choice, since high driving distance reduces the annoying need for frequent stops at charging stations. But the choice actually isn't so obvious, because the battery's size and weight also have large implications on vehicle performance. The larger and heavier battery takes away from cabin/storage space and worsens the energy efficiency and fuel economy. The best way to optimize performance, then, is to maximize the battery's energy densitythat is, having a small, lightweight battery that stores as much electric energy as possible.

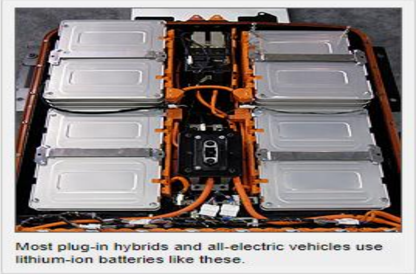

Fig 5. Battery used in EVs and HEVs

- **Battery Management System(BMS)**

  The Battery Management System(BMS) manages the battery's many cells so that they can operate as if they are a single entity. The EV's battery consists of as little as tens to as many as thousands of mini-cells, and each cell needs to be in a similar condition to the others in order to optimize the battery's durability and performance.

- **On-board Charger(OBC)**

  The On-board Charger(OBC) is used to convert Alternating Current(AC) from slow chargers or portable chargers used on home outlets into Direct Current(DC). This may make the OBC look similar to the traditional inverter, but they differ crucially in function; the OBC is for charging, and the inverter is foracceleration/deceleration. Incidentally, the OBC is not needed in fast-charging, since fast chargers already supply the electricity in direct current.

E. FUEL CELL

A fuel cell is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions. Fuel cells are different from most 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 usually comes from metals and their ions or oxides that are commonly already present in the battery, except in flow batteries. Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.

- **Types Of Fuel cell**

- Solid Oxide Fuel Cell (SOFC)
- Direct Methanol Fuel Cell (DMFC)
- Phosphoric Acid Fuel Cell (PAFC)
- Polymer Electrolyte Membrane Fuel Cell (PEMFC)
- Alkaline Fuel Cells (AFC)

- **Working Of Fuel Cell**

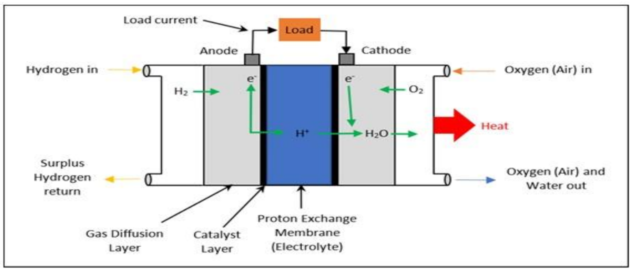

Fig 6. Fuel cell working

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Figure 6 clearly illustrates the operation of the fuel cells. In fact, the oxygen (O_2) at the cathode attracts the hydrogen atoms (H_2) located at the anode. To join O_2, the H_2 atoms must divide into H^+ ions because the electrolyte blocks the electrons.Theelectrons(e-)thuspassintoanexternalcircuit, generating an electric current, while on their side the H^+ ions pass through the electrolyte and join the oxygen to form water. The reaction also produces heat that can berecovered.

◆ **CHARGE CONTROLLER**

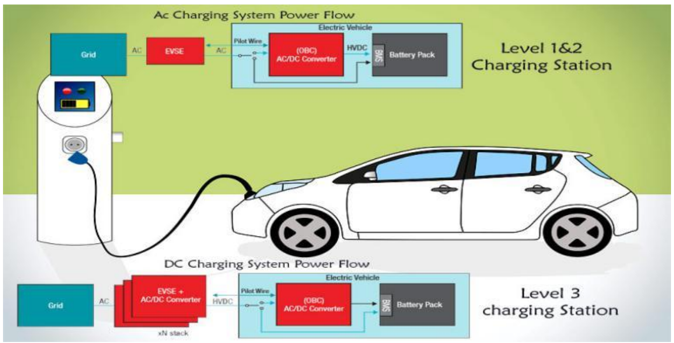


Fig 7. Basic block diagram of charge controller of an OBC system

The charge controller is the one that limits the rate at which the current is added to the battery of the vehicle.The charge controller prevents the overcharging of the battery and also protects the battery against over-voltages.The PWM(Pulse Width Modulation) based charge controller is used here.PWM charge controllers are a standard type of controllers that are simpler than MPPT controllers.PWM controllers basically work by slowly reducing the amount of power going into the battery when the battery approaches its full capacity.

III.COMPARATIVE STUDY OF FUEL CELL AND HEV TECHNOLOGY

Currently, a considerable portion of the research anddevelopment work in the automotive industry is focused on fuel cell vehicles and hybrid electric vehicles. Although the advantages of HEVs are clear, there are uncertainties about FCVs' benefits in terms of cost-effectiveness, overall well-to-wheels efficiency, performance, energy savings, and impact on the environment. A brief comparison with respect to the performance and parameter characteristics of FCVs andHEVs keeping in mind the relative performance of these vehicles is presented in this section. The two technologies are compared with respect to their drive train topologies, total incremental cost, total emissions, vehicle-to-wheels efficiencies, and vehicle-to-wheels fuel economies. A typical hybrid fuel cell based drive train is shown in Fig 8.

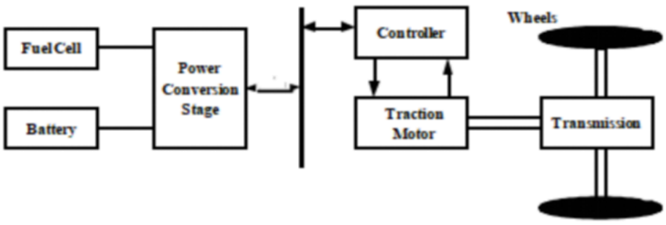


Fig 8. Typical hybrid fuel cell based vehicular drive train.

In the case of direct hydrogen FCV (DHFCV), the output voltage from each cell is collected and sent to the power electronic converter stage, where it is converted to usable power by using a DC/DC converter. This power is then supplied to the motor based on the optimized control strategy. As mentioned earlier, the power control unit processes acceleration commands of the driver and produces the necessary power by specific operation of the fuel cell system. In case of indirect methanol FCV (IMFCV), hydrogen is supplied to the fuel cell stack via an on-board reformer and the power control unit supplies the required power by specific operation of the reformer and the fuel cellstack.In case of hybrid electric vehicles, there exist two popular topologies. The first is the series hybrid configuration and the second option is the parallel hybrid topology. The differences between the two are presented here through depiction of their individual schematic layouts. A typical drive train configuration of a series HEV is shown in Fig 9. The electric motor is connected to the wheels and an electric generator supplies electricity for the battery pack, which, in turn, feeds the traction motor.

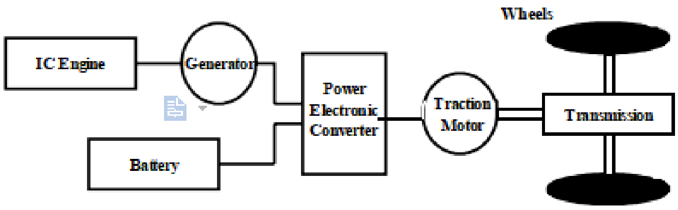


Fig 9. Typical block diagram of a series HEV drive train.

A typical layout of a parallel HEV is shown in Fig 10. In this case, the wheels are supplied through both the electric motor and the heat engine. It is useful to point out here that the parallel HEV topology does not need a generator since the traction motor itself serves this purpose. Furthermore, there also exists a series-parallel HEV configuration, which is essentially a combination of the above-mentioned topologies. Thus, the combined arrangement provides the advantages of both the series HEV as well as the parallel HEV configurations.

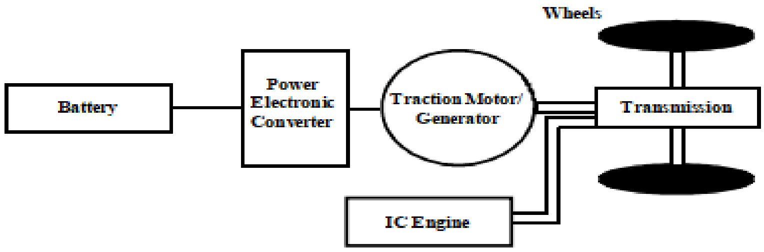


Fig 10. Typical block diagram of a parallel HEV drive train.

The cost comparison of FCVs and HEVs is a major issue keeping in mind the final goal of market breakthrough that these technologies are aiming at in the automotive industry. This section discusses the incremental total cost of the components of FCV and HEV compared to the conventional ICEV. HEVs are currently available commercially. However, the FCV technology is in the very early stage of research. It is predicted that they will not be economically feasible at least for the next 15-20 years. In addition, there exists a fair amount of uncertainty with regards to the cost benefit of FCVs in the longterm.Based on research results of the recent past, there exists high possibility of reducing harmful toxic gas emissions by better control of emissions from vehicles, use of cleaner fuels, and use of clean transportation alternatives, such as mass transit and public transportation. Basically, HEVs and FCVs aim at reducing emissions by implementing at least a couple of points mentioned above. Although FCVs and HEVs offer positive prospects for low vehicle emissions, a complete analysis of the vehicle-to-wheel emissions needs to be done in order to confirm the environmental advantages that they may offer. For the comparison, well-to-wheels and vehicle-to- wheels efficiencies must be considered. Basically, vehicle-to- wheels efficiency is the efficiency calculation based on the final use of the fuel in a vehicle, wherein the fuel is processed to provide power to a vehicle.

A. BENEFITS OF FUEL CELL VEHICLES

Besides the absence of CO2 emissions during vehicle operation, FCVs promise benefits among multiple dimensions:

- Refueling time – a few minutes (like for ICE engines) will be needed to refill the tank compared to the longer duration expected to recharge batteryelectric vehicles (BEVs).
- Driving range – with more than 450km of driving allowance, FCVs are already commercially attractive and, on average, they support larger ranges than BEVs.
- Fuel efficiency – FCVs are more energy efficient than gasoline-powered vehicles: a fuel cell uses about 40 to 60 percent of the available energy in hydrogen, compared to about 20 percent in ICE vehicles. However, it is important to highlight that EVs are more efficient than FCVs, using about 75 percent of the energy available from the batteries.
- Weight and volume of energy storage – Compared to EV batteries, H2 requires less weight and volume for energy storage to enable the same distance range.

- Sustainability – besides emitting zero GHG while the vehicle is running, FCVs' drive batteries are smaller than those of BEVs, therefore with lower environmental impact related to the usage of heavy metals in the manufacture of Li-ion battery packs.

B. FURTHER OBSTACLES

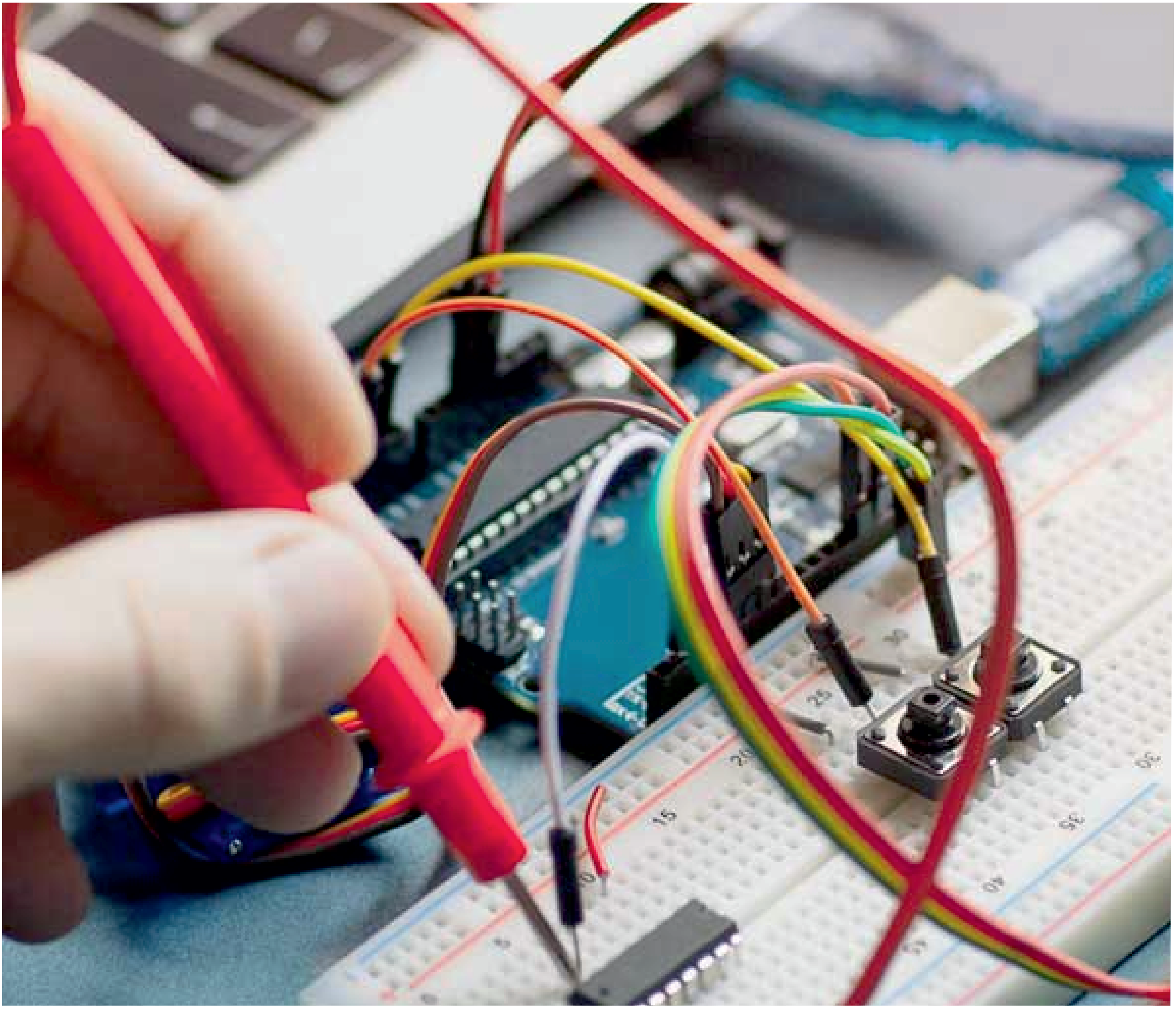
- Durability and reliability: FCV lifetimes will need to be comparable to those of conventional passenger vehicles.
- Hydrogen is in the gas state at room temperature and pressure, so it is difficult to store in the car.
- Fuel cells and electric motors are less durable than petrol engines and diesel engines, so they are not so long-lasting.
- Fuel cells are very expensive.
- There is no countrywide network of hydrogen filling stations at the moment.
- some methods of producing the hydrogen fuel release carbon dioxide and other pollutants into the atmosphere.

IV.CONCLUSIONS

In an automotive industry characterized by increasing competition between alternative fuel and traditional ICE vehicles, fuel cell vehicles still have to fully demonstrate their attractiveness to the mass market. Among FCVs' benefits, the most recognized by the market is the absence of CO2 emissions during vehicle operation. Besides that, other advantages in comparison with BEVs are shorter refueling time, longer driving range, lower weight, less volume needed for energy storage, scalability, and sustainability. In comparison with ICE vehicles, FCV benefits are greater fuel efficiency and lower levels of GHG production. Despite these, FCVs' mass-market adoption is limited by three major problems: the cost of the vehicle, distribution infrastructure, and hydrogen production. In the context of increasingly stringent automotive emissions regulations, in the future, expectations of the FCV market are growing, but the uptake is predicted to be significant only in the long term. This is due to significant constraints such as achievement of cost reductions by OEMs, development of infrastructures, and identification and standardization of the most efficient solution for hydrogen production. To promote and accelerate the adoption of FCVs, various policy options could be put into action, but this also depends on governments' and industry players' willingness to invest in hydrogen technology.In this paper, an investigation into hydrogen-based energy generation using fuel cells and their utilization in hybrid vehicles was conducted. Various types of FCs and their applications were analyzed, namely the application of FCs in hybrid vehicles. Hydrogen fuel cells will play a significant role in the transportation industry in the near future. The price of fuel cells will reduce when producing fuel cells in large quantities and commercializing them. Fuel cell-based transportation, power plants, and electricity generators to become prominent in the coming decades.Through this paper, I try to explain to you all that the advantages and disadvantages of a fuel cell electric vehicle, and also this gives a clear picture of what is an electric vehicle, hybrid electric vehicle, plug-in hybrid electric vehicle, and fuel cell vehicles and their different topologies used.

REFERENCES

1. Gergana Vacheva, NikolayHinov "An Overview of the State of Art of Fuel Cells in Electric Vehicles" 978-1-7281-3467-3/19 (2019).
2. A. Emadi, S. S. Williamson"Fuel Cell Vehicles: Opportunities and Challenges" IL 60616-3793 (2018).
3. Sanghoon Kwak , Taehwan Chung , Gunsoo Kang and Jinhwan Jung"The Design of an Integrated Power Control Unit for Hybrid/Electric Vehicle" 9th International Conference on Power Electronics (2015).
4. Bobbie Timothea Christian, Arif Sasongko, Arief Syaichu Rohman, Langgam Bagaspratomo, Cindy Agustina"The Prototype Development Of Electronic Control Unit For Electric Power Steering" 978-1-4673-8504-6/20 (2020).
5. Zhongyuan Wang, Dejun Yin"Design and Implementation of Vehicle Control System for Pure Electric Vehicle Based on AUTOSAR Standard" 978-1-7281-3398-0/19 (2019).
6. Annette von Jouanne , Iqbal Husain , Alan Wallace , Alex Yokochi"Innovative Hydrogen/Fuel Cell Electric Vehicle Infrastructure Based on Renewable Energy Sources" 0-7803-7883-0/03 (2003).



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