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Fuel Cell in Hybrid Electric Vehicle

Shital Madhukar Nikam[1], Er. Dr. Rakesh G. Shriwastava[2]

[1]Student of Electrical Engineering department, Matoshri College of Engineering, Nashik, MS, India
[2]Assistant Professor at Electrical Engineering Department, Matoshri College of Engineering, MS, India

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Abstract - *This paper look towards nowadays most emerging component in hybrid electric vehicle i.e. fuel cell. Generally batteries are use in electric vehicle along with IC engine or vehicle with external port for charging but due to most of advantages of fuel cell over batteries the researchers focus on fuel cell to make it more efficient and reliable to be use in electric vehicle to gain its better average. This paper also includes working of fuel cell, its types and mostly used type of fuel cell in electric vehicle and all its characteristics. It also includes comparison between battery and fuel cell, then weight of fuel cell in car and its advantages and disadvantages to overcome.*

Key Words: **Fuel cell Electric vehicle(FCEV),Proton exchange Membrane Fuel Cell(PEMFC), The Alkaline fuel cell (AFC),The phosphoric acid fuel cell (PAFC),The molten carbonate fuel cell (MCFC),Solid oxide fuel cell (SOFC),Plug in Hybrid Electric Vehicle(PHEV)**

1. INTRODUCTION

The total automobile sector has been run on fossil fuels like petrol, diesel etc. from decades till up to nowadays. But due to limited sources of these fossil fuels stored in the belly of the earth and their disadvantages such as contribution to causing pollutions of all types, continuously increasing prices etc. encourages to find subway or new options to propel the automobile sector.

Hence the researchers have fixed the renewable energy sources can be proving as best option to these leading problems. The photovoltaic, wind, fuel cell are some options of renewable sources. The application of fuel cells in electric vehicles has been the focus of auto manufacturers in recent decades. The fuel cell generates electrical energy rather than storing it and continuously generates as long as fuel supply is maintained as compares to chemical battery. Fuel cells are promising candidate to reduce emission and energy consumption to improve global climate situation.

A fuel cell is electrochemical component that can continuously convert fuels chemical energy into electrical energy. The working principle of a fuel cell is similar to electrochemical batteries. The main difference is that the chemical energy converted by a battery is stored inside the battery. Thus once the chemical energy converted into electrical energy the battery must be recharged or its life ends.

But for fuel cell the converted chemical energy is stored externally so the chemical reaction to supply electrical energy can take place continuously as long as hydrogen and oxygen are supplied and their only byproducts are heat and water.

The practical application of fuel cell in vehicle has been introduced here are some examples of that are 'Hyundai Tucson'FCEV was first fuel cell automobile introduce in 2013,'Toyota Mirai' followed in 2015,'Honda Clarity Fuel Cell ' introduce in 2017,'HYndai Nexo' introduce in 2018.

2. Types of fuel cell

There are mainly five types of fuel cells are as follows:

1. The Alkaline fuel cell (AFC)

2. The proton exchange membrane fuel cell (PEMFC)

3. The phosphoric acid fuel cell (PAFC)

4. The molten carbonate fuel cell (MCFC)

5. Solid oxide fuel cell (SOFC)

The five types of fuel cells are differ in terms of efficiency, operating temperatures and input fuel requirements. Compared to other types of fuel cells ,the PEM fuel cell is considered to be a prime candidate for use in automotive application due to its higher power density(power per fuel cell active area) and lower operating temperature (around 80°C)as well as faster start up time (less than 1 min).

3. Operation and Characteristics of PEM fuel cell

The fundamental constructions of PEM fuel cell can be illustrated as shown in fig. it consist of mainly of an anode and cathode and an electrolyte between the electrodes. Hydrogen gas is supplied to anode terminal and oxygen is supplied to cathode terminal. the catalyst on the anode breaks down the hydrogen into electrons and protons .the electrons flows through external circuit resulting as current floe to the cathode while the protons pass through electrolyte to the cathode .once the electrons and protons reach the cathode they are reunited and react with oxygen on the cathode catalyst to form a waste product water .several cells are normally connected in series or parallel to form a fuel cell stack in order to produce sufficient voltage for many practical application.

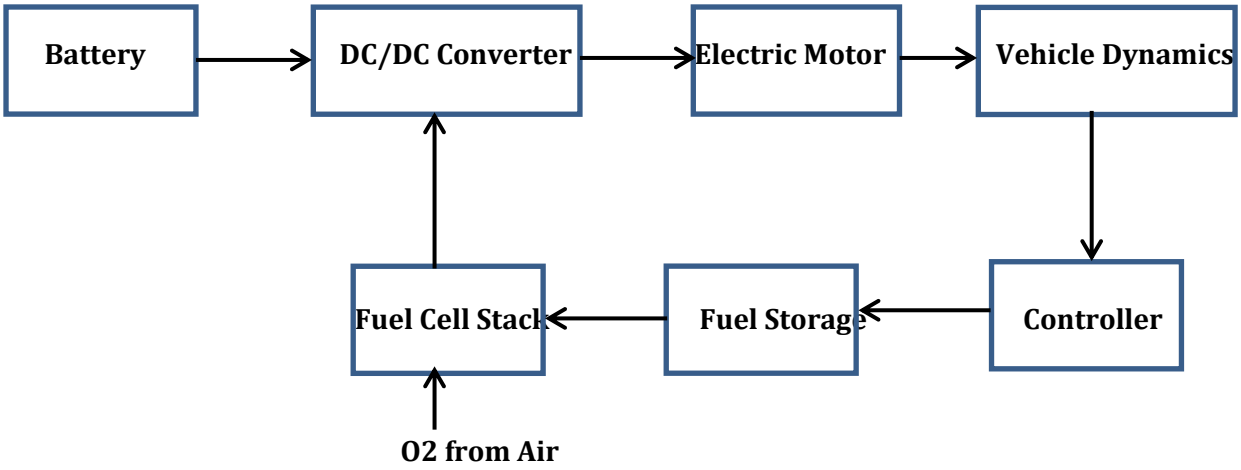

Fig.1: Schematic representation of a fuel cell /battery hybrid power system

4. Comparison Between fuel cell and plugin hybrid electric vehicle

4.1 Fuel Cell:

As compared to other electric vehicle FCEV's produce electricity using fuel cell powered by hydrogen fuel rather than get electrified only from battery. During the vehicle design method the vehicle manufacturers defines the power of the vehicle by the size of electric motor that will get powered by appropriately sized fuel cell and battery combination. Components of hydrogen fuel cell electric car:

1) Battery (Auxiliary): this auxiliary battery supplies electricity to start the car before the traction and also electrifies to other accessories of vehicle like headlight,AC etc.

2) Battery Pack: This batteries stores energy generated from regenerative braking and provides supplemental power to electric traction motor.

3)DC/DC Converter: This converts high voltage DC power supplied from traction battery pack to low voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

4) Electric traction motor: These motor drives the vehicle wheels by using power supplied by fuel cell and traction battery pack.

5) Fuel cell stack: This is an assembly of individual membrane electrodes that use hydrogen and oxygen to produce electricity.

6) Fuel filter: A nozzle from a high pressure dispenser attaches to the receptacle on the vehicle to fill the tank.

7) Fuel Tank (Hydrogen): This stores hydrogen gas on board the vehicle until it is needed by the fuel cell.

8) Power electronics controller: This unit manages the flow of electrical energy delivered by the fuel cell and the traction battery controlling the speed of the electric traction motor and torque it produces.

9) Thermal system (cooling): this system maintains a proper operating temperature range of the fuel cell ,electric motor, power electronics and other parts.

10) Transmission (electric): The transmission transfers mechanical power from the electric traction motor to drive the wheels.

4.2 Plug in hybrid electric vehicle:

This vehicle typically use batteries to power an electric motor and use another fuel such as gasoline to power internal combustion engine .this vehicle batteries can be charged using a wall outlet or charging station by the ICE or through regenerative braking. This vehicle normally runs on electric power until the battery is depleted and then the car automatically switches to use the ICE.

Key Components of PHEV Car:

1) Battery (Auxiliary): As like FCEV the auxiliary battery is use normally to electrify vehicle accessories and to provide electricity to ignite the engine.

2) Charge Port: this charging port is provided to accept the external electric power to charge the traction battery Pack.

3)DC/DC Converter: this converts high voltage DC power supplied from traction battery pack to low voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

4) Electric Generator: Generates electricity from the rotating wheels while braking and transfers that energy back to the traction battery pack.

5) Electric traction motor: by power getting from traction battery pack these motor drives the vehicle's wheels.

6) Exhaust system: the exhaust system transfers the exhaust gases from the engine out through the tailpipe. A three way catalyst is designed to reduce engine out emissions within the exhaust system.

7) Fuel filter: A nozzle from a high pressure dispenser attaches to the receptacle on the vehicle to fill the tank.

8) Fuel Tank: this tank stores gasoline on board the vehicle until it needed by the engine .

9)Internal Combustion Engine(spark ignited):in this configuration ,fuel is injected into either the intake manifold or the combustion chamber where it is combined with air and the air/fuel mixture is ignited by the spark from a spark plug.

10) Onboard charger: takes the incoming AC electricity supplied via the charge port and converts it to Dc power for charging the traction battery. It monitors battery characteristics such as voltage ,current temperature and state of charge while charging the pack.

11) Power electronics controller: This unit manages the flow of electrical energy delivered by the fuel cell and the traction battery controlling the speed of the electric traction motor and torque it produces.

12) Thermal system (cooling): this system maintains a proper operating temperature range of the fuel cell, electric motor, power electronics and other parts.

5. Weight of fuel cell in car

A hydrogen fuel cell vehicle's tank is sized in kilograms. A 4-kilograms hydrogen tank (87.8 pounds) held the energy equivalent to of 4 Gallons of gasoline.

6. Advantages of fuel cell:

1) High Efficiency: most of fuel cells are 60-80% energy efficient. However his efficiency can get increase to85% when these fuel cells are use in cogeneration system.

2) Clean: Fuel cells work with little to no emissions, the byproducts are only electricity, heat and water .they are much cleaner than traditional power generation producing 97% less nitrogen oxide emission than the thermal power plant.

3) Scalable: Can be stacked into one another.

4) No noise: More silent in operation when compared to the conventional sources of power generators. There are no moving parts in a fuel cell stack, making them quieter.

5) Low Maintenance: Though the initial cost is higher, fuel cell technology does not involve much maintenance .fuel cells does not degrade over time, unlike batteries and can therefore, provide electricity continuously.

7. Disadvantages of fuel cells

The fuel cell technology has failed to gain much popularity and some have reasons to believe that they might not become economically competitive with other clean technologies. One of the major criticisms of this technology is the challenge in production, transportation, flammability and storage of hydrogen gas, which is the main constituent in the fuel cell. Though the technology has been around three decades now, still much work/research is yet to be done. As such, the technology is still costly to use.

8. CONCLUSION

As from all this study of fuel cell in hybrid electric vehicle fuel cell is most efficient and environmentally cleaner source to be use in vehicles though its initial cost is high. From the comparison with battery electric vehicle, fuel cell electric vehicle should must be developed along with cogeneration techniques to improve its efficiency and get better average. Also research must done so that fuel cell can be use along with renewable energy source.

REFERENCES

[1] Z. Mokrani, D. Rekioua, N. Mebarki, T. Rekioua and S. Bacha, "Proposed Energy Management Strategy in Electric Vehicle for Recovering Power Excess Produced by Fuel Cells", Int. Journal of Hydrogen Energy, 2017

[2] Nicola Briguglio, Laura Andaloro, Marco Ferraro and Vincenzo Antonucci "Fuel cell Hybrid Electric Vehicles".

[3] R.Ahluwalia, X Wang, A.Rousseau "Fuel Economy of Hybrid Fuel Cell Vehicles" Argonne National Laboratory, Argonne, IL

[4] Wei Liu "Hybrid Electric Vehicle System Modeling and Control". Second Edition

[5] Sheldon S. Williamson "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles". Springer