A Study on Hydrogen Fuel Cell Technology for Automobiles: A Review

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Abstract: - The perilous poisons emitted from the auto tailpipe are the central point in environmental change because of the ozone depleting substance emanations development in the air. Consuming petrol based items in the vehicle discharge carbon dioxide, which is the significant wellspring of ozone harming substance development in the air. So after watching the hurtful impacts of petroleum derivatives logical world begins searching for a substitute wellspring of energy that is climate amicable and will not deliver any unsafe outflows. Despite the fact that there are such countless substitutes for the petroleum derivatives like Solar Energy, Electricity, Fuel Cell, Biofuel yet Hydrogen is wonderful to use as energy in vehicles. Hydrogen is a decent wellspring of energy and conveys a decent measure of energy in the event that we contrast it and different wellsprings of energy. In this investigation the current status of the energy component vehicles, late turns of events, their future perspective, it's working, and the benefits and detriments were examined. As hydrogen is perhaps the most proficient fuel sources which can straightforwardly deliver Direct Current (DC) power which can run an electric vehicle. The aim of this study is to discuss the working, use, current status its future aspects and recent developments happened in the fuel cell.

Keywords: - Automotive, Battery, Fuel Cell, Hydrogen, Transportation Fuel.

I. INTRODUCTION

Energy is the deciding component of any nation's economy, foundation, transportation and the way of life. By and by all countries are subject to petroleum derivative for their energy requests however because of its non inexhaustible nature and the destructive outflows delivered from it which are the central point contributing towards nursery impact and environmental change, so it is the ideal chance to push ahead and searches for an other fuel which is enviornment well disposed and sustainable in nature [1,2]. As oil holds are exhausting and going to end which is the one of the fundamental issue of current energy situation, which makes the energy area truly flimsy because of its fluctuating costs and the accessibility, and furthermore it influences enviornment contrarily by transmitting nursery gases [3,4]. By and by the greater part of the energy requests are satisfied by petroleum derivatives and the portion of petroleum product is still high in the total share of all energy assets. There are parcel of choices for petroleum products present at this moment however power as another wellspring of energy is rising step by step in cars. Indeed, even half and half vehicles are utilizing battery just as customary motors to diminish the dependance over petrol. Battery worked electric vehicles otherwise called EVs are likewise present in the market which utilizes a footing battery back for controlling up the motor.EVs are much powerful in changing over energy from the battery into tractive force[5]. Despite the fact that EVs enjoy a few benefits however there are a few impediments of BEVs:-

1. They have limited range due to the high price of the battery.

2. The EVs are generally bit costlier than coventional IC engines.

3. Recharging the batteries is a time consuming process.

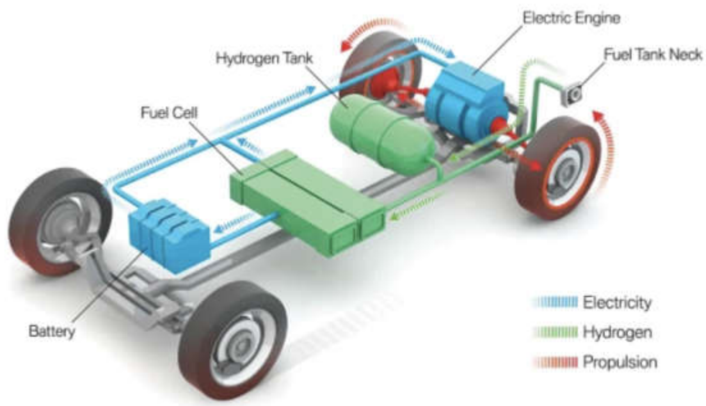

Fig-1 Basic parts of the vehicle based on fuel cell.

So for satisfying the hole between IC motor based vehicles and Electric vehicles another wellspring of energy come into light that is Hydrogen. Hydrogen is a dull and scentless gas and is accessible in bountiful amount in our climate. In the event that I talk about the energy content, Hydrogen on a normal has almost multiple times the energy substance of gas. Like in Internal ignition motors the compound energy of petroleum/Diesel is changed over in to the mechanical energy which assists with impelling the vehicle [6]. Similarly a power device changes over the substance energy of hydrogen into electrical energy and in this way helps in moving the vehicle. In battery worked vehicles their reach would be low a direct result of their battery yet in the event of energy component it gives continuos power till there is sufficient oxygen and hydrogen in the tank, so power module is obviously superior to electric vehicles as far as giving the continuos capacity to the vehicle. Subsequently we can infer that hydrogen fuel can beat certain issues of battery worked vehicles.

1.1 What is Hydrogen Fuel Cell?

As the name suggests hydrogen fuel which implies we are utilizing hydrogen as a fuel by blending hydrogen in with oxygen. A power device is fundamentally an electrochemical gadget which changes over synthetic energy of hydrogen into electric energy. At first power module was created by Welsh Scientist William Robert Grove in 1839 yet it wasn't utilized economically until the 1960s. Essentially it comprises two elctrodes, one electrolyte, hydrogen as a wellspring of fuel and force supply. An electrolyte which seperates the two anodes is a directing substance, which helps in the free progression of particles in the cell. Oxygen courses through hydrogen and after the response it produces water of drinking quality and create some measure of warmth. As hydrogen is available in the plentiful amount in the nature however it is not difficult to deliver energy from hydrogen everywhere scale without leaving any destructive effect on enviornment. Figure 1 shows the schematic outline of hydrogen energy unit.

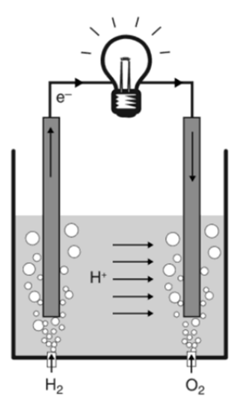

Fig-2. Fuel Cell [7].

1.2 How Fuel Cell Produces Energy?

The working principle of fuel cells is same like the batteries yet there is just one key contrast between the energy unit and battery and that is battery run out of charge some time and will require re-energizing yet as long as there is fuel in the power module it continues delivering power till it runs out of fuel. It comprises of two terminals a negative anode known as anode and a positive terminal known as cathode combined with the assistance of an electrolyte which seperates cathode and anode. In energy component hydrogen as a fuel is provided at the cathode end[8]. An impetus which is available at the anode end helps in isolating hydrogen particles into protons and electrons, electron creates power by going through an outer circuit. The protons compasses to the cathode through electrolyte and consolidates with oxygen to create water and warmth.

II. COMPONENTS OF A FUEL CELL

There are different sorts of power devices yet the majority of the energy units depend on the combination of electrode and membrane construction, in this sort of power module numerous layers of various materials were sandwiched together. The primary pieces of a PEM fuel are:-

2.1 Polymer Electrolyte Membrane

The polymer electrolyte film is otherwise called a proton trade layer, it is a slender layer comprised of extraordinary materials which permit just protons to go through it yet forestalls the section of electrons. It is quite possibly the main pieces of energy component innovation: it needs to permit just allowed ios to stream between the anode and cathode.

2.2 Impetus sheets

A slim film of impetus is utilized at the two sides of the layer at anode and cathode. The standard impetus layers depend on nanometer-sized particles of platinum scattered on a high surface territory carbon support. This platinum impetus is then blended in with particle leading polymer and surfaced between the polymer electrolyte film and gas dispersion layers. This impetus assists with parting Hydrogen into protons and electrons at the anode side and helps in decrease at the cathode side by aiding in the response of oxygen of protons which produces Water as a result.

2.3 Gas Diffusion Layers

The gas dissemination layers exist at the external side of impetus layers and helps in the smooth progression of the reactants to the impetus layer. This layer is for the most part comprised of carbon paper in which carbon filaments are moderately covered with poly-tetra-fluro-ethylene. Gases leave through the little pores of the dispersion layers, these pores are stayed open by the assistance of hydrophobic polytetrafluroethylene, it turns away in the extreme development of water in the cell.

2.4 Anodes

Each blend of film and cathode produces under 1V of energy under ordinary conditions. These cells are in this manner associated in arrangement to create huge measure of current from it. These plates are comprised of either composite material or metals and helps in the progression of electrones between the cells and give strength to the energy unit.

2.5. Coating

Every mix of film with anode in an energy component is pressed between the terminals, yet covering or sealant is needed around the boundaries to make an impermeable seal, these linings are by and large comprised of eubber.

III. TYPES OF THE FUEL CELL

Fuel cells are based on the type of memebrane used. There are various kinds of fuel cells based on the usage of various membranes, like:-

Table-1 Types of fuel cells based on the type of membrane used [9].

Fuel Cell	Membrane Used
Solid Oxide Fuel Cell	Yttria-stabilized zirconia
Direct methanol fuel cell	Solid polymer electrolyte
Polymer electrolyte fuel cell	Solid polymer electrolyte
Alkaline Fuel Cell	Aqueous solution potassium hydroxide.

3.1 Solid oxide fuel cell

A regular fuel cell that is used in stationery applications is nown as solid oxide fuel cell [10]. It uses a ceramic membrane called as yttrium stabilized zirconia that allows the passage of oxygen ions. It works at somehow high temperatures ranges between 650- 800 degree Celsius. It has an advantage and that is because it works on high temperature and oxxidizing ion flow, it can manage a number of fuels [11]. These types of fuel cells are generally used for stationery applications like providing power pack for cell phone towers. The reactions that are linked with this type of fuel cell are shown below [12].

Complete Reaction:

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \tag{1}$$

Oxidation:

$$H_2 + O^{2-} \rightarrow H_2O + 2e^- \tag{2}$$

Reduction:

$$H_2 + O^{2-} \rightarrow H_2O + 2e^- \tag{3}$$

CO and hydrocarbons can likewise be utilized in SOFC at high temperatures, subsequently a water gas shift reaction is also conceivable:

$$CO + H_2O \rightarrow H_2 + CO_2 \tag{4}$$

3.2 Direct Methanol Fuel Cell

As the name suggests, direct methanol fuel cell it uses methanol directly in this fuel cell. Methanol is a biological fuel generated from coal or agricultural products. In this type of cell both of the electrodes are made up of platinum. The electrolyte that is used in this cell is trifluromethane sulfonic acid. This type of cell works on low temperature ranges. These types of fuel cells were used in the starting in portable devices like laptops and mobile phones [13].

3.3 Polymer Electrolyte Membrane Fuel Cell

This is the most common type of the fuel cell and it uses an solid polymer membrane as a electrolyte. Here the membrane is made up of perflurosulfonic acid. This membrane allows protons to pass through it, it blocks the passage of electrons. This is an low temperature range fuel cell and works around 80 degree celsius. These types of cells are nowadays mostly used in the automotive field. The advantage of these types of fuel cells is that they are very efficient and power density in the automotive engine size [14].

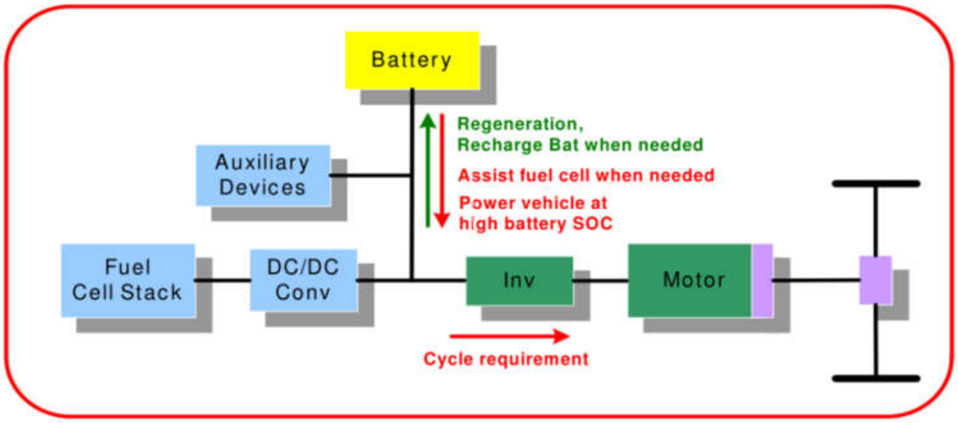

Fig-3 Components used in vehicle based on fuel cell [15].

IV. CURRENT STATUS OF HYDROGEN FUEL CELL

Current there are very less number of vehicles available commercially who are totally based on ythe Hydrogen fuel cell but as we are moving towards the future the technology is growing and slowly slowly all conventional engines will be replaced by the engines baswed on renewable sources like hydrogen fuel cell. In 2019, the worldwide hydrogen fuel market stands at $0.25billion. It is expected that it will reach by $0.38billion by the end of 2023. All this shows that hydrogen fuel cell market is growing slowly.

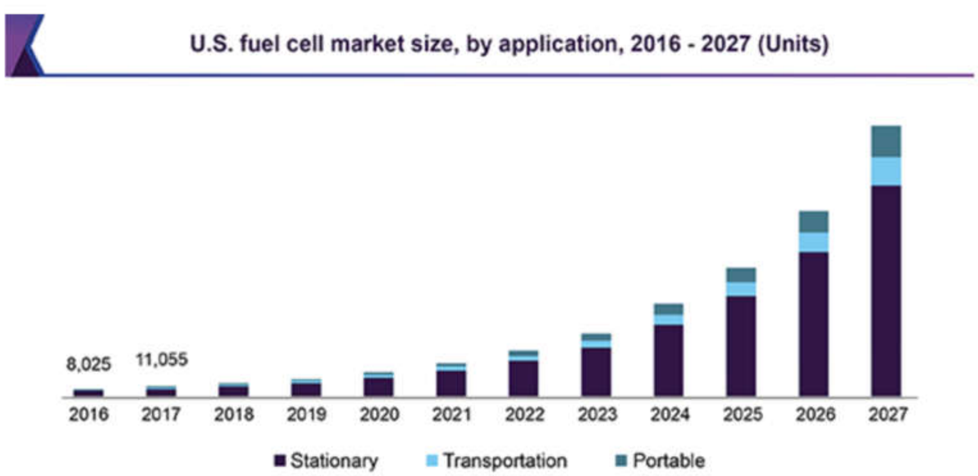

Fig-4 hydrogen fuel cell market growing structure

As we can see in the above figure the market share of fuel cell is increasing gradually and it will become as a major source of energy for the transportyation sector in the upcoming years as per the prediction.

V. TYPES OF VEHICLES BASED ON FUEL CELL

In automobile sector fuel cell plays a crucial role because we are moving towards the end of fossil fuels amnd there are lot of disadvantages of using biofuel as a primary source of energy, so right now it is our primary need to move forward from fossil fuels. There are various types of drive trains in which we use fuel cell as a source of energy.

5.1. Hybrid Vehicle based on fuel cell:

i. Parallel Hybrid

ii. Series Hybrid

iii. Series-parallel hybrid

5.1. Hybrid Vehicles

Vehicles based partially on fuel cell and partially on other fuel are known as hybrid vehicle. Because vehicles based on the fuel cell uses an motor to move the vehicle and it seems to be an electric vehicle without the use of fuel cell, and the motor was developed in the early 19th century. In the initial 1970s, K. Kordesch [16] modified a sedan to operate from a 6kw fuel cell and with the help of a lead acid battery pack. in 1993. In 1994 and 1995, H-power built three fuel cell based hybrid buses, each working a 50kw fuel cell and a 100kw ni-cd battery [17].

i. **Parallel Hybrid:-** Parallel hybrid drive train is the earliest drive train structure for hybrid vehicles. In this type of structure, both the IC engine and the electric motor can be used to propel the vehicle independent of each other. IC engine gives can be used in this type of drive train when more torque is required because motor can't provide that much power ast full load so motor is useful when we drive the car at lower rpm. Implementing a parallel hybrid system allows the each power source to work independently and at varying degrees when it is most effectibve in the drive cycle [18]. In the parallel configuration we can also use both ICE and electric motor together to get high torque when needed because independent torque production would be low in both of ICE and electric motor [19].

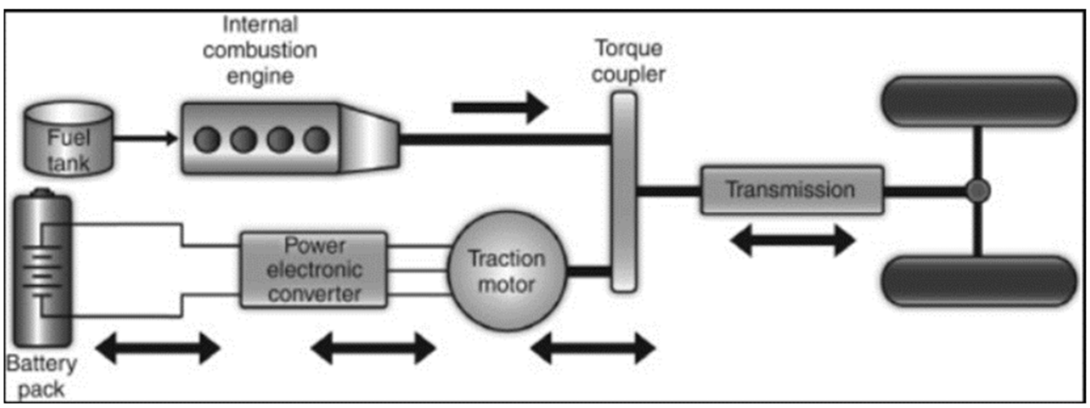

Fig-5 Schematic Diagram of Parallel hybrid drive train [20].

ii. **Series Hybrid:-**An arrangement half breed drive train engineering contrasts from an equal cross breed drive train in that the two power sources are not, at this point autonomously ready to control the vehicle. In this setup, by and large the ICE will go about as a charger for the batteries that supply power to the electric engine—the as it were source to push the vehicle [21]. One of the upsides of this plan is that there is no requirement for a transmission, since the ICE isn't fueling the vehicle straightforwardly. Disposing of the transmission from the motor framework diminishes the heaviness of the vehicle, which straightforwardly connects to expanded productivity. In an arrangement setup, the ICE doesn't need to represent any of the transient elements in the drive cycle as it would in an equal design. Along these lines, the motor can be worked at a consistent state at its most productive rpm, further expanding its effectiveness. In an arrangement design, there is greater adaptability in regards to the execution of elective energy gadgets. For instance, for this project, the ICE was supplanted with a hydrogen FC. In an arrangement half breed, the ICE changes over substance energy to mechanical energy and afterward to electrical energy, subsequently it is in reality more effective to utilize a FC to convert straightforwardly from substance energy to electrical energy to charge the battery pack. This is one of the primary reasons the choice was made to carry out an arrangement design in this task. It ought to be noticed that an energy component can be utilized in an equal arrangement too. Notwithstanding, to accomplish equal use, the power module would should be sufficiently strong to deal with the transient elements made by the drive cycle. Most energy units have sufficiently high force thickness to deal with transient powerful stacking well. Ordinarily, power devices are needed to work close to consistent state conditions, which makes them ideal for arrangement half breed structures [22-26].

iii. **Series-parallel Hybrid:-** In an arrangement equal cross breed, both the electric engine and the ICE can control the vehicle freely or together. The ICE can split its force between driving the vehicle and charging the batteries at the same time [27]. This arrangement gives the most control adaptability, since the methods of activity can be improved to make up for the current drive cycle. Be that as it may, one of the downsides to this plan is the measure of equipment required. Since the ICE should have the option to drive the vehicle, a transmission is required, and a generator is needed to empower the ICE to charge the batteries. The arrangement equal plan has every one of the advantages of both the arrangement plan and the equal plan, which makes it more adaptable to various drive cycles; nonetheless, it additionally has every one of the downsides of both designs [28-32].

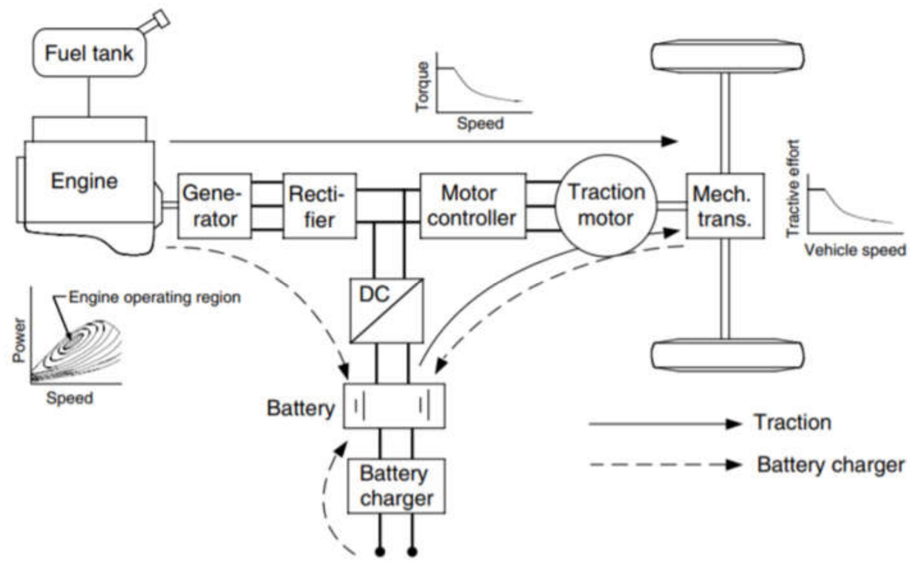

Fig-6 Series Hybrid Drive train [33].

CONCLUSION

So due to the non renewable nature of the fossil fuels, its availability, grrenhouse emissions we have moved towards the renewable sources of enrergy which don't have any negative impacyt on the enviornment. Hydrogen is the sustainable fuel for the future which can replace fossil fuels completely and also it doesn't have any negative impacts on the enviornment and also produces the quality drinking water. So the major conclusions of this study are to promote the use of fuel cell based vehicles at individual level and also government should provide incentives to the companies so the the cost of vehicles based on fuel cells will come down, it will also enforce companies to make more vehicles based on fuel cell available for commercial use.

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