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HYDROGEN FUEL CELL

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Abstract -*FUEL CELLS are the devices that convert chemical energy directly into electrical energy, recent analysis shows that the fuel cell electric vehicles are among the most promising options to reduce greenhouse gas emissions and petroleum use, hydrogen has long been advocated as the ultra-clean fuel because its combustion produces pure water and no pollutants, hydrogen fuel can provide stationary fuel cell applications, utilizing hydrogen is in an electro chemical fuel cell to generate electricity to drive an electric motor , hydrogen can be produced from a no. of diverse domestic resources. Hydrogen fuel used as renewable energy, invests in clean energy technologies to improve economy, protect environment and reduce dependence on foreign oils. Problems are with generation, distribution, storage of hydrogen, Cost of the fuel cell. Compressed gas storage is the cheapest option for storing hydrogen onboard fuel cell vehicles, it is difficult to store in either high pressure tank or a cryogenic tank, the major advantage is that it is a zero emission fuel.*

Key Words: Fuel cell, Hydrogen fuel cell

1. INTRODUCTION

Hydrogen fuel cell technologies are not new, a hydrogen mixture was widely used for street lamps in the 1880's and the first fuel cell was invented by Sir William Robert groove in 1839. Within a fuel cell hydrogen and oxygen are converted into heat and water to produce electricity in the process.

A fuel cell is a device which is used to convert chemical energy directly into electrical energy, it is formed by a fuel electrode (anode) an oxidizing electrode (cathode) and an electrolyte is placed in between them, hydrogen is the one of the most abundant elements on the planet and can be obtained from numerous sources such as water, biomass, natural gas, coal among all other elements hydrogen can be used as a fuel. For further usage of hydrogen in fuel cell vehicles it must be separated before, and then it is stored and transported. steam reforming is the main method of production of hydrogen and other methods such as coal gasification and electrolyses are also useful for the production of Hydrogen, after production it needs to be stored and this is made in the form of compression, liquefaction, physical or chemical storage in hydrides, and the delivery system mainly having the forms are compressed gas and as a cryogenic liquid of higher density with higher energy cost. There are several types of fuel cells under development and the main types of fuel cells are

1) Proton exchange membrane fuel cells (PEM)

2) Alkaline fuel cells (AFC)

3) Direct methanol fuel cells

4) Phosphoric acid fuel cells (PAFC)

5) Solid oxide fuel cells (SOFC)

6) Molten carbonate fuel cells (MCFC)

fossil fuels are responsible for emission of green house gases, to reduce global warming problem in the world and to minimize the demand for usage of fossil fuels hydrogen fuel cell vehicles are more useful, these are more advantageous than normal vehicles, efficiency of hydrogen fuel cells are more when compared to that of combustion engines, to achieve advantages we have followed some control strategies because these fuel cell vehicles contains fuel cells , batteries, super capacitors and smart control units with their control strategies. Two characteristics are important for the application of hydrogen as a fuel they are specific energy and energy density.

Hydrogen fuel cells still have higher cost and don't show good durability till now, and the storage techniques are under the development stage, this is the most challenging difficulty facing in today world, but in future hydrogen is potentially a great substitute for fossil fuels, it is used to reduce carbon emissions in urban areas and to meet our requirements.

METHODS OF PRODUCTION OF HYDROGEN:

The main methods of production of Hydrogen are:

1) Steam reformation

2) Coal gasification

3) Electrolysis

STEAM REFORMATION:

Steam reformation of hydrocarbons has been preferred route for manufacturing of hydrogen and other synthesis gases. In this process the natural gas is subjected to thermal cracking over nickel catalyst and followed by auto thermal cracking by adding air at 800 degrees centigrade temperature to form hydrogen and other synthesis gases, the hydrogen is purified by separating it from synthesis gas and pure hydrogen is obtained.

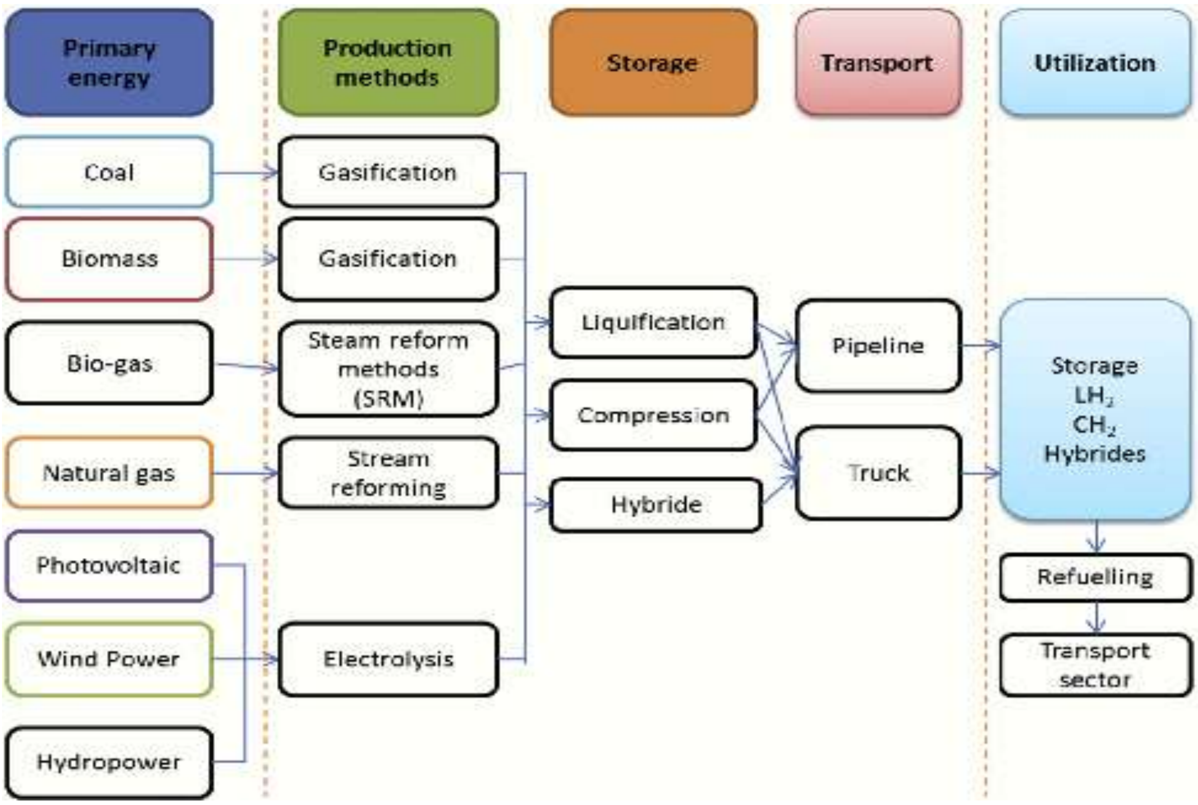
COAL GASIFICATION:

The basic raw materials used in this process are coal and some other fuels they reacted with oxygen and that oxidation process is carefully observed then H2, CO2, CH4, and other products are formed due to gasification of coal and the formed hydrogen is purified by removing impurities then pure hydrogen gets separated and ash leftovers.

ELECTOLYSIS OF WATER:

Electrolysis of water is the simplest method of producing hydrogen, oxygen and hydrogen are separated from water through electrolysis, it is a method of separating elements by pushing an electrical current through a compound so it is also use to separate hydrogen from oxygen from water in this way hydrogen is produced.

The flow chart representing production, storage, transport and utilization of hydrogen is:



(Adapted from Salvi et al.) [17]

There are also a number of production methods under development that could become significant in future hydrogen supply chains, including:

1) Electrolysis at high temperatures, using heat from nuclear reactors or concentrating solar power, which makes the process more efficient
2) Thermolysis, which uses extreme heat from nuclear or solar energy to split hydrogen from water
3) Photocatalytic water splitting, the process of obtaining hydrogen directly from water using sunlight
4) Production of hydrogen from direct fermentation of biological material.

Hydrogen is not a sustainable energy vector unless the production process produces low emissions.

STORAGE OF HYDROGEN:

Two characteristics are important for the application of hydrogen as a fuel those are specific energy and energy density. In comparison with hydrocarbons, hydrogen has a good density by weight, low density by volume. This is the main difficulty faced for hydrogen storage, by altering hydrogen physical state to use it as a fuel and to improve its density by volume.

The storage process may be performed by the following methods:

1) Compression
2) Liquefaction
3) Physical or chemical storage of hydrides

COMPRESSION:

Hydrogen compression method is most widely used method of storage today and it is the popular and easily understood process. In this process hydrogen is compressed in tanks, with similar technologies used in natural gas compression. Hydrogen storage pressures ranges from 20 to 25 Mpa, In future it reaches to use 70 Mpa for tank storage. It is desired to have high density storage, low weight and low cost for using it in vehicles.

The main difficulties encountered with storage of hydrogen by compression are:

- Storage system security
- Low volumetric density

These deficiencies found difficulties in storage of hydrogen by large scale compression in automobiles, gas tanks with compressed hydrogen offers commercialization.

LIQUEFACTION:

Hydrogen can be stored in its liquid state, being colorless and non corrosive, the liquid hydrogen storage is more advantageous than compression because of density of liquid, storing of hydrogen as liquid requires temperatures below -253 degrees centigrade, the tank in which hydrogen is storing is thermally isolated and stays in vacuum condition.

Some difficulties need to be reduced to make this technique more feasible, those are:

- From 30 to 33% of the total energy of the hydrogen is used for liquefaction of hydrogen gas
- In storage tanks high cost of materials are used
- Problems with security
- Evaporation losses in storage tanks

It is used in large scale in vehicles only when there is room for improvement in storage of liquid hydrogen.

PHYSICAL OR CHEMICAL STORAGE IN HYDRIDES:

Some metals or alloys can absorb hydrogen and release after heating, which are called metallic hydrides (physical hydrides), theoretically metal hydrides are one of the simplest process for hydrogen storage. There are several metal elements that can store hydrogen but only a few are suitable for storing at moderate temperatures and pressures examples are carbon and other nano structures and these metal hydrides are having high storage capacity only at cryogenic temperatures. The main advantages of this type of storage is it is a safe method, little time for storage and is a reversible process under moderate conditions of temperatures and pressures.

Chemical hydrides are the materials having chemically concentrated hydrogen, metal hydrides, formic acid, ammonia, synthetic hydrocarbons are the materials the materials which can store hydrogen chemically, to obtain higher densities chemical hydrides are preferable when compared to that of physical or metallic hydrides but having some limitations to overcome those are irreversibility, impurities adsorption, reaction kinetics and cost. The hydrogen chemical storage is having advantage of regeneration efficiency.

After storing of hydrogen it is need to be transported or delivered to usage points those are fuel cells used in onboard vehicles.

DELIVERY OR TRANSPORTATION OF HYDROGEN:

Hydrogen transportation is the important step in hydrogen economy and its usage in fuel cells, to choose the mode of transport some elements are needed to be considered those are technical factors, cost, environmental impacts, safety etc. Hydrogen carried by some ways they are:

- In pipelines for gaseous hydrogen such as natural gas
- Trucks and cryogenic tanks for liquid hydrogen
- Primary energy can be transported and hydrogen is produced at point of use

For long distances hydrogen must be delivered as in a liquid form, it can be transported in oil tankers; for small distances in high pressure cylinders. Using of pipelines are most effective way of transport only preferred for gaseous hydrogen, the cost of maintaining pipelines are low but having high capital costs but they increase the hydrogen economy. When comparing the cost of gaseous hydrogen and liquid hydrogen it is concluded that the distribution in gas pipelines is preferable for large scale production while the transport in trucks are preferable for small scale hydrogen production.

USE OF HYDROGEN IN FUEL CELLS:

A fuel cell is formed by a fuel electrode acts as an anode and an oxidizing electrode acts as a cathode and an electrolyte intercalated between them. Fuel cell systems are considered as an alternative to the generation of energy through combustion, due to their low emissions and high efficiency, the energy efficiency reaches maximum of 70%, the main advantage are static nature of fuel cells and operating without having noise or vibration.

There are several types of fuel cells under development, the main types of fuel cells are:

1) Proton exchange membrane fuel cells (PEM)
2) Alkaline fuel cells (AFC)
3) Direct methanol fuel cells
4) Phosphoric acid fuel cells (PAFC)
5) Solid oxide fuel cells (SOFC)
6) Molten carbonate fuel cells (MCFC)

Each one are having advantages and limitation and some developments those are discussed below.

PROTON EXCHANGE MEMBRANE FUEL CELL (PEM):

The proton exchange membrane fuel cell uses a polymer membrane as its electrolyte. The low weight of the cell and its high efficiency have made them it a major candidate for future auto motive applications, which has attracted large investment from many automotive companies. Power generation applications also developed alongside these other applications.

The membrane that forms the electrolyte of the PEM cell is usually a compound called poly-perfluoro carbon sulfonate. This is a close relative of Teflon but with acidic sulfonate molecular groups attached to its polymer backbone to provide conductivity. In its normal state the membrane is not conductive, but it is allowed become saturated with water the acidic groups attached to the membrane release protons, allowing it to conduct hydrogen ions. The membrane itself is usually between 50 microns and 175 microns thick, the latter equivalent to seven sheets of paper. As a consequence of the fact that the conductivity is provided by the water, the cell must be kept well below the boiling point if it is to remain stable. Practical cells normally operate around 80 degrees centigrade; this makes it catalyst more susceptible to poisoning than other, higher temperature cells.

The electrodes of a PEM fuel cell are made from porous carbon containing platinum that can be printed directly on to the membranes. A further porous carbon backing layer provides structural strength to each cell as well as supplying electrical connections, typical cell voltage is 0.7-0.8 V. Cells are joined in series and parallel to provide sufficient current and voltage. A PEM fuel cell requires both hydrogen and oxygen to operate, oxygen is normally supplied from air and hydrogen produced from reforming natural gas. This hydrogen must be purged of carbon monoxide and sulfur compounds to avoid catalyst poisoning, the low cell operating temperature also means that there is no heat from the cell to use to help drive the reforming reaction so additional natural gas must be burned, reducing overall cell efficiency.

When supplied with pure hydrogen, a PEM fuel cell is capable of a theoretical fuel to electrical conversion efficiency of 60% but in practice the efficiency is likely to closer to 50%.

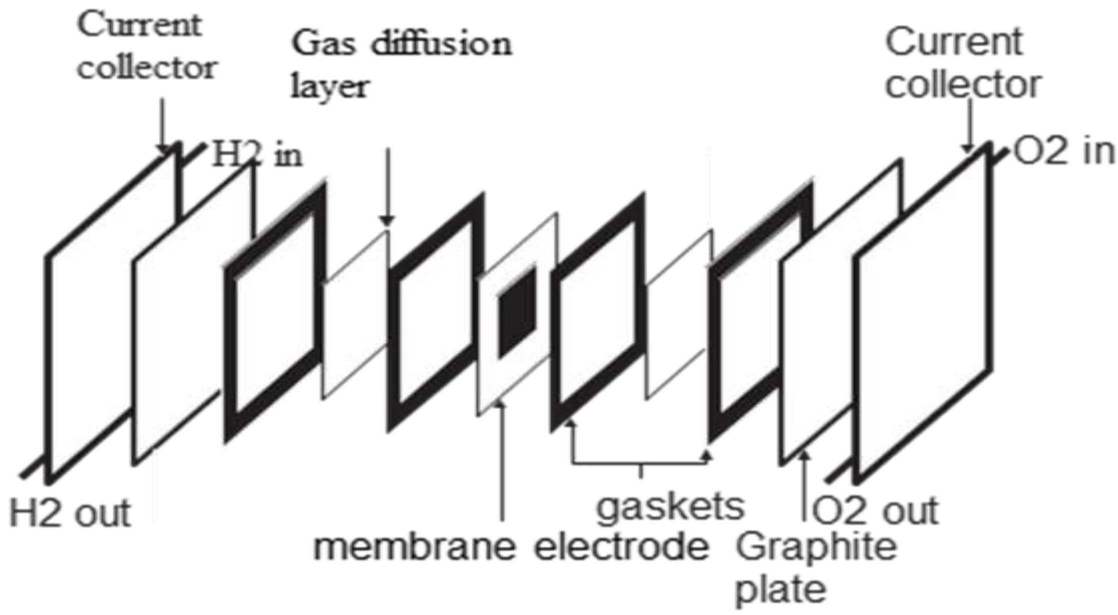


FIG: PEM FUELCELL

This relatively high efficiency is one of the attractions for the automotive industry, when the hydrogen is derived from the natural gas by reforming, efficiency falls so that practical natural gas based PEM fuel cells can achieve an efficiency around 42%, the need for a reformer also leads to a startup time around 20 minutes while the reformer reaches its operating temperature, with hydrogen, the startup time would be instantaneous.

Efficiency might be improved with higher temperature operation and this would also reduce sensitivity to catalyst poisoning, this is driving research into newer types of membranes. One that has achieved some success is a polybenzimidazole membrane containing phosphoric acid that can operate between 160-180 degrees centigrade, and a number of companies are offering cells that operate in this temperature range.

The operation life time of PEM fuel cell has been lower than that of phosphoric acid fuel cells (PAFC) with practical life times of 10000 hours typical. This is considered adequate for automotive applications but is too short for many stationary applications. However, some products claim a lifetime of 40000 hours.

There are a range of stationary applications for PEM fuel cells but they have yet to establish themselves in any one part of the market, early development was directed at large stationary cell stacks with capacities of up to 250 KW and there has been 1 MW utility application. However larger units today are likely to be below 100 KW that can be used for backup and standby, smaller units perhaps around 3 KW and less are being developed for the domestic market. Another application is the portable power generation; these units take advantage of the high efficiency of PEM fuel cell when operating with hydrogen to provide a cheap, highly efficient source of portable power. However this is a market to which the direct methanol fuel cell is also directed. The main global research drive is to find the means to reduce the amount of platinum needed in a PEM fuel cell. While alternative catalysts may be possible, platinum remains the best material, but it is expense and the cost can vary widely due to global commodity market volatility.

ALKALINE FUEL CELLS (AFC):

The alkaline fuel cell (AFC) employs an electrolyte composed of a concentrated solution of potassium hydroxide, this is the base that has the highest conductivity of the alkaline hydroxides, the cell requires metal catalyst such as platinum, but the actual used varies with application.

The cell reaction in the AFC is slightly different to the standard fuel cell reaction because the electrolyte conducts hydroxide ions (OH-) rather than the protons, hydrogen molecule is supplied to anode and splits into hydrogen atoms and each one releases an electron form a hydrogen ion, meanwhile, at cathode oxygen molecules dissociate to form atoms, but in this case two electrons and then react with water to form hydroxide ions. These can then pass through the electrolyte to the anode where they react with the hydrogen ions generated there to regenerate water. The series of reactions are as follows:

$$H2 = 2H^+ + 2e^-$$

$$O2 + 4e^- = 2O2^-$$

$$O2^- + 4H2O = 2OH^-$$

$$2H^+ + 2OH^- = 2H2O$$

In essence the reaction is exactly the same as the standard fuel cell reaction described before but it is mediated by the hydroxide ions, these are generated at the cathode in the reaction between oxygen ions and water and then consumed at the cathode.

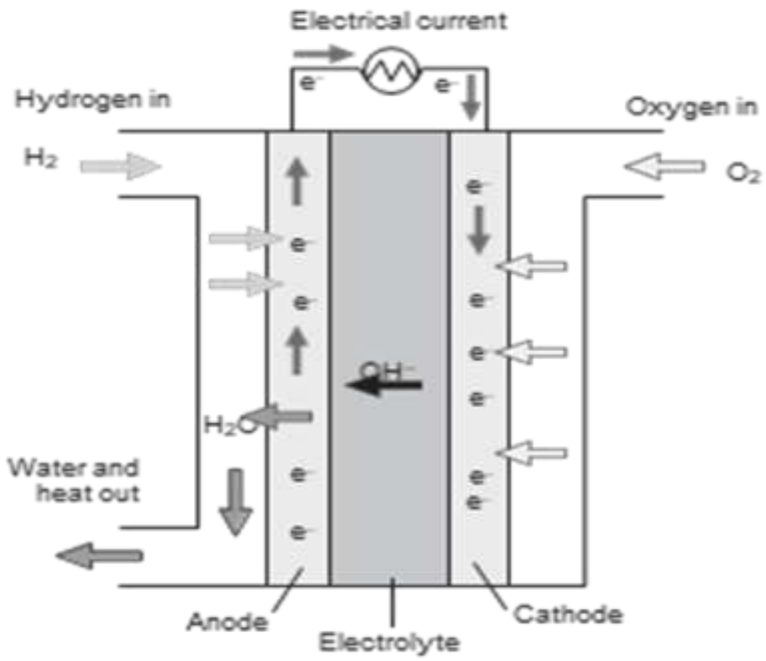


FIG: ALKALINE FUEL CELL; source: united states department of energy

In earlier AFC cells are operated at a relatively high temperature around 260 degrees centigrade and some modern cells use similar temperatures. These cells are capable of practical efficiencies of 60%, developers are hoping to develop cells that can operate at ambient temperature, in a classic AFC cell used in space program the electrolyte is held between porous solid matrix of an asbestos like material, for less demanding applications simple catalysts can be employed. Cell life time is so far been the main factor limiting the use of AFC. Modern AFC have a life time of 5000 hours appears feasible over the short term, limiting factors include the buildup of potassium carbonate generated from carbon dioxide both in air and as an impurity within the hydrogen fuel.

One of the key recent AFC developments is the use of a circulating electrolyte rather than an electrolyte immobilized within a matrix, cycling the electrolyte allows carbon impurities to be removed, potentially increasing cell life time, other research is aimed at developing hydroxyl ion exchange membranes similar to proton exchange membranes already developed for acidic fuel cells, these fuel cells are used today only where efficiency and reliability are more important than cost , these are used mostly in vehicle applications such as fork lift trucks and golf trolleys. Costs are too high and lifetime too short for their use for general automotive applications, but if they could be reduced they could have great potential.

DIRECT METHANOL FUEL CELL:

The direct methanol fuel cell (DMFC) is a polymer membrane fuel cell, similar in concept to PEM fuel cell. The major difference is that is in the DMFC the fuel supplied to the anode of the cell is not gaseous hydrogen but methanol in liquid form. The methanol, mixed with water, can react directly at the cell electrode without the need for reforming. This simplifies the cell, reducing costs. The use of liquid rather than gaseous fuel is extremely attractive too as it makes fuel handling much easier. The application of DMFC is a portable power supply and it is of interest to the automotive industry for the same reason.

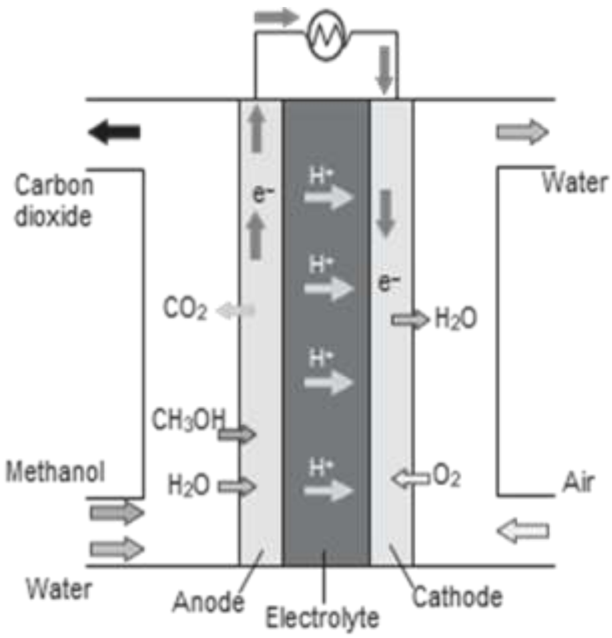


FIG: DIRECT METHANOL FUEL CELL

Research into the DMFC was carried out in the 1950s and 1960s, then revived during the 1990s. Early cells had exhibited low current densities but this has subsequently been improved. However, efficiency remains poor, with practical cell efficiencies around 25%, low compared to other types of fuel cell. The interest in liquid fuel based fuel cells has also extended to ethanol and direct ethanol fuel cells are also under development. The DMFC cell reaction combines reformation of methanol in the presence of water to generate hydrogen at anode and then the anode reaction of a conventional hydrogen fuel cell. This can be expressed in the two following equations:

CH3OH + H2O = CO2 + 6H

H = H+ + e-

The first one represents the reforming of methanol to generate hydrogen with the production of gaseous carbon dioxide, second one is hydrogen atoms generated in first reaction releasing electrons to form hydrogen ions that then migrate through the electrolyte to the cathode, at cathode the cell is supplied with the oxygen from air and oxygen subsequently reacts at the electrode to generate water, in stationary application a DMFC will operate at a relatively higher temperature up to 130 degrees centigrade and the water generated at the cathode will simply be swept away with the air as water vapor. For portable applications, however, it is important to try and recover this water and return it to anode of the cell for recycling through the cell, this will allows pure methanol fuel supply. Active water recycling systems are relatively complex, adding to the cost of the cells, and research is directed at finding passive methods for recycling water between the cell electrodes.

The membrane electrolyte for the DMFC is an acidic polymer membrane similar to that used in PEM fuel cell, saturated with water, the anode is made from a mixture of carbon and ruthenium deposited on to a carbon support that can then be printed on to the membrane while the cathode is platinum on carbon. One of the problem with DMFC is diffusion of methanol through the electrolyte from anode to cathode where it can react to produce carbon monoxide which will poison the cathode catalyst, it should be able to reach efficiency of 40% but practically it is 25%, this may not be a problem for portable applications provided the cell is cheap enough but would probably be too low for large stationary applications, cell life time is 1000 hours and it is problematic one.

These having the advantages to use in portable power supplies such as laptop computers, mobile phones where they can provide a higher energy density and more power from a single charge of methanol than most batteries. Main disadvantage is DMFC release a carbon dioxide during their operation in the same way as a fossil fuel releases.

PHOSPHORIC ACID FUEL CELLS (PAFC):

The phosphoric acid fuel cells are among the technologies of most promising fuel cells, and it is expected to be commercialized in next few years, this is because these cells posses several characteristics such as high durability, low operating temperature and low cost electrolyte and the disadvantage is that low power density and its electrolyte is a liquid acid, the operating temperature of PAFC is between 200-220 degrees centigrade, the water produced be eliminated in the form of steam, are low for the steam can be used in thermal machines for generating more electricity which would increase the efficiency of the system. The efficiency of this type of cell is around 40%, but in combined heat and power cycles, the efficiency of the system can reach 85%, this cell also tolerates carbon monoxide poisoning when the concentration is above 1%, despite lower operating temperature, the anode is made of material formed by carbon graphite supported platinum, at anode, hydrogen gas, with the help of platinum catalyst, free electrons and H+ ions, as

$$H2 = 2H+ + 2e-$$

The material that makes up the cathode is carbon supported platinum, at cathode the electrons from the anode, which arrive through an external circuit, react with O2 and forming the ion of oxygen, it is also in the cathode that the H+ ions from the anode, arriving through electrolyte, react with the oxygen ions to form water.

$$O2 + 2e- = O22-$$

$$2H+ + 1/2O22- = H2O$$

The electrolyte of this cell is formed by concentrated phosphoric acid, which is confined in a solid polymer matrix, the silicon carbide, which is a porous structure, which allows the H+ ions to travel through the electrode from the anode to the cathode.

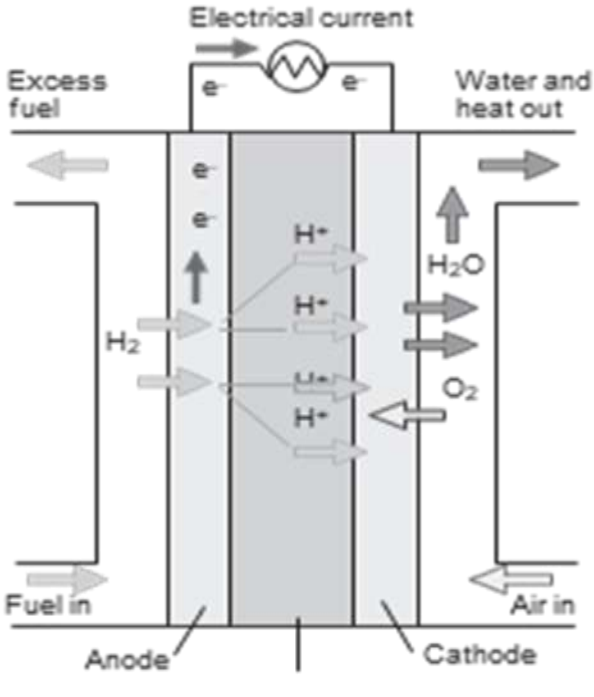


FIG: PHOSPHORIC ACID FUEL CELL source: united states energy

These cells are connected in series to each other through bipolar plates, forming a pile. Bipolar plates also have the channels of gases that will be removed from cells, the exhausted gas temperature of this cell allows it to be powered by natural gas, and its steam is used in natural gas reform, the PAFC are manufactured for stationary power generation, with modules that provide power in the range of 50-400 KW, most of them having the reformer to be fueled with natural gas.

SOLID OXIDE FUEL CELLS (SOFC):

The solid oxide fuel cell (SOFC) is the second major high temperature fuel cell under development. It is unique among fuel cells for having a solid electrolyte, making it potentially the most robust of all fuel cells. The electrolyte is usually made from zirconium oxide, ZrO2, zirconia. When traces of other oxides such as yttrium, calcium, or magnesium oxide are added to the zirconia, it becomes capable of conducting oxygen ions but it is significant at 1000 degrees centigrade, the cell reaction in the SOFC involves that also between hydrogen and oxygen producing water, the solid oxide that forms the cell electrolyte is an electrical insulator so electrons cannot pass through it, at the cell operating temperature it will allow oxygen ions but not hydrogen ions to pass. It is this oxygen ion conductivity that permits the fuel cell to operate. In operation, molecular oxygen is delivered to the cathode of the cell where it dissociates and takes up electrons to produce oxygen ions that migrate through the electrolyte to the anode. Hydrogen is delivered to the anode where it too dissociates, releasing electrons to the external circuit and leaving hydrogen ions that reacts with the migrating oxygen ions to produce water, at the elevating operating temperature this water is produced as vapor that is swept away in the fuel gas stream.

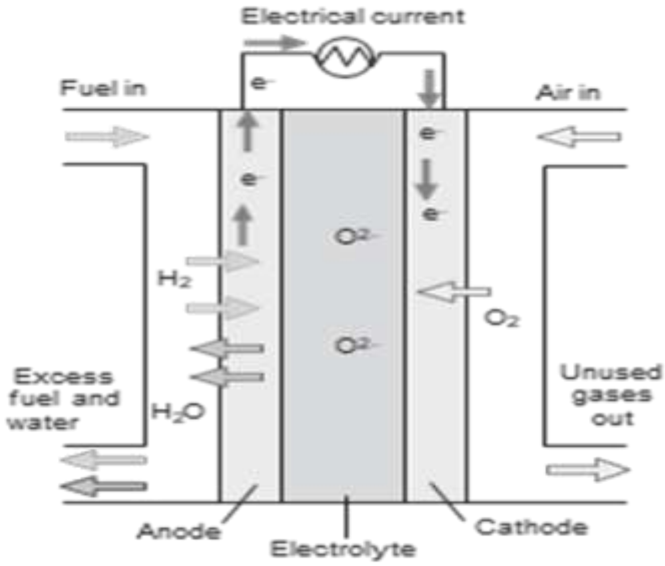


FIG: SOLID OXIDE FUEL CELL source: united states department of energy

The electrolyte used in the SOFC is very thin, a thickness of around 100 microns is common but they may be as thin as 10 microns, electrons must be bonded to the electrolyte layers and these also serve as a support structure to give the cell strength. Since the cell operating temperature is too high, the different materials used in cell construction must be carefully designed to have the same coefficient of expansion, otherwise the cell would crack apart as it was heated.

The solid electrolyte requires extremely high operating temperature to facilitate oxygen ion conductivity, the most common zirconia-based electrolytes must be heated above 800 degrees centigrade to ensure they are adequate for cell operation. Newer materials may be able to provide sufficient conductivity at a much lower temperature. However, the temperature needs to remain around 600 degrees centigrade to allow reforming of natural gas to take place within the cell, the high temperature means that no electrode catalyst is necessary to facilitate generation of hydrogen and oxygen atoms at the electrodes, the anode is normally made from metallic nickel dispersed in a ceramic matrix that is un reactive toward hydrogen and the cathode is made from a conductive oxide that will not react with oxygen, reformation of natural gas into hydrogen can take place directly on the nickel anode. The major attraction of the SOFC is the robust nature of its electrolyte that is expected to confer extremely long life times, operating lives of 20 years or more are achievable.

MOLTEN CARBONATE FUEL CELLS (MCFC):

Molten carbonate fuel cell is a type of fuel cell that works at high temperatures making it important in the energy scenario for two main reasons. One is that this cell can be fueled by natural gas, and it is not necessary to have hydrogen gas, another reason is that the exhaust gas is also at high temperatures and can therefore be designed for various purposes, increasing the total efficiency of the system. The operating temperature of this type of cell is between 600-700 degrees centigrade, allowing natural gas feeding, which inside the cell undergoes a chemical reaction called steam reforming. The reform is the reaction of water vapor with natural gas, producing hydrogen and carbon dioxide or producing carbon monoxide and hydrogen

$CH4+2H2O=CO2+4H2$

$CH4+H20=CO+3H2$

Carbon monoxide molecules react with water vapor, called the shift reaction, producing more hydrogen and carbon dioxide, according to,

$CO+H2O=CO2+H2$

In addition to these reactions that happen with natural gas, within the cell occur oxidation-reduction reactions that produce water in the form of steam, carbon dioxide, heat, and electric energy generation, this cell the anode is composed of an alloy of nickel and chromium, at anode the reaction is,

$H2+CO3- = CO2+H20+2e-$

The cathode of this cell composed of nickel oxide, which is quite thinner than the anode, at cathode the reaction is,

$O2+CO2+2e- = CO3-$

This cell electrolyte is composed of 68% Li2CO3 and 32% of K2CO3 and has the function of allowing the carbonate ions that originate from the cathode to reach the anode. In addition, it prevents the fuel from reacting directly with the oxidant, because the molten carbonate fuel cells operate at high temperatures, these applications are related to the stationary power generation of a large scale, around 30-60 MW. They are suitable to generate energy for industries and for distributed power generation.

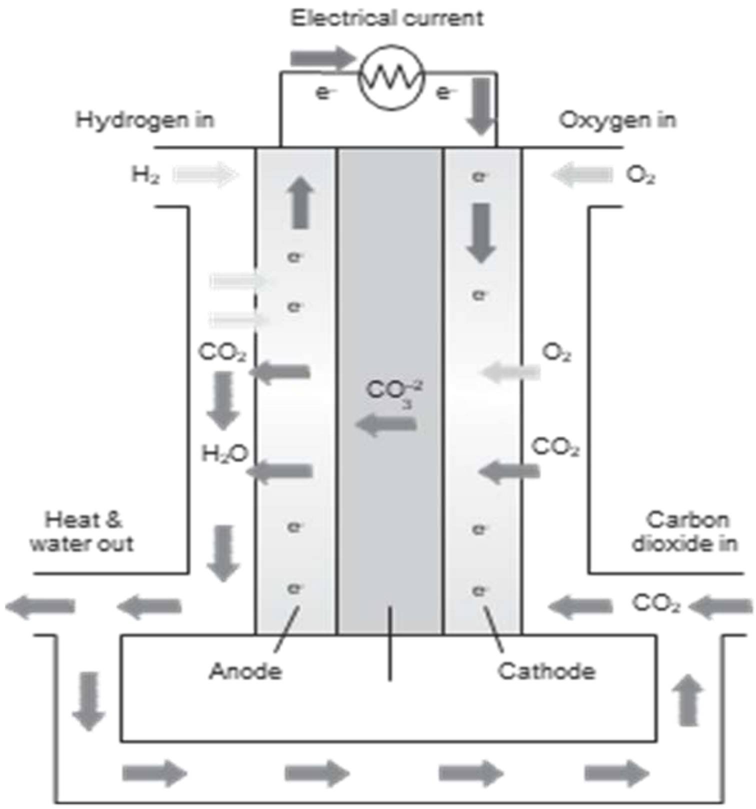


FIG: MOLTEN CARBONATE FUEL CELL

This cell can reach efficiencies around 60%, but when the heat generated is used in a combined cycle, this system can achieve the efficiency of 85%, the exhaust water vapor goes out at a higher temperature allowing these cell to be manufactured in combined cycles of electrical energy and heat cogeneration, the heat can be destined, for example, to industrial process that require warm water, steam turbines, which use this heated water vapor for electric energy generation, substantially increasing the efficiency of the system.

APPLICATIONS AND CURRENT DEVELOPMENTS OF HYDROGEN FUEL CELLS:

The main reason for hydrogen fuel cell technology development is due to its flexibility, these fuel cells are seen by many commentators as a solution to a whole range of environmental challenges, such as global warming and harmful levels of local pollutants, for instance those from cars in urban environment. Fuel cells found use in transport from bicycles to spacecraft and can be used to power devices as small as a mobile phone or to provide a electricity to a factory.

TRANSPORT APPLICATIONS:

The automotive market is highly regulated particularly in terms of its environmental impact, in fact, almost all gasoline all gasoline engine improvements have been made because of forcing legislation, which has required technical alternations to be made. Driving forces for further improvement in automotive technology continue to exist. Local emissions of pollutants, global warming and national energy security are the three most important. Fuel cells can provide solutions to all of these issues and currently appear to be an attractive proposition, perhaps alongside other innovations such as hybrid electric vehicles.

In technical terms PEMFCs dominate in transport, in part of their dominance is simply because of the large number of companies engaged in PEMFC development for this sector but, on a more fundamental level, such fuel cells have the high energy density required to meet the space constraints in a light duty vehicle. A low operating temperature should also lead to quick start up and shut down, the tolerance of PEMFC to the presence of carbon dioxide is also attractive. Even though these technologies still has several technical difficulties such as sensitivity to poisoning by other chemicals, water management and start up for temperatures below freezing, one possible side effect of this concentrated automotive research into PEMFC is that costs may be reduced more quickly than for the other types of fuel cell. BMW is one company that has already examined this technology in prototype vehicles.

PORTABLE PRODUCTS:

The market drivers for fuel cells in the portable sector are very different to those for transportation. Here, environmental issues are not the key driver and the main advantages of fuel cells are, instead, potential long run times and high energy density and storage, which allow portable electronic devices to function for longer periods than those with batteries.

In terms of fuel cell type, portable applications promise to be one of the battle grounds between the different technologies, in this sector both PEMFC and DMFC are being investigated, DMFCs distinct advantage is the comparative ease of refueling. A variety of electrical products could benefit from the use of fuel cells, but laptop computers appear likely to be one of the first consumer markets, outside military applications which are able to bear higher costs.

LARGE SCALE POWER GENERATION:

Many of the fuel cells commercially sold have been used for multi kilowatt power generation, such as 200 KW PC25 units produced by UTC fuel cells. To date, phosphoric acid fuel cell technology has taken the major share of the market, but MCFC, PEMFC and SOFC units have all also been demonstrated and these technologies are more likely to meet the criteria for mass market acceptance, particularly cost, than PAFC. At higher power, perhaps above 250 KW, MCFCs and SOFCs are more likely to be adopted, due to their higher overall efficiencies.

In both large and small scale power generation, the selling point of the fuel cell is much more variable than, for example, in the portable and transportation sector. In general, though, distributed generation rather than centralized electrical power generation is the key selling point. This allows the supply of both heat and power together, which makes best use of fuel cell efficiency.

OVERALL INDUSTRY REQUIREMENTS:

There is a competition between the different types of fuel cell in many of the individual market segments. Which will be adopted should depend on meeting the requirements of the customer, whether that is manufacturer of a product or its end user. In part, these requirements will be for specific performance targets, such as power density and efficiency, which are difficult to forecast. A fueling infrastructure also has to be in place whether, for example, to supply methanol in cartridges for mobile phones or sulfur free natural gas for residential power generation.

3. CONCLUSIONS

Fuel cells are being seen increasingly as an enabling technology for a number of environmentally friendly energy resources. Large scale power generation using MCFC and SOFCs coupled with sequestration of carbon dioxide has attracted attention. Other projects look to renewable energy like wind or solar power to provide hydrogen through electrolysis. This hydrogen could then be stored and used as required in fuel cells and thus, allow renewable sources to provide power around the clock. This explicit linking of fuel cells to renewable energy will help to drive the market forward. The development of fuel cells is also gained momentum over the last few years, with an increase in interest from governments and a higher profile in terms of public interest.

Hydrogen is potentially a great substitute for fossil fuels in the future. The automobile industry is already developing hydrogen vehicles in order to reduce carbon foot print in urban areas. In this work the review was made analyzing the impacts on the environment as well as the economical and the technological viability of hydrogen use in internal combustion engines and fuel cells, contemplating the all the phases of the life cycle, from the production to its use as a fuel.

The final considerations of this summary can be summarized as follows:

- The best hydrogen production process is the simplest lowest cost and environ mentally benign. The viability of production methods depends on more expressive results and greater advances.
- Hydrogen storage techniques are at various stages of development, but do not present an experimental result that can fully meet the requirements, this is the most challenging difficulty faced in making the hydrogen economy viable.
- The transportation that needs a lot of care, the viability of the hydrogen transport methods depends on the feasibility of the efficient storage.
- By Considering the efficiency and cost of the hydrogen fuel cell and also the customer requirements the type of the fuel cell can be adapted and out of six major types which one have more advantageous that can be adapted on board vehicles.
- The fuel cells still have higher cost and do not show up now a good durability and reliability.

Vehicles running with batteries achieve ranges up to 200 km but hydrogen powered vehicles having higher ranges but there is no refuel network today. This is the challenging situation facing today but in future it will overcome to reduce environmental pollution and thereby safe using of hydrogen fuel cell vehicles. IRJET sample template format ,Conclusion content comes here. Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here Conclusion content comes here . Conclusion content comes here

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