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Feasibility of Hydrogen-Wire Car in Near Future

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Abstract

The depletion of fossil fuels encouraged the exploration of alternate source of energy. Hydrogen has emerged as a clean energy technology with the advantages of formation of harmless by products. This paper addresses the utilization of hydrogen gas in running vehicles, mostly cars. Hydrogen is provided as a fuel for running cars. As in this system, all the mechanical links are eliminated, so this is termed as hydrogen-wire car. The main advantage of using this system is that this is a environmental friendly, exhausting no harmful emissions. Mostly, proton exchange membrane (PEM) fuel cells have gained much attention over the last few decades as a promising Hydrogen producing source. This study mainly concerns with the design of a hydrogen-wire system and its feasibility..

Keywords: *Hydrogen, hydrogen-wire cars, PEM (proton exchange membrane)*

1. Introduction

Until now, the growing energy requirement is primarily being satisfied with the fossil fuel reserves. These fuels are harmful for the environment as it emits greenhouse gasses; also their reserves are diminishing day by day. So, energy security has become major concern in order to provide a safe, clean, secure, and reliable energy [1][2]. The main area of the fuel consumption, automobiles, is therefore working towards the direction of switching the conventional fuels with other available options. One of the recent areas of research for them is the applicability of hydrogen fuel in automobiles. No doubt hydrogen-wire solves many problems related to conventional energy sources for automobiles, but it still has certain limitations [3][4]. So, this study is mainly concerns with understanding the design of hydrogen-wire cars and also we will try to investigate the feasibility of utilizing this system and to find out whether it is possible to run the vehicle produced from the Hydrogen fuel cell using Proton Exchange Membrane (PEM) fuel cells that govern hydrogen wire system. The detailed working of the PEM fuel cells are given in the upcoming section. We begin with understanding the difference in the car using conventional fuels and a hydrogen-wire car system. The two basic components explaining the car design and internal combustion engine are mechanical & hydraulic linkages. The defining characteristic of the hydrogen-wire system is that it does not have abovementioned two elements, i.e engine and linkages. In the system, a fuel cell stack and a wire system is present instead of engine & mechanical & hydraulic linkages respectively. An US based automobile company; General Motors developed the concept of hydrogen-wire cars before anyone. The shape of this system is like a skateboard, which consists of only chassis and does not own any body. There is no hydraulic and mechanical linkage because of the wire system concept. Moreover, to control the system a computer is installed under the chassis.

Fuel Cell is an example of electrochemical device that generates electricity by converting chemical energy in a fuel directly into electrical energy. The electricity produced by the fuel cells can differ in the range of only a few watts for tiny devices, right up to large

power plants generating megawatts. A fuel cell can run for an unspecified time period, as long as it is supplied with a source of hydrogen and a source of oxygen (usually air). Oxidation & reduction electrochemical reactions occur inside the fuel cell, generating heat and low-voltage current. The former is wasted however the latter is used to do useful work.

1.1. PEM fuel cells

The PEMFC or proton exchange membrane fuel cell is a frequently used fuel cell that utilizes a proton exchange membrane as electrolyte. Its working temperature is around 82 degree C and efficiency is around 45 to 55 percent. The working principle of a PEMFC is described as: fuel hydrogen is oxidised releasing electrons & generating protons at the anode. The protons & electrons move through the external circuit & through proton exchange membrane placed closely in the middle of anode & cathode, respectively, they merge at the cathode with the liquified oxidant oxygen to release water along with heat [5][6].
PEFCs are being follwed for a large variety of applications, mainly for powering fuel cell vehicles (i.e. FCVs). Due to much concern in fuel cell vehicles & hydrogen, the investment in PEFC over the past few decade surpasses all other kinds of fuel cells together. Although notable growth of PEFC for immobilized applications has been developed, many researchers now concentrate on automotive & portable applications.

1.2. Components of PEM fuel cells

PEM fuel cell composed of bipolar plates and membrane electrode assembly (generally termed as MEA) as represented in figure 1. The cell is connected in series in the fuel cell pile using bipolar separator/collector. The Bipolar separator/collector also divides the gases in different adjacent cell. It is generally composed of two families of material i.e. graphite composite & metallic. Generally, MEA is made up of a Polymer Electrolyte Membrane (PEM), catalyst layers, & Gas Diffusion Layers (GDL).

- Gas diffusion layer is a porous material made by pressing carbon fibres altogether in a carbon paper (Toray, Sigracet). It is used in transportation & distribution of heat & fluids between bipolar plate gas channels & the catalyst layer. GDL also transport electrons from and to bipolar plates. Now a days, a micro porous layer and hydrophobic treatment (PTFE) is made with GDL for the distribution of the fluids moreover in the layers of catalyst.

- The electrochemical reaction occurs in the catalyst layer. There protons, electrons & oxygen electrochemically react & generate water along with heat. Platinum (Pt) is commonly used catalyst for the PEM fuel. The availability & the size of the active area of catalyst plays an important role rather than the amount of the catalyst. Therefore, researchers reduced the volume of platinum from 5 mg/cm2 to 0.5 mg/cm^2 to reduce the overall price.

- To split the anode side from the cathode side a membrane is used. Simultaneously, it helps in the transport of proton from anode side to cathode side. The membrane is fabricated from perfluorosulfonic acid ionomer (PSA). Teflon-like material known as Nafion is the best membrane as it gives dimensional stability along with mechanical strength & proton conductivity. Electro-osmotic drag along with permeation & diffusion mechanisms govern the

water transportation in the membrane assembly. The electro-osmotic pull helps in the transport of water from anode side to cathode side, as a result of proton transfer mechanism. However, the diffusion & permeation (depending on concentration difference) can transport water from any of the sides to the other.

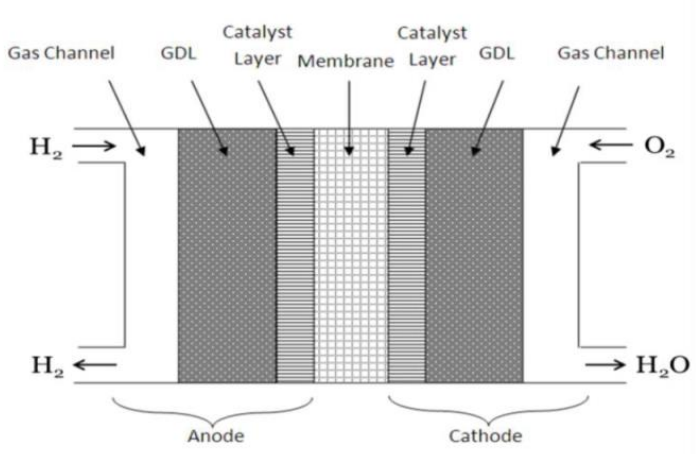

Figure 1. Components of Fuel Cells

1.3. Working of PEM fuel cell

The general diagram of PEM cell is represented in figure 1. Anode of PEM cell is fed up with hydrogen gas, which passes over GDL to anodic catalytic layer for oxidation, ensuring proton transfer between proton exchange membrane & transfer of electron between an external electrical circuit. Simultaneously, the cathode is fed up with the oxygen & merges with the protons to be transformed to water. The reactions at anode & cathode along with the complete cell reaction are:

Anode: $2\ H_2 \longrightarrow 4\ H^+ + 4\ e^-$ (i)

Cathode: $O_2 + 4\ H^+ + 4\ e^- \longrightarrow 2\ H_2O$ (ii)

Complete Reaction:

$O_2 + 2\ H_2 \longrightarrow 2\ H_2O$ + heat + electrical energy

2. Designing A Hydrogen-Wire Car

Figure 2 shows the schematic of a hydrogen-wire car. Major components of hydrogen-wire car system

1. Fuel cell pile
2. By-wire structure
3. Hydrogen storage tank
4. Wheel hub motor
5. Battery
6. Electric motor

The main controlling unit of a hydrogen-wire car is the central computer kept in the middle of the chassis. It control three important function a) Motor control for varying speed, b) Steering control for maneuvering the vehicle, c) Break control for slowing the car.

Fuel-cell pile, comprised of hundreds of individual cell, is utilized as the power source of the vehicle. The pile provides 129 KWs at peak power and 94 KWs of continuous power. A significant environment change can be brought by using the concept of hydrogen-wire car in automobile industries.

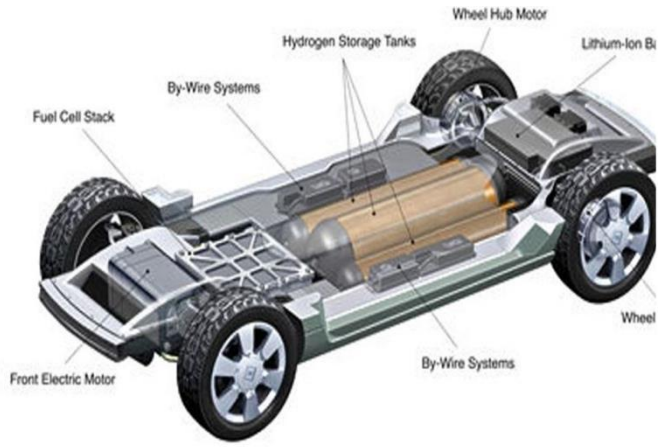

Figure 1. Schematic view of hydrogen-wire car

3. Design

The hydrogen-wire cars are driven by hydrogen fuel cell system; revamping the conventional layout of the vehicle. Mechanical linkage & single electric motor are designed into a plane skateboard arrangement without any conventional engine block . This helps in lowering the C.G. of car, but more basically to systematize vehicle's drive train systems. The skateboard contains all motion and power storage systems, thus passenger's compartment can be designed easily by the researchers. This permits a modular vehicle layout of high flexibility which can be managed on the same drive structure, with the shape of the upper body of car & the position of seats being the only difference. The skateboard consists of crumple zones that are nearly same as that of conventional automobiles.

Major components of hydrogen-wire car system

1. Fuel cell stack
2. By-wire system
3. Hydrogen storage tank
4. Wheel hub motor
5. Battery
6. Electric motor

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4. Advantages Of Hydrogen-Wire Cars

When compared with the conventional fuel cars, the major advantage of using hydrogen-wire car is that it does not require the diminishing fossil fuels; also the by-product of using the hydrogen fuel is water, which is a boon for the environment by saving it from the toxic emissions. This car has better fuel efficiency corresponding to distance per gallons. Moreover, contrasting the process of combustion of fossil fuels, the electrochemical reactions of the fuel cells is almost silent. Additionally, hydrogen-wire cars are easy to maintain.

5. Limitations of hydrogen-wire cars

Although hydrogen-wire cars have several advantages, still this vehicle is in the dark ages. Very little information is available about the feasibility of this system. Some of the limitations of this system are that it is an expensive vehicle, unavailability of hydrogen fueling station, which distribute hydrogen. When compared with the permanence of conventional engines, fuel cell systems are hugely deficient in strong durability. This system has l**ow Reliability**.

6. Feasibility of hydrogen-wire cars

Hydrogen cars are assumed to be a fine linking between vehicle using fossil fuels & full electric due to:

- Hydrogen cleaner solution than fossil fuels
- It can be fueled like we do with a gasoline or diesel powered car
- Hydrogen car mileage is likely to be more adequate than the mileage obtained from batteries car
- Hydrogen fuel cells are considered not to erode as soon as batteries

However, all this future will remain in theory, if we can't deal with the cost issues. By improvising the safety & efficiency of the fuel cell, we can transform this theory from paper to practice. Some of the suggestions by us are as follows:

1) Using proper storage for hydrogen
2) Installation of some absorbent system in the car
3) Increasing the efficiency of the system by using lighter material in car designing
4) Increasing the durability of the car so that minimum fueling is required.

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7. Conclusion

Aiming to move beyond the conventional fossil fuel car and towards a computerized, environmentally friendly alternative, this paper reported the major issue impacting the feasibility of hydrogen-wire cars and its durability. From this study, it is evident that it is desirable to use hydrogen-wire vehicle in the near future because of its better fuel efficiency and eco-friendly nature. Benefit of using hydrogen-wire car is that it reduces the dependency on conventional fuels and it has no mechanical and hydraulic linkages. This system has certain limitations which prevent the global use of this technology. However we have provided some suggestions through which it is feasible to see a running hydrogen-wire car. This paper also discussed the detailed barriers to hydrogen-wire cars and the technical targets to meet these challenges in order to guide the development of this technology.

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