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Hydrogen Operated Internal Combustion Vehicle

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Abstract- Now a days in every country like India we have a scarcity of fossil fuels. A hydrogen vehicle is a vehicle that uses hydrogen as its onboard fuel for motive power. Hydrogen vehicles include hydrogen fueled space rockets, as well as automobiles and other transportation vehicles. The credential part of this paper gives the theoretical application of hydrogen cells in vehicles of the modern century for lower emissions and higher efficiency. As the quantity of fossil fuels are very limited that is why we need an alternative source of energy or the fuels so we can save the fossils fuels for our future generation and the hydrogen.

Index Terms- fuel cell, trams, Plug-in hybrid, Natural gas vehicle, fuel cell bus, PHB (bicycle)

I. INTRODUCTION

The power plants of such vehicles convert the chemical energy of hydrogen to mechanical energy either by burning hydrogen in an internal combustion engine, or by reacting hydrogen with oxygen in a fuel cell to run electric motors. Widespread use of hydrogen for fueling transportation is a key element of a proposed hydrogen economy. Hydrogen fuel does not occur naturally on Earth and thus is not an energy source; rather it is an energy carrier. As of 2014, 95% of hydrogen is made from methane. It can be produced using renewable sources, but that is an expensive process. Integrated wind-to-hydrogen (power to gas) plants, using electrolysis of water, are exploring technologies to deliver costs low enough, and quantities great enough, to compete with traditional energy sources.

The drawbacks of hydrogen use are high carbon emissions intensity when produced from natural gas, capital cost burden, low energy content per unit volume, low performance of fuel cell vehicles compared with gasoline vehicles, production and compression of hydrogen, and the large investment in infrastructure.

II. HYDROGEN VEHICLES

1. Automobiles

Many companies are working to develop technologies that might efficiently exploit the potential of hydrogen energy for use in motor vehicles. As of November 2013 there are demonstration fleets of hydrogen fuel cell vehicles undergoing field testing including the Chevrolet Equinox Fuel Cell, Honda FCX Clarity, Hyundai ix35 FCEV and Mercedes-Benz B-Class F-Cell.

Toyota launched its first production fuel cell vehicle, the Toyota Mirai, in Japan at the end of 2014 and began sales in California, mainly the Los Angeles area, in 2015. The car has a range of 312 mi (502 km) and takes about five minutes to refill its hydrogen tank. The initial sale price in Japan was about 7 million yen ($69,000). Former European Parliament President Pat Cox estimates that Toyota will initially lose about $100,000 on each Mirai sold.

Fig:-1TheChevrolet Sequel hydrogen fuel cell-powered concept SUV vehicle

Many automobile companies have been researching the feasibility of commercially producing hydrogen cars, and some have introduced demonstration models in limited numbers (see list of fuel cell vehicles). Since 1980, car companies have made numerous predictions about the commercialization of FC vehicles. At the 2012 World Hydrogen Energy Conference, Daimler AG, Honda, Hyundai and Toyota all confirmed plans to produce hydrogen fuel cell vehicles for sale by 2015. Charles Freese, GM's executive director of global powertrain engineering, stated that the company believes that both fuel-cell vehicles and battery

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electric vehicles are needed for reduction of greenhouse gases and reliance on oil. The use of hydrogen as fuel in an automobile is problematic because of hydrogen's low density

In 2012, Lux Research, Inc. issued a report that stated: "The dream of a hydrogen economy ... is no nearer." It concluded that "Capital cost, not hydrogen supply, will limit adoption to a mere 5.9 GW" by 2030, providing "a nearly insurmountable barrier to adoption, except in niche applications". Lux's analysis concluded that by 2030, the PEM stationary market will reach $1 billion, while the vehicle market, including automobiles and forklifts, will reach a total of $2 billion.

2. Buses

Fig:-2Toyota FCHV-BUS at the Expo 2005.

Fuel cell buses (as opposed to hydrogen fueled buses) being trialed by several manufacturers in different locations. The Fuel Cell Bus Club is a global fuel cell bus testing collaboration.

Hydrogen was first stored in roof mounted tanks, although models are now incorporating onboard tanks. Some double deck models use between floor tanks.

Tata Motors and ISRO have already developed a hydrogen bus which is being tested in India. The bus is expected to get on road in 2015.

Trams

In March 2015, China South Rail Corporation (CSR) demonstrated the world's first hydrogen fuel cell-powered tramcar at an assembly facility in Qingdao. The chief engineer of the CSR subsidiary CSR Sifang Co Ltd., Liang Jianying, said that the company is studying how to reduce the running costs of the tram. A total of 83 miles of tracks for the new vehicle have been built in seven Chinese cities. China plans to spend 200 billion yuan ($32 billion) over the next five years to increase tram tracks to more than 1,200 miles.

Bicycles

Fig:-3PHB (bicycle)

Hydrogen Bicycle

Pearl Hydrogen Power Sources of Shanghai, China, unveiled a hydrogen bicycle at the 9th China International Exhibition on Gas Technology, Equipment and Applications in 2007.

III. OVERVIEW ON HYDROGEN VEHICLES

1. Internal Combustion Vehicle

Main articles: Hydrogen internal combustion engine vehicle and List of hydrogen internal combustion engine vehicles.

Hydrogen internal combustion engine cars are different from hydrogen fuel cell cars. The hydrogen internal combustion car is a slightly modified version of the traditional gasoline internal combustion engine car. These hydrogen engines burn fuel in the same manner that gasoline engines do; the main difference is the exhaust product. Gasoline combustion results in carbon dioxide and water vapour, while the only exhaust product of hydrogen combustion is water vapour.

In 1807 Francois Isaac de Rivaz designed the first hydrogen-fueled internal combustion engine. In 1970 Paul Dieges patented a modification to internal combustion engines which allowed a gasoline-powered engine to run on hydrogen US 3844262.

Mazda has developed Wankel engines burning hydrogen. The advantage of using ICE (internal combustion engine) like Wankel and piston engines is the cost of retooling for production is much lower. Existing-technology ICE can still be applied for solving those problems where fuel cells are not a viable solution insofar, for example in cold-weather applications.

HICE forklift trucks have been demonstrated based on converted diesel internal combustion engines with direct injection.

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IV. FUEL CELL

1. Fuel Cell Cost

Hydrogen fuel cells are relatively expensive to produce, as their designs require rare substances such as platinum as a catalyst .The U.S. Department of Energy (DOE) estimated in 2002 that the cost of a fuel cell for an automobile (assuming high-volume manufacturing) was approximately $275/kW, which translated into each vehicle costing an estimated 100,000 dollars. However, by 2010, DOE estimated the cost had fallen 80% and that automobile fuel cells might be manufactured for $51/kW, assuming high-volume manufacturing cost savings.

The projected cost, assuming a manufacturing volume of 500,000 units/year, using 2012 technology, was estimated by the DOE to be $47/kW for an 80 kW PEM fuel cell. Assuming a manufacturing volume of 10,000 units/year, however, the cost was projected to be $84/kW using 2012 technology. The Department of Energy wrote: "Hydrogen fuel cells for cars have never been manufactured at large scale, in part because of the prohibitive price tag. But the DOE estimates that the cost of producing fuel cells is falling fast".

In 2014, Toyota said it would sell its Toyota Mirai in Japan for less than $70,000 by April 2015and that it has brought the cost of the fuel cell system down to 5 percent of the fuel cell prototypes of the last decade. Former European Parliament President Pat Cox estimates that Toyota will initially lose about $100,000 on each Mirai sold.

2. Freezing Conditions

The problems in early fuel cell designs at low temperatures concerning range and cold start capabilities have been addressed so that they "cannot be seen as show-stoppers anymore"Users in 2014 said that their fuel cell vehicles perform flawlessly in temperatures below zero, even with the heaters blasting, without significantly reducing range.

3. Service Life

The service life of fuel cells is comparable to that of other vehicles. PEM service life is 7,300 hours under cycling conditions.

V. HYDROGEN

Hydrogen does not come as a pre-existing source of energy like fossil fuels, but is first produced and then stored as a carrier, much like a battery. A suggested benefit of large-scale deployment of hydrogen vehicles is that it could lead to decreased emissions of greenhouse gases and ozone precursors. However, as of 2014, 95% of hydrogen is made from methane. It can be produced using renewable sources, but that is an expensive process. Integrated wind-to-hydrogen (power to gas) plants, using electrolysis of water, are exploring technologies to deliver costs low enough, and quantities great enough, to compete with traditional energy sources. According to Ford Motor Company, "when FCVs are run on hydrogen reformed from natural gas using this process, they do not provide significant environmental benefits on a well-to-wheels basis (due to GHG emissions from the natural gas reformation process)." While methods of hydrogen production that do not use fossil fuel would be more sustainable, currently renewable energy represents only a small percentage of energy generated, and power produced from renewable sources can be used in electric vehicles and for non-vehicle applications.

The challenges facing the use of hydrogen in vehicles include production, storage, transport and distribution. The well-to-wheel efficiency for hydrogen is less than 25%. A study sponsored by the U.S. Department of Energy said in 2004 that the well-to-wheel efficiency of gasoline or diesel powered vehicles is even less.

1. Production

The molecular hydrogen needed as an on-board fuel for hydrogen vehicles can be obtained through many thermo chemical methods utilizing natural gas, coal (by a process known as coal gasification), liquefied petroleum gas, biomass (biomass gasification), by a process called thermolysis, or as a microbial waste product called bio hydrogen or Biological hydrogen production. 95% of hydrogen is produced using natural gas, and 85% of hydrogen produced is used to remove sulfur from gasoline. Hydrogen can also be produced from water by electrolysis or by chemical reduction using chemical hydrides or aluminum. Current technologies for manufacturing hydrogen use energy in various forms, totaling between 25 and 50 percent of the higher heating value of the hydrogen fuel, used to produce, compress or liquefy, and transmit the hydrogen by pipeline or truck.

Environmental consequences of the production of hydrogen from fossil energy resources include the emission of greenhouse gases, a consequence that would also result from the on-board reforming of methanol into hydrogen. Analyses comparing the environmental consequences of hydrogen production and use in fuel-cell vehicles to the refining of petroleum and combustion in conventional automobile engines do not agree on whether a net reduction of ozone and greenhouse gases would result. Hydrogen production using renewable energy resources would not create such emissions or, in the case of biomass, would create near-zero net emissions assuming new biomass is grown in place of that converted to hydrogen. However the same land could be used to create Biodiesel, usable with (at most) minor alterations to existing well developed and relatively efficient diesel engines. In either case, the scale of renewable energy production today is small and would need to be greatly expanded to be used in

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producing hydrogen for a significant part of transportation needs. As of December 2008, less than 3 percent of U.S. electricity was produced from renewable sources, not including dams. In a few countries, renewable sources are being used more widely to produce energy and hydrogen. For example, Iceland is using geothermal power to produce hydrogen, and Denmark is using wind.

2. Storage

Fig:-4Compressed hydrogen storage mark

Hydrogen has a very low volumetric energy density at ambient conditions, equal to about one-third that of methane. Even when the fuel is stored as liquid hydrogen in a cryogenic tank or in a compressed hydrogen storage tank, the volumetric energy density (megajoules per liter) is small relative to that of gasoline. Hydrogen has a three times higher specific energy by mass compared to gasoline (143 MJ/kg versus 46.9 MJ/kg). Some research has been done into using special crystalline materials to store hydrogen at greater densities and at lower pressures. A recent study by Dutch researcher Robin Gremaud has shown that metal hydride hydrogen tanks are actually 40 to 60-percent lighter than an equivalent energy battery pack on an electric vehicle permitting greater range for H2 cars. In 2011, scientists at Los Alamos National Laboratory and University of Alabama, working with the U.S. Department of Energy, found a new single-stage method for recharging ammonia borane, a hydrogen storage compound.
Hydrogen storage is a key area for the advancement of hydrogen and fuel cell power. An article discussing the issue of storage states, "Alternatives to large storage tanks may be found in hydrides, materials that can absorb, store, and release large quantities of hydrogen gas. More work and development needs to be performed with hydrides before they are of practical use". Some other options available for hydrogen fuel cells storage include: High pressure tanks and cryogenic tanks. Both of which strive to improve volumetric capacity, conformability, and cost of storage. The DOE's efforts on this matter have focused on on-board vehicular hydrogen storage systems that will allow for a driving range of 300+ miles while meeting all requirements in order to stay competitive with current means of transportation.

3. Infrastructure

Fig:-5 Hydrogen fueling

The hydrogen infrastructure consists mainly of industrial hydrogen pipeline transport and hydrogen-equipped filling stations like those found on a hydrogen highway. Hydrogen stations which are not situated near a hydrogen pipeline can obtain supply via hydrogen tanks, compressed hydrogen tube trailers, liquid hydrogen tank trucks or dedicated onsite production.

Hydrogen use would require the alteration of industry and transport on a scale never seen before in history. For example, according to GM, 70% of the U.S. population lives near a hydrogen-generating facility but has little access to hydrogen, despite its wide availability for commercial use. The distribution of hydrogen fuel for vehicles throughout the U.S. would require new hydrogen stations that would cost, by some estimates approximately 20 billion dollars and 4.6 billion in the EU. Other estimates place the cost as high as half trillion dollars in the United States alone.

The California Hydrogen Highway is an initiative to build a series of hydrogen refueling stations along California state highways. As of 2013, 10 publicly accessible hydrogen filling stations were in operation in the U.S., eight of which were in Southern California, one in the San Francisco bay area, and one in South Carolina.

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VI. COMPARISON WITH OTHER TYPES OF ALTERNATIVE FUEL VEHICLE

Hydrogen vehicles compete with various proposed alternatives to the modern fossil fuel powered vehicle infrastructure.

1. Plug-in Hybrids
This section is outdated. Please update this article to reflect recent events or newly available information.

Last update: No content is presented about series production PHEVs launched starting with the BYD F3DM and the Chevrolet Volt. Figures presented do not reflect current technology available.(November 2013)

Plug-in hybrid electric vehicles, or PHEVs, are hybrid vehicles that can be plugged into the electric grid and contain an electric motor and also an internal combustion engine. The PHEV concept augments standard hybrid electric vehicles with the ability to recharge their batteries from an external source, enabling increased use of the vehicle's electric motors while reducing their reliance on internal combustion engines. The infrastructure required to charge PHEVs is already in place, and transmission of power from grid to car is about 93% efficient. This, however, is not the only energy loss in transferring power from grid to wheels. AC/DC conversion must take place from the grids AC supply to the PHEV's DC. This is roughly 98% efficient. The battery then must be charged. As of 2007, the Lithium iron phosphate battery was between 80-90% efficient in charging/discharging. The battery needs to be cooled; the GM Volt's battery has 4 coolers and two radiators. As of 2009, "the total well-to-wheels efficiency with which a hydrogen fuel cell vehicle might utilize renewable electricity is roughly 20% (although that number could rise to 25% or a little higher with the kind of multiple technology breakthroughs required to enable a hydrogen economy). The well-to-wheels efficiency of charging an onboard battery and then discharging it to run an electric motor in a PHEV or EV, however, is 80% (and could be higher in the future)—four times more efficient than current hydrogen fuel cell vehicle pathways." A 2006 article in Scientific American argued that PHEVs, rather than hydrogen vehicles, would become standard in the automobile industry. A December 2009 study at UC Davis found that, over their lifetimes, PHEVs will emit less carbon than current vehicles, while hydrogen cars will emit more carbon than gasoline vehicles.

2. Natural Gas
ICE-based CNG, HCNG or LNG vehicles (Natural gas vehicles or NGVs) use methane (Natural gas or Biogas) directly as a fuel source. Natural gas has a higher energy density than hydrogen gas. NGVs using biogas are nearly carbon neutral. Unlike hydrogen vehicles, CNG vehicles have been available for many years, and there is sufficient infrastructure to provide both commercial and home refueling stations. Worldwide, there were 14.8 million natural gas vehicles by the end of 2011.

Advantages of Hydrogen Energy
- Readily Available
- No Harmful Emissions
- Environment Friendly
- Used as Fuel in Rockets
- Fuel Efficient
- Renewable

Disadvantages of Hydrogen Fuel
- Require very high capacity storage tank.
- Highly inflammable.
- Dependant on fossil fuels.
- Very expensive.
- Not easy to replace existing infrastructure.

VII. CONCLUSION

Hydrogen-operated internal combustion engine vehicles (HICEVs) offer a transitional solution toward cleaner transportation by utilizing existing engine technology with a cleaner-burning fuel. While they reduce carbon emissions compared to fossil fuels, they still produce some pollutants like nitrogen oxides (NOx). Compared to hydrogen fuel cell vehicles (FCEVs), HICEVs are less efficient but easier to adapt using current infrastructure. Overall, HICEVs represent a practical step toward decarbonizing transport, especially in applications where full electrification or fuel cells are not yet viable.

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