Pakistan Journal of Hydrocarbon Research
Vol.4, No.2(July 1992), P.49-51

Prospects of Hydrogen Technology in Pakistan

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ABSTRACT

Hydrogen manufacturing technologies are reviewed using case studies on utilization of Hydrogen in developed countries; some R&D proposals for carrying out work in Hydrogen manufacturing and utilization technology in developing countries like Pakistan are also indicated.

The study indicates that at this juncture, hydrogen could only be considered as an alternate fuel on environmental cleanliness reasons, the available technology to store liquid or gaseous hydrogen cannot compete on economic ground.

INTRODUCTION

Hydrogen, the smallest member of element family is available in abundance in association with oxygen in the form of water. Hydrogen is also an inherent part of fossil fuel together with carbon to form hydrocarbon. Hydrogen as a fuel is an ideal source of energy since it burns to liberate water. It has advantage over other fuels from environment point of view. Its availability in commercial quantities is a challenge in terms of manufacture, storage and distribution. Although significant R&D has been carried out on the use of hydrogen as a source of energy in developed countries (J.E Sinor Consultants Inc., 1991), but due to technology limitation not much head way is made in developing countries.

HYDROGEN MANUFACTURING PROCESSES

The principal commercial processes for hydrogen manufacturing are catalytic steam reforming, partial oxidation of petroleum residue, coal gasification and water electrolysis.

The cost of manufacture of hydrogen increases as we proceed from gaseous to liquid and solid fuels, the cost of electrolysis of water is similar to methane reforming in small plants. In case of larger plants, electrolysis cost exceeds significantly as economics of scale do not apply in latter case.

HYDROGEN MANUFACTURING IN PAKISTAN

In Pakistan most of hydrogen is produced from steam reforming of methane and mainly used for hydrogenation of vegetables, manufacture of fertilizers and petroleum refining.

In the petroleum sector a large hydrogen generation unit is planned to produce 45,000 tonnes of hydrogen per year at a capital outlay of US$ 54 million. In view of the increased awareness of sulphur content of petroleum fuel, more hydrogen generation units are expected to be installed for desulphurization of petroleum fuels. The use of hydrogen is depleting in vegetable oil industry due to health consideration. In fertilizer sector use of hydrogen would remain significant.

In liquid form hydrogen has approximately 3 times more calorific value as compared to liquid natural gas. However, in view of bulkiness of hydrogen molecules in gaseous form, hydrogen gas has only 12.3% heat content as compared to natural gas (natural gas has 1000 Btu/SCFT, whereas hydrogen has only 123 Btu/SCFT). The pipeline transportation cost of hydrogen is, therefore, extremely prohibitive.

Hydrogen as a source of energy has not yet become a candidate because it is capital intensive to produce, and is not yet cost effective on commercial grounds.

USE OF HYDROGEN IN DEVELOPED COUNTRIES

In developed countries legislative measure towards tail pipe restriction in automobiles and exhaust from chimneys from industry is compelling original equipment manufacturer of automobiles and industrialists to look for alternate clean fuels. The state of California in the United States has taken a lead in this direction.

In US if a factory is emitting pollution and it is not able to reduce it on technically justifiable reasons then the owner has to compensate this pollution by using alternate clean fuel in other area of use for example, he or she may have to use natural gas in automobiles. In the following paragraphs,

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we give salient features of some on-going R&D projects in developed countries.

Arizona Cities Hydrogen Fleet Project

According to the American Hydrogen Association (AHA), consortium of Arizona cities may develop plans to implement the largest fleet of hydrogen fueled vehicles in the world.

Phase I of the project would involve converting 25 fleet vehicles to hydrogen operation with advanced fuel storage and injection technology. Phase I is schedule to last 2 years and cost about US$ 3 million.

The project is planned to include an advanced carbon storage technology as well as research to determine the most cost effective methods of extracting hydrogen from biomass resources such as sewage sludge, paper and other wastes.

Initially, however, the hydrogen for the fleet vehicles will be generated from water with an electrolyzer. Electricity will be generated during day time with a solar point-focus concentrator Stirling engine electrical generator set. At night and on weekends, off-peak electricity will be used by the electrolyzers. Assuming off-peak electricity will cost about US$ 0.03 to 0.04 per kilowatt-hour, the cost of the hydrogen produced is expected to be in the US$ 1 to US$ 1.40 per gallon range.

The fleet will also be used to demonstrate the value of fuel cell electric vehicles as well as renewable energy resources.

Liquid Hydrogen Filling Station

The Hydrogen Letter reports that the first test runs of a liquid hydrogen refuelling facility began in early June 1991 at a prototype solar hydrogen plant in Bavaria, Germany.

The experimental facility, designed and built by Linde AG of Germany, has a 3,000 litre storage tank and is intended for refuelling BMW Sedans equipped with 120 litre liquid hydrogen tanks.

At present, refuelling with liquid hydrogen takes about 10 minutes if all components of the fuel system are at cryogenically compatible temperatures. However, if the hoses and pipes are at ambient temperatures, they have to be cooled, purged and rewarmed after the refuelling process has been completed. This procedure takes about an hour.

The goal of the project is to design an automated system that will permit "user-friendly" refuelling without special procedure in 10 minutes or less.

In the meantime, German car maker BMW continues to make progress towards a practical hydrogen car. Toward that effort, BMW has temporarily assigned one of its Research Engineers to hydrogen refuelling system.

The long-term goal is a robotic refuelling system where the driver parks the car in a precise position, checked by sensors and a video system. The driver opens the fuel tank lid from inside the car and from then on everything is done automatically. This fully automatic refuelling system could be achieved by the end of this decade, according to BMW engineers.

The company hopes to develop an efficient coupling device integrated inside the tank by about 1994. This would eliminate the cooling, purging and rewarming currently necessary at ambient temperatures. BMW officials hope to be able to turn hydrogen cars over to a few average drivers in about 5 years, followed by small test fleets of hydrogen powered cars.

Magnetic Liquefaction of Hydrogen

Magnetic liquefaction could become an important tool to substantially lower the cost of liquid hydrogen. Lowering the cost of liquid hydrogen would have significant implications for its use as a transportation fuel.

Progress in Hydrogen as Vehicle Fuel

The German Aerospace Research establishment (DLR) has been involved in automotive applications for liquid hydrogen since 1979. Research and development in the area of liquid hydrogen refuelling have been part of this ongoing effort.

Fully automated refuelling equipment developed by DLR can be used and handled safely by non experts. Program control via microprocessors makes the system fail-safe. The experience gained with liquid hydrogen may also be applied to liquid natural gas (LNG). The automatic system meets the following requirements:

- The escape of liquid hydrogen into the air is prevented.
- The refuelling process is interrupted automatically if a failure in the electronic system or the hydrogen-carrying lines occurs.
- Refuelling is stopped automatically when the fuel tank is full.
- It is possible to stop refuelling by external command.
- Hydrogen-carrying lines and valves are protected against infiltration of air and humidity.

- Engine starting is prevented automatically as long as there is a connection between the car and the hydrogen station.

- It is not possible to disconnect the vehicle from the hydrogen station as long as the filling continues.

PROPOSAL FOR R&D PROJECTS IN THE FIELD OF HYDROGEN MANUFACTURE AND UTILIZATION IN PAKISTAN

In order to get familiarized with hydrogen manufacturing and utilization technology following four projects are recommended for Pakistan:

1. Use of hydrogen in automobile in urban transport.

2. Production of hydrogen on pilot scale by electrolysis technique.

3. Production of hydrogen on pilot scale by steam reforming technique.

4. Use of hydrogen as domestic fuel.

CONCLUSION

Hydrogen is a superior quality fuel and an excellent source of energy storage medium. Its heat of combustion is more than two times as compared to methane on weight basis. Hydrogen storage, transportation and usage is capital intensive, therefore, it is not an affordable fuel, at present. More R&D work is needed to be done to adopt hydrogen as a source of energy in our daily life. Whereas significant R&D work is being carried out in developed countries, adaptive research is needed to be done in Pakistan and other developing countries so that waste energy from hydroelectricity or from any other source could be tapped effectively.

In addition to projects proposed in this paper on hydrogen manufacture and utilization, other R&D projects such as adsorption of hydrogen on a suitable medium and safety related studies may also be conducted to make this technology work in reality.

REFERENCE

J.E. Sinor Consultants Inc., 1991(November), The clean Fuels Report, v.3, no.5, p.115.