



Original Research Article

The future of important energy - hydrogen

Xiaolei Ma, Hongjun Dai, Minzhong Chen

School of Materials Science and Engineering, Chengdu Jiaotong University, Sichuan, China

ABSTRACT

Hydrogen as a kind of clean energy has been paid more and more attention in recent years. Hydrogen production of raw materials is water; therefore, relative to gasoline, diesel and other energy sources, its use will not cause pollution to the environment. In the promotion of sustainable development and protection of the environment today, such a pollution-free energy more and more people of all ages. At the same time, we can believe that in the near future, hydrogen will become one of the important energy for our production and living convenience.

KEYWORDS: Hydrogen; Important Energy; No Pollution

1. Introduction

Today, the global economy and technology in the interaction continue to develop, showing some thriving scene. However, behind these developments is also a series of problems. Development brought about by the energy consumption, has almost led to the number of some energy began to run out. Some of the environmental problems caused by the use of energy is also constantly surfaced. Now and in the future, people need to think about not only how to save resources, but more should find clean, rich resources to meet the needs of social development. Hydrogen has a wide range of applications in the fields of petrochemical, electronic industry, metallurgical industry, food processing, float glass, fine organic synthesis, aerospace and so on with its high calorie, abundant resources and cleanliness. The practical application of hydrogen to humans can be traced back to 200 years ago. Rich in hydrogen reserves, easy to obtain, is the ideal energy carrier. There are many advantages of hydrogen fuel, one of which is to achieve zero emissions of carbon dioxide. This feature makes the hydrogen fuel which everywhere shouting energy-saving emission reduction world is particularly eye-catching.

What is hydrogen?

1.1. The physical and chemical properties of hydrogen

Hydrogen is colorless and has a lower density than air (the density of hydrogen is the smallest in all gases, and the mass of 1 liter of hydrogen is 0.0899 grams and the same volume is much lighter than air). Because hydrogen is difficult to dissolve in water, so you can use the drainage gas collection method to collect hydrogen. In addition, the pressure of 101 kPa, the temperature $-252.87\text{ }^{\circ}\text{C}$, the hydrogen can be converted into a colorless liquid; $-259.1\text{ }^{\circ}\text{C}$, into a snow-like solid. At room temperature, the nature of hydrogen is very stable, not easy to react with other substances. But when the conditions change (such as ignition, heating, the use of catalyst, etc.), the situation is different. If the hydrogen is palladium or platinum and other metal adsorption has a strong activity (especially by palladium adsorption). The adsorption of metal palladium on hydrogen is the strongest.

1.2. The main performance of hydrogen

High flammability, reducing agent, liquid temperature are lower than nitrogen. The main properties of hydrogen are:

1) Flammability

The combustion of hydrogen, essentially hydrogen and oxygen, reflects the generation of water ($2\text{H}_2 + \text{O}_2 = \text{ignited} = 2\text{H}_2\text{O}$). During this reaction there is a large amount of heat released, and the heat released during combustion is three times the amount of gasoline under the same conditions. So it can be used as a high-energy fuel for use on rockets. China's Long March 3 is rocket on the use of liquid hydrogen fuel. However, impure hydrogen ignites and explodes.

According to the combustion properties of hydrogen, it can be used as fuel; can be applied with aerospace, welding, military and other aspects;

2) Reducibility

According to its reductive, it can also be used to smelt some of the metal materials and so on.

1.3. Preparation of hydrogen

Can be divided into the following:

1) Industrial hydrogen production methods:

- Production of hydrogen from coal and water (production equipment gas production equipment, pressure swing adsorption equipment)

- Cracked LPG production (production equipment cracking equipment, pressure swing adsorption equipment, decarbonization equipment)

- Electrolysis of water production (production equipment electrolyzer equipment)

- Industrial's waste gas.

2) Civil hydrogen production methods:

- Ammonia decomposition (production equipment vaporization furnace, decomposition furnace, pressure swing adsorption equipment)

- By the active metal and acid (production equipment, stainless steel or glass container equipment)

- Strong alkali and aluminum or silicon (production equipment, hydrogen balloon machine equipment) General use of hydrogen balloons are used in this method.

- Methanol cracking (production equipment, thermal oil furnace, methanol vaporization cracking equipment, pressure swing adsorption device) generally use a large amount of hydrogen plants are used in this method.

3) Laboratory hydrogen production methods:

Sulfuric acid and zinc particles (production equipment Kai Pu generators)

4) Other

- Heavy water electrolysis

- Liquid hydrogen low temperature distillation

1.4. The use of hydrogen

Hydrogen is the main industrial raw material, and the most important industrial gas and special gas, in the petrochemical industry, electronics industry, metallurgical industry, food processing, float glass, fine organic synthesis, aerospace and other aspects of a wide range of applications. At the same time, hydrogen is also an ideal secondary energy (secondary energy refers to the need for a primary energy such as solar energy, coal, etc. to produce energy). Under normal circumstances, hydrogen easily combined with oxygen. This property makes it a natural reducing agent used in the production to prevent oxidation. In the high-temperature processing of glass and the manufacture of electronic microchips, hydrogen is added to the nitrogen atmosphere to remove residual oxygen. In the petrochemical industry, hydrogenation is required to extract crude oil by de-sulfur and hydrocracking. Another important use of hydrogen is the hydrogenation of fatty oils in margarine, edible oils, shampoos, lubricants, household cleaners and other products. Due to the high fuel economy of hydrogen, the aerospace industry uses liquid hydrogen as fuel.

1.5. Hazardous characteristics of hydrogen

Hydrogen and air mixed to form an explosive mixture, the case of heat or fire will explode. Gas is lighter than air, used and stored in the room, the leaky stranded roof is not easy to discharge, and the case of Mars will cause an explosion. Hydrogen and fluorine, chlorine, bromine and other halogen will react violently.

1.6. Advantages of hydrogen

1) Resource rich

Hydrogen to water as raw material, electrolysis can be obtained. Water resources on the earth are quite adequate, that is, by breaking water to get hydrogen.

2) High calorific value

Hydrogen combustion heat value of the highest value of a variety of fuels, according to the determination of hydrogen combustion per kilogram of heat generated 1.4×10^8 joules, more than 3 times the value of oil. Therefore, it stores a small volume, carrying large, long travel.

3) Hydrogen is the cleanest fuel

Hydrogen combustion products are water; the environment does not produce any pollution. On the contrary, gasoline, diesel fuel for vehicles, emissions of large amounts of nitrogen oxides, tetraethyl lead [Pb (C₂H₅)₄], will lead to acid rain, acid mist and severe lead poisoning. More importantly, the exhaust gas also contains 3, 4 - Benzopyrene strong carcinogenic substances, pollution of the atmosphere, hazardous to health. Therefore, in recent years, countries around the world to hydrogen as a new type of energy research are very important. Japan on May 24, 1984 in the Fuji Expressway to 200 kilometers per hour speed for the first time is to test (hydrogen as fuel) success.

2. Hydrogen in the practical application

Hydrogen has been given the desired energy for the future because it has a wide range of applications and has a unique advantage over other sources of energy.

2.1. Automotive industry

Water energy hydrogen fuel, which can be used as a fuel for internal combustion engines alone, or can be infiltrated with gasoline or natural gas as a fuel mixture, 'fuel hydrogenation', fuel hydrogenation results, can greatly improve the combustion of gasoline, water, 2.8 times the gasoline. Fire boundaries are wide, burning in the air fire limit of 4% to 74%, than gasoline and diesel fire boundaries are much larger. This means that you can burn, the air as long as there are 4% of the water fuel ingredients can be fierce combustion, gasoline is far behind. This characteristic is important for reducing the energy consumption at the time of partial load on the engine. Water energy hydrogen fuel has a high flame propagation speed. Antivirus is better than gasoline. Ignition energy is low and can be as low as 0.019 MJ much lower than gasoline. Therefore, the water energy of hydrogen fuel infiltration and gasoline combustion, the required ignition energy can be reduced, in short, it can be asserted that: in today's world, no one of the fuel performance than water energy hydrogen fuel.

One of the most important features of water is the hydrogen fuel is a clean fuel, the combustion products turn into water, no carbon and soot. The key is to hydrogen the energy from the car to add a matching generator, the raw material is water, almost no money. So low cost of environmental protection and environmental protection is the other way is no comparable. We also assert that the protection and contribution of the human environment, without any kind of fuel can be compared with our water energy hydrogen fuel.

The advantages of hydrogen as a fuel for cars are compared to cars that use gasoline or diesel as fuel:

1) Hydrogen and air mixed, complete combustion, high efficiency, the expansion of the explosive speed of power is not only far more than the traditional combustion mode, and hydrogen fuel (cost) consumption less. When the maximum expansion peak of the explosion and when the crankshaft structural torque is the largest, the engine running torque, strong power. And only emissions of trace water vapor, the atmosphere without any pollution. Exhaust emissions of carbon monoxide can be reduced to 0, nitrogen oxide down 60ppm, the hydrocarbon down to 0, lead content reduced to 0. Is the real environmental green energy

2) Hydrogen combustion calorific value is higher and better dynamic performance can be lean to burn.

3) Hydrogen is not like gasoline (diesel) will enter the crankcase dilution oil, affecting the lubrication effect. As a result, the consumption of oil is reduced and the service life of the engine is extended.

4) Because hydrogen is produced and is very volatile in the air, unlike gasoline (diesel) from the tank and carburetor to evaporate into the atmosphere, causing pollution of the atmosphere.

5) Because the vehicle is used with the system in the cylinder with less storage, and the cylinder than the tank strength, and impact resistance, in the event of an accident, hydrogen will not flow out of their own. Even if there is leakage is because the proportion of hydrogen light will quickly evaporate to high altitude, will not cause harm.

6) As the vehicle hydrogen system has a perfect complete structure, to prevent, over-voltage, over-current, also has anti-leakage and isolation devices.

7) Relatively speaking, with the engine's own power to produce hydrogen cost is relatively low, can reduce operating costs.

2.2. Aerospace Engineering

Liquid hydrogen is a colorless, odorless, transparent liquid that is liquefied from hydrogen. And liquid hydrogen as a propellant in the late 70s, the early 80s began to attract the attention of countries. Low temperature propellant liquid hydrogen is currently the most advanced propellant for aerospace, its main feature is the high energy, than the red; in the world has a rocket launcher technology used by various propellants in the use of liquid hydrogen more widely.

Whether it is the United States, Europe, or Japan, the demand for liquid hydrogen is with the development of the cause of the increase. The United States from the late 50s on the industrial scale production of liquid hydrogen, the production of liquid hydrogen in addition to the supply of large rocket engine test sites and rocket launch base, but also supply universities, research institutes, liquid foam room, food industry, chemical industry, Semiconductor industry, glass industry and other departments. The United States industrial scale hydrogen liquefaction equipment, are built after 1957 put into operation, 071 / d-171 / d of the factory 6, 301 / d 4, 601 / d of a. With the needs of the US aerospace industry, 1965 - 1970 liquid hydrogen production reached the highest level in history, Nissan liquid about 220t. Subsequently, due to the US aerospace industry tightening, liquid hydrogen production also decreased. At present, the old small and medium-sized equipment has been discontinued, only a few large equipment in operation. Europe, Japan, although there is industrial-scale production equipment, but its production scale, liquid hydrogen production, especially the product price, simply cannot be compared with the United States. China's situation is even worse, at present only Shaanxi Xingping fertilizer plant liquid hydrogen production plant and 101 new liquid hydrogen production plant can be produced. Xingping device nominal production up to 1200L / h, but the start productivity of less than 10%, is because the product is only for space launch and hydrogen. Oxygen engine development test, and the process behind, the production equipment of the old days, liquid hydrogen prices are unusually expensive, the user a purchase of more than 100m³ price of 20,000 yuan / m³ less than 20m³, the price was as high as 50,000 yuan / m³. Moreover, each liquid hydrogen rail tanker to add 10 million pre-cooling fee. 101 new hydrogen liquefaction plants is still trial operation stage, many aspects cannot be concluded. But there are two points that can be sure: one is the technical level of hydrogen liquefaction process to improve a big step; the second is the liquid hydrogen production costs will be reduced, but will not reduce a lot. This is mainly because the production scale is small, raw material hydrogen production process backward (electrolysis of water to hydrogen), high production costs. The United States due to the large-scale hydrogen liquefaction equipment at the same time, the Government also provides all the equipment to provide loan assistance, and provides equipment repayment costs and products, production has nothing to do. Many liquid hydrogen production plant and the use of waste from the extraction of raw materials, hydrogen, so the liquid hydrogen prices are very low, to the late 70s with the continuous expansion of production scale, liquid hydrogen prices have dropped to 10-20 cents / lb (15.6-31.2 USD / m³).

2.3. Other aspects

Hydrogen is also used in the electronics industry, metallurgical industry, food industry, float glass, fine organic synthesis and other fields, of which the largest application is as important chemical raw materials for the production of synthetic ammonia, methanol and oil refining process of the hydrogenation reaction. Most of the hydrogen used in the synthesis of ammonia and methanol is from the steam or partial oxidation of natural gas, naphtha or heavy oil. The amount of hydrogen used in the petroleum refining industry is second only to synthetic ammonia.

3. Hydrogen development trend

3.1. Performance perspective

Compared to traditional fuels, hydrogen combustion is almost zero pollution to the environment. Traditional fuels show the limited resources and pollution of the environment caused by the drawbacks, making hydrogen as the future development of human society, the advantages of important energy has become increasingly prominent.

From the above statistics we can see that the amount of CO₂ released by hydrogen combustion is almost no compared to the amount of CO₂ released during combustion of other fuels because of the main water and a small amount of hydrogen nitride, And other fuels in addition to carbon dioxide will produce CO, NO₂, hydrocarbons, lead compounds and dust particles and other environmentally harmful pollutants, a small amount of hydrogen nitride through appropriate treatment will not pollute the environment, and combustion The water can also continue to produce hydrogen, repeated recycling. Therefore, from the perspective of environmental protection, relative to coal, diesel and other traditional fuels, hydrogen energy is more environmentally friendly.

On the other hand, we analyze the value of hydrogen from the fuel calorific value. From the above table to analyze the calorific value of various common fuels, the calorific value of hydrogen is the largest, that is to say, in order to obtain the same value of the calorific value, the use of hydrogen in the amount can be much less than the use of other fuels, This can also greatly reduce the fuel storage space. Hydrogen can reduce the fuel weight and can increase the payload of the vehicle, which can reduce the cost of transport from the full benefits to consider the total social benefits better than other energy, more portable.

From the future of the automotive industry and the development of space flight wait and see, we firmly believe that the fuel environmental protection, safety and efficiency will be their first choice, and hydrogen with all the advantages of this is undoubtedly the future development of these industries an important choice.

3.2. Economic point of view

Relative to the most widely used oil, in recent years, international crude oil continues to rise, the continuous growth of prices on people's production and life have brought a great impact. On the one hand, the limited resources of oil, mainly in the Middle East, mining and transportation are the main factors to create higher prices; on the other hand, oil pollution on the environment pollution is also growing, mainly because of human production Life continues to develop due to resource demand, which will further accelerate the consumption of oil energy. Hydrogen production of the main raw material is water. Therefore, hydrogen resources are endless. As the hydrogen fuel combustion products of water on the environment is almost zero pollution, which will undoubtedly make hydrogen as the future of human energy 'darling'

The main obstacle to the current development of hydrogen is the cost, but we have good reason to believe that in the increasingly demanding environmental requirements today, the huge commercial interests will drive the hydrogen industry to a rapid development path. The process of understanding is the role and status of hydrogen, that is, hydrogen from the 'soldiers to the marshal' process. In the future society, hydrogen can play the role of: the use of hydrogen instead of fossil fuels, fossil fuels for chemical raw materials; reduce long-distance high-voltage transmission, through the pipeline network, hydrogen to thousands of households; gradually reduce inter-provincial Power supply, save a lot of metal materials; various types of air, hydrogen fuel cells become widely used power generation tools; reduce the internal combustion engine power, significantly reduce energy pollution hazards and diesel locomotive noise sources; urban sewage into hydrogen energy supply and recovery of the perfect circulation system The

The cost of hydrogen is analyzed from the production of hydrogen. Now the world's annual production of hydrogen is about 36 million tons, most of which is made from oil, coal and natural gas, which would have to consume the already very scarce fossil fuels; another 4% of the hydrogen is electrolytic Water method, but the consumption of electricity is too much, it is not worthwhile, therefore, people are actively exploring new ways to study hydrogen.

People began to think of the sun to decompose the water to produce hydrogen, imagine the addition of a catalyst in the water, so that the water in the sunlight, the role of the catalyst to decompose water. In this way, in the future of the car, the use of aircraft, as long as the inside of the mailbox to add water, then add Photolysization catalyst, then, as long as there is sunlight, the water can break down the hydrogen, for the car, aircraft to launch energy.

Scientists also found that some microbes can also produce hydrogen under the action of sunlight. People use hydrogen under the photosynthesis can release hydrogen microorganisms, through the hydrogenase induced electrons, the water in the hydrogen ions combined to generate hydrogen. Scientists in the former Soviet Union have discovered such microbes in the lakes, where they put the microbes in special containers suitable for their survival and then collect the hydrogen produced by the microorganisms in the hydrogen cylinders. This microbial contains a lot of protein, in addition to the release of hydrogen, but also can be used for pharmaceutical and vitamin production, and use it for livestock and poultry feed. Nowadays, people are trying to cultivate such microbes that can produce hydrogen efficiently to meet the needs of developing and utilizing new energy sources.

It is interesting to note that many primitive low organisms can also release hydrogen during the metabolic process. For example, many bacteria can release hydrogen under certain conditions. Japan has found a called 'fl agellant bacteria' bacteria, is a hydrogen donor. In the glassware, starch as raw material, mixed with some other nutrients made of the culture medium can be cultured in this bacteria, then, and in the glassware will produce hydrogen. The effectiveness of this bacteria hydrogen production is high, and consumption of five milliliters of starch nutrient solution, can produce 25 ml of hydrogen.

The US aerospace department is ready to bring a photosynthetic bacterium - neonatalus into space, using it as a source of energy for spacecraft. The growth and reproduction of these bacteria is very fast, and the culture method is simple and easy, both in the agricultural and sideline products waste water slag cultivation, can also be dairy products in the cultivation of garbage.

For the preparation of hydrogen, it was proposed a bold idea: the future construction of some electrolytic water for the production of hydrogen dedicated nuclear power plant. For example, the construction of artificial islands, the nuclear power plant built on these islands, electrolysis and cooling water are taken from the sea. Because the island is far from

the residential area, it is safe and economical. Preparation of hydrogen and oxygen, with laying in the underwater ventilation pipe into the land, so that people can use at any time.

The current use of hydrogen is widely used in its production costs, but in the future development, as people explore the hydrogen economic point of the preparation method, the widespread use of hydrogen will be possible.

Although there are many difficulties in the extensive production and application of liquid hydrogen, hydrogen has its unique advantages, making it one of the best energy sources for future energy development. Since the product of hydrogen combustion is water, the environment is almost zero pollution, so it is the most clean, the ideal energy carrier.

With the development of human society and scientific and technological progress, hydrogen in many sectors, such as aerospace, aviation, transportation, electronics, metallurgy, chemicals, food, glass, and even civilian fuel sector will be widely used. As the market expansion, liquid hydrogen production scale will be expanded, the level of technology continues to increase, and thus the cost of liquid hydrogen production will be greatly reduced, so that liquid hydrogen production and application to a virtuous circle. To do this, in addition to engaged in liquid hydrogen research, the production of engineering and technical personnel make unremitting efforts to improve the production process, the development of advanced equipment, the more important is the government to develop appropriate policies to vigorously support the liquid hydrogen industry, effective publicity, organization, and promote the promotion of various departments of liquid hydrogen, application.

We firmly believe that the future development must be scientific and sustainable. Human beings hope to coexist with the environment in the process of development and promote common progress. Therefore, not only hydrogen, as long as the survival and development of our role and promote the environment, will become the future development of human important raw materials. Of course, in this process, we must recognize the double nature of things, a clear understanding of the negative effects brought about by the natural ecology, the environment, or the survival of human harm. Optimize the use of energy, so that the use of energy to achieve low, efficient and economical.

References

1. Yan Weidong, Liu Jixiang. Overview of hydrogen energy development at home and abroad. *New Energy New Energy*.2003
2. Mao Zongqiang. Hydrogen energy and its recent application prospects. 2005. *Science Bulletin* Volume 23 No. 2
3. Hao Er, editor. Yang Dengwei, translation. Hydrogen as a general fuel potential and its comparison with fossil fuels. From the energy of the future. Petroleum Industry Press, April 1999 First edition