The Urine Engine

Asst. Prof. Nirav K. Bais[1], Darshil P. Trivedi[2]

Department of Automobile Engineering, Ganpat University, Mehsana, Gujarat, India[1]
Department of Automobile Engineering, Ahmedabad Institute of Technology, Ahmedabad, Gujarat, India.[2]

Abstract: *Everything can be reused now a day's. So in a real sense we can say that nothing is a real waste. Everything has their value in this world. Now a day's the level of pollution is increasing day by day and the pollution from the automotives plays a big role in this pollution. Due to this pollution the temperature of earth has been increased for 5^0C. The other problems like hike in price of conventional fuel, environmental degradation, the decreasing quantity of conventional fuel, and the last but not least the lack of availability of fossil fuel and non-conventional ways are supposed to control for future in the coming day and which lead us to the way of alternative fuel. The hydrogen is the one of its member which we can get with the help of many ways. And the easy, cheaper, and efficient way to produce hydrogen is from urine. It takes less amount of voltage to break a urine molecule is to break the hydrogen molecule in water. So urine electrolyzed and then releasing hydrogen gas from it, and finally hydrogen gas is purified. The purified hydrogen gas is then pushed for the further.*

Keywords: *Pollution, degradation, conventional fuel, urine, electrolysis, hydrogen.*

1. Introduction

Nowadays energy demand continues to increase rapidly, year after year. Traditional crude energy sources such as oil, coal are ultimately decreasing and the growing gap between increasing demand and shrinking supply. In the soon upcoming years we have to stand for the alternative energy sources. We must strive to make these more sustainable to avoid the negative impacts of atmosphere climate change, the growing risk of supply disruptions, price rises and air pollution that are associated with today's energy systems. The leaders of the world are trying to produce an efficient and safe energy sources. And we are very near to the next generation of the fuels which will be in place of the running conventional fuels. The energy policy of the European Commission advocates securing energy supply while at the same time reducing emissions that are associated with climate change. This calls for immediate actions to promote greenhouse gas emissions-free energy sources such as renewable energy sources, alternative fuels for transport and to increase energy efficiency."The whole fun of living is trying to make something better" said by Charles Kettering, American inventor and social philosopher. In future there is a large scope for hydrogen is available. It is very alternative source to fossil fuels because the only hydrogen gas is available in water. But a major problem with this approach is the lack of a cheap, renewable source of the fuel. From the research now we have found the answer in an unexpected place, i.e. cow urine.

Although the hydrogen is most abundant element in the universe, on Earth it tends to be locked away in molecules such as water (H_2O). To gain hydrogen gas (H_2) from water the strong hydrogen–oxygen bonds must be broken. The bond can be broken bypassing an electrical current through water (the electrolyte) in a process called electrolysis. Urine contains urea, (NH2)2CO, which has four hydrogen atoms in each molecule. Importantly these are easier to remove hydrogen than in water because nitrogen–hydrogen bonds are weaker than oxygen–hydrogen bonds. And thus it's easier to get hydrogen from it. During the electrolysis the hydrogen can be achieved at the top of the cathode and the rest at the anode. The gases which are produced at anode are N_2, CO_2 & NH_3.

In addition to sustaining hydrogen resources, such a process could denitrificate urea-rich water that is commonly purged into rivers, creeks, and tributaries from municipal waste water treatment plants. Converting urea to valuable products before it naturally hydrolyzes to ammonia, which generates gas-phase ammonia emissions and contributes to ammonium sulphate and nitrate formation in the atmosphere, will save billions of dollars spent each year on health costs. Here we demonstrate a technology for improving hydrogen resources for energy sustainability by recycling waste materials such as human excreta. As well as producing an environmentally friendly fuel, this process could also be used to clean up waste water. Current methods to remove urine from water are expensive and not efficient. Plans to try and combine the two ideas, so that hydrogen can be collected for use as fuel during the cleanup of effluent from sewage works.

2. Why Hydrogen as a Fuel

1. Hydrogen can be used as liquid or gas both.

2. Hydrogen can be converted to electricity electrochemically in fuel cell with high efficiency.

3. Hydrogen has lean burning characteristic. It making a good fuel for vehicles and it make stop-go type city driving vehicles.

4. Hydrogen is a light element so it use suitable for spacecraft.

5. Energy required to initiate combustion is less than the natural gas and flame speed of hydrogen burning in air is higher than the natural gas.

6. Mixture of hydrogen and air is combustible over a high range of compositions.

7. Liquid hydrogen has a higher heating value i.e. 120 MJ/kg than gasoline which is 44 MJ/kg.

8. Due to combustion of hydrogen does not produce carbon dioxide and green house gases and preventing the global warming.

9. Hydrogen is clean energy water is both the source and end product.

11. Hydrogen is a unique fuel with unique properties with compare to other fuel, which make it an ideal fuel.

Hydrogen has the highest energy content per unit weight (120.7 KJ/g). The amount of energy produced by hydrogen per unit weight of fuel is about three times the amount of energy contained in equal weight of gasoline and seven times that of coal.

Combustible properties of hydrogen:

- **Amazing flammability limits:-**
- **Low ignition energy:-**
- **Small Quenching distance:-**
- **High auto ignition temperature:-**
- **High flame speed:-**
- **High diffusivity:-**
- **Low density:-**

3. Methodologies:

The electrolysis of urine will take part first to produce hydrogen with which we will run our engine. This mixture then goes into the water filter. The water filter is to remove any impurities that might have come in with the gas and then it goes into an empty gas cylinder which serves as the gas storage. The gas cylinder pushes hydrogen into a cylinder of liquid borax, which is used to remove the moisture from the hydrogen gas. Borax serves as a drying agent and this is because we do not want lots of moisture going into the compressor. Also, borax helps to remove any other impurities that might have come in with the gas.

Then the produced hydrogen will be compressed with the help of compressor so we can rich the high pressure under which the hydrogen is stable. Then it will be moved through the pipes towards the storage tank where the hydrogen will be stored under a very high pressure up to 30MPa. When the pressure inside the tank will be reduced under the 25MPa the intake valve will open with the help of poppet valve (working on principle of electrical solenoid actuation) and the tank will be refilled.

When we ignite the engine it is needed to inject the fuel for that purpose the injection system will be in action. The economical way to inject the fuel is with the help of "**Direct cylinder injection system**". In which the hydrogen will be transferred through the pipes to the engine by the injector. The injector which is used to inject the hydrogen fuel is a **"Homan Injector"** invented by Dr. Homan in the 20^{th} century. It is working with the help of diaphragm which will reduce the hydrogen pressure but will increase the velocity of hydrogen. To ignite the hydrogen fuel inside the cylinder of engine the normal spark plug will not work it is needed to have the cold spark plug so it can produce sparks and ignites the fuel.

4. Electrolysis of Urine

An efficient way to produce hydrogen from urine that could not only fuel the cars of the future but a major stumbling block is the lack of a cheap, renewable source of the fuel. Using hydrogen to power engine has become an increasingly attractive transportation fuel, as the only emission produced is water. But a major stumbling block is the lack of a cheap, renewable source of the fuel. Using an electrolytic approach to produce hydrogen from urine is the most abundant waste on Earth at a fraction of the cost of producing hydrogen from water. Urine's major constituent is urea, which incorporates four hydrogen atoms per molecule importantly, less tightly bonded than the hydrogen atoms in water molecules. Electrolysis process is used to break the molecule apart, developing an inexpensive new copper based electrode to selectively and efficiently oxidize the urea.

To break the molecule down, a voltage of 0.38V needs to be applied across the cell much less than the 1.20V needed to split water. During the electrochemical process the urea gets adsorbed on to the copper electrode surface, which passes the electrons needed to break up the molecule. Pure **"hydrogen is evolved at the cathode"**, while nitrogen plus a trace of oxygen and hydrogen were collected at the anode. While carbon dioxide is generated during the reaction, none is found in the collected gasses as it reacts with the potassium hydroxide in the solution to form potassium carbonate. Urea is oxidized at the anode as shown in above equation at a standard electrode potential of 0.46 V.

Nitrogen is generated from the anode demonstrating nitrate remediation of wastewater while water is reduced at the cathode producing valuable hydrogen for the impending hydrogen economy. An electrolytic cell potential of only 0.38V is thermodynamically required to electrolyze urea at standard conditions. This is significantly less than the 1.20V required electrolyzing water theoretically generating 75% cheaper hydrogen. Urea naturally hydrolyses into ammonia before generating gas phase ammonia emissions. These emissions lead to the formation of ammonium sulphate and nitrate particulates in the air, which cause a variety of health problems including chronic bronchitis, asthma attacks and premature death. The figure shows the set up of the electrolysis process for producing the hydrogen gas from the urine. As we can see in the figure that at the anode produced gases are NH_3, CO_2 & N_2. And H_2 is collected at the anode.

Purification:-The hydrogen gas mixture from the electrolytic cell then goes into the water filter. The water filter is to remove any impurities that might have come in with the gas and then it goes into an empty gas cylinder which serves as the gas storage. The gas cylinder pushes hydrogen into a cylinder of liquid borax, which is used to remove the moisture from the hydrogen gas. Borax serves as a drying agent and this is because we do not want lots of moisture going into the generator. Borax, also known as sodium borate, sodium tetra borate, or disodium tetra borate, is an important boron compound, a mineral, and a salt of boric acid.

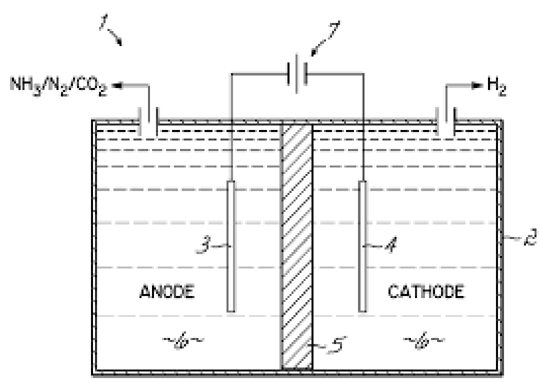


Fig. No.1: Electrolysis of Urine

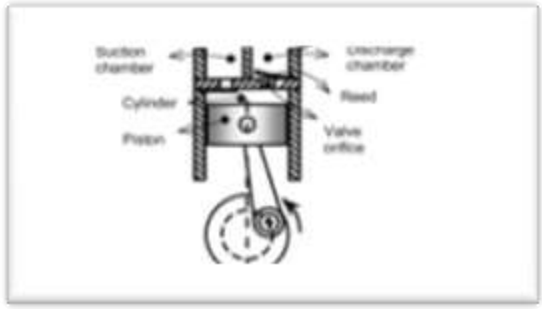
5. Hydrogen Compressor

Hydrogen compressors are closely related to **hydrogen pumps** and **gas compressors**: both increase the pressure on a gas and both can transport the fluid through a **pipe**. As gases are compressible, the compressor also reduces the volume of hydrogen gas, whereas the main result of a pump raising the pressure of a **liquid** is to allow the **liquid hydrogen** to be transported elsewhere.

To store the hydrogen in the Storage tank it is essential that the hydrogen must have a storage pressure of at least 30MPa. But the produced hydrogen has not enough pressure to be store in tank. Thus it is essential that it must be compressed up to 30MPa.then it should be stored in tank.

A proven method to compress Hydrogen is to apply reciprocating piston compressors. Widely used in refineries, they are the backbone of refining crude oil. Reciprocating piston compressors are commonly available as either oil-lubricated or non-lubricated; for high pressure (250 - 700 bar), non-lubricated compressors are preferred to avoid oil contamination of the Hydrogen. Expert know-how on piston sealing and packing rings can ensure that reciprocating compressors outperform the competing technologies in terms of MTBO (Mean Time between Overhaul).

Fig. No. 2: Hydrogen Reciprocating Piston Compressor



6. Hydrogen Storage Tank

The Purpose of using storage tank is to store the hydrogen under a high pressure in between which the hydrogen is stable. The hydrogen is stable in between the pressure of 25MPa to 75MPa. So, storage tank can be designed in between for these much pressure. The safety is the most sensible factor for the design purpose it should be designed as per the safety because if we will not design as per the specifications it can blast and the intensity of that blast can effect as far as nearer 2-3 km area.

The material which you are choosing should have adequate strength and can sustain these much stress and pressure. The most material which we can use for the storage tank is Aluminum with suitable grade and it must be wrapped with fiberglass or graphite.

The storage tank should be designed under the calculation by clavarino's equation. Which is as bellows: -

$$t = r_i[\frac{\sigma_t + (1-2\mu)p}{\sigma_t - (1+\mu)p} - 1]$$

And for the length of the of storage tank we should use the equation as per follows:

$$R = \sigma_{tl} * 2t * l$$

Where,

R= load acting on the storage tank inside the cylinder

t= thickness of the storage tank

l= length of the storage tank

r_i= inner radius

p= pressure acting on tank

μ= poison's ratio

Since hydrogen is one of the lightest element and has very small molecules, it an escape from tank and pipe more easily than conventional fuels. However, if it is to be used as a fuel for transport or power generation then there must be used way of storing it cost-effectively.

Injection System

There should be three types of injection system on which hydrogen will be injected. Which are as per follows:-

1. Carbureted Injection system
2. Manifold Injection system
3. Direct Cylinder Injection system

Carbureted Injection system:-

The simplest way of delivering fuel to a hydrogen engine is via a carburetion. Although carburetion is no longer a viable technology for modern vehicles, there were several advantages to using a carburetor for early hydrogen engine developments. This system is as same as the gasoline carburetor, which converts it to a duel fuel model like gasoline-hydrogen duel fuel mode engine or a simple hydrogen engine. This injection does not require any sophisticated high pressured injector.

But the major issue about this technique is a backfire and knocking and pre-ignition problems. And the power output of an ideal hydrogen engine and a carburetor is about 15% lower than that of a comparable gasoline engine. The carbureted engine is shown in figure.

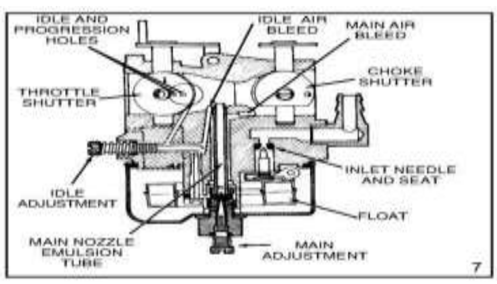


Fig. No. 3: Carbureted Injection System

Inlet Manifold Injection:

An experimental electronically controlled manifold injection system was fabricated. Pressure to the injectors was maintained constant (40 psig for most tests) and pulse duration alone used to meter hydrogen delivery per injection. Maximum and minimum pulse durations (and thus ~) were manually set to match the test conditions. Although basically a quality governed system, air throttling was available to establish an acceptable idling condition.

Injection valves were located in positions adjacent to each intake port. The outlet nozzles terminated approximately one centimeter behind each intake valve to provide a clear spray path into the cylinder when the intake valve was open. Triggering of injection cycle initiation was accomplished using a phototransistor - LED pair sensing system.

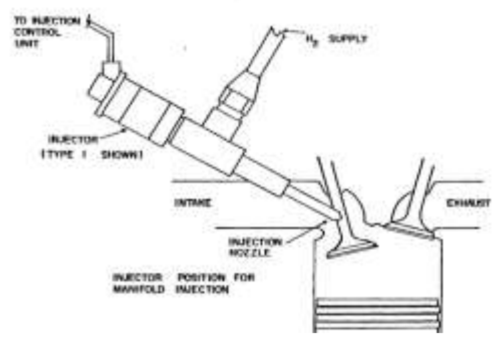


Fig. No. 4 Manifold Injection System

DIRECT CYLINDER INJECTION:

Direct injection will here imply a timed hydrogen injection technique employing direct delivery of fuel in cylinder. An early example of a direct injection scheme was demonstrated by Dr. Erren in his work from 1923-1939 in which a third valve was used as a pressurized hydrogen inlet. More recent works by Saga and Furuhama have demonstrated timed high pressure mechanical injection techniques on test engines. Direct injection shares the same fuel metering and late injection onset characteristics as outlined for manifold injection, but additionally allows for fuel delivery after the closure of the intake valve during the compression stroke.

Due to the pseudo-exponential nature of the isentropic compression, it is calculated that only moderate injection pressure (30 psig) is sufficient to overcome cylinder pressure as late as 90° after bottom dead center. Also it is a condition of no pressurization until the intake valve is completely closed as an approximation for intake flow at low RPM., Both are based on the geometry of a 326 cc per cylinder air-cooled, high speed test engine. If the duration of injection occurs entirely in the compression stroke, it is possible to recover the volumetric efficiency loss previously discussed. A power output improvement of 42% is possible. Partial overlap of injection into the intake stroke proportionally reduces this advantage. A problem exists if injection takes place in the vicinity of BDC due to late closure of the intake valve.

It is possible that backflow of hydrogen out the intake manifold may occur in the period between BDC and the point where the intake valve is fully shut. This can only occur to a significant degree at lower engine speeds (compared to the 10 RPM of maximum power), due to gas inertia in the intake manifold. The consequence of this is a small residual amount of hydrogen upstream of the intake valve. While this would make the system non-ideal, it is not anticipated to significantly alter the argument for backfire suppression.

Stratified charge formation may be valuable for very low overall ¢ mixtures as a means of achieving complete detonation. It is undesirable for mixtures approaching ¢=1. Optimum injector discharge direction and in-cylinder turbulence are required for higher pressure injection with timing closer to TDC. System control in direct injection schemes is similar to the manifold injection case.

It is possible that backflow of hydrogen out the intake manifold may occur in the period between

BDC and the point where the intake valve is fully shut. This can only occur to a significant degree at lower engine speeds (compared to the 10 RPM of maximum power), due to gas inertia in the intake manifold. The consequence of this is a small residual amount of hydrogen upstream of the intake valve. While this would make the system non-ideal, it is not anticipated to significantly alter the argument for backfire suppression. Saga and Furuhama and others have noted problems with adequate fuel-air mixing for injection timing positions late in the compression stroke. The heterogeneous fuel-air charge resulting after late injection can cause problems of erratic ignition and incomplete combustion.

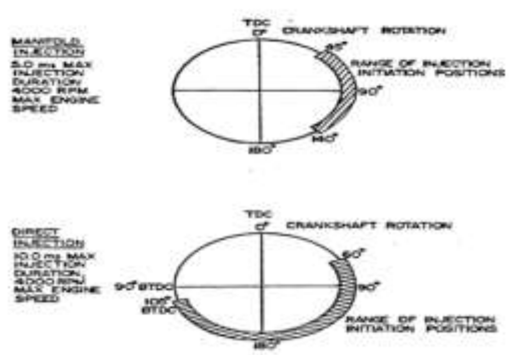


Fig.No.5 Timing Diagram from manifold injection and direct injection

7. HOMAN INJECTOR

The injector is shown in Fig. 6.

The principle specifications of the injector are given below:

l needle travel, 0.5 mm;

l hydrogen supply pressure, 10MPa;

Daphra material, spring steel;

l diaphragm thickness, 0.127 mm;

l diaphragm diameter, 50 mm to edge of clamped region;

l diaphragm designed for infinite life.

The injector is closed when the diaphragm is in its uppermost position and the diaphragm and needle assembly are supported individually in both the open and closed positions by the diaphragm backing plates, as shown in Fig. 2. The holes drilled in these plates are large enough to allow the flow of diesel oil and hydrogen onto the diaphragm, but small enough to ensure that the diaphragm is not unduly stressed. The surfaces of the backing pieces were roughened to prevent the diaphragm sealing against them and restricting the flow of the hydrogen, or diesel oil. When closed by the force of the hydrogen, the needle assembly elongates slightly under tension.

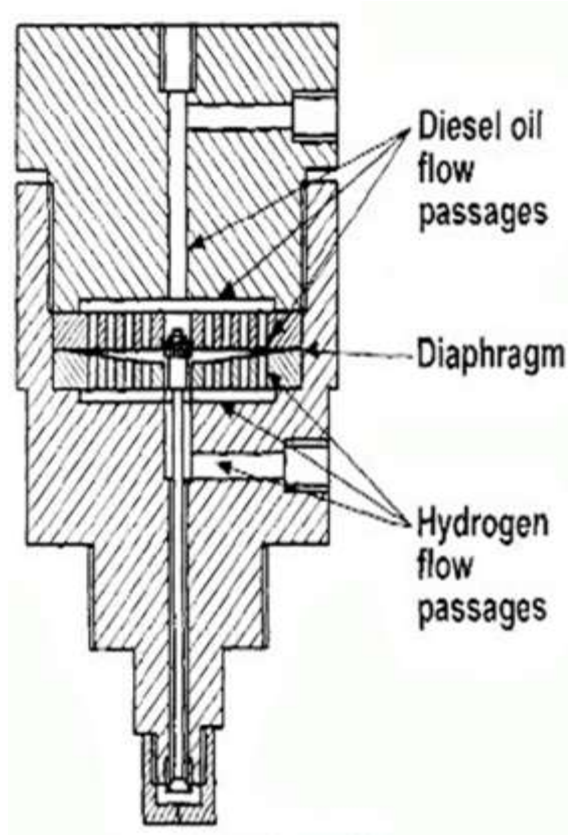


Fig. No. 6 Homan Injector

Conclusion:-

The energy is required for urea electrolysis is 35% less, which generated 40% cheaper hydrogen compared to water electrolysis. For this system, the exhaust gas is the water vapor. It does not emit carbon monoxide like the normal fuel-based engine so this ensures clean environment for people. Again, one litter of urine can give you six hours of electricity. The source of urine is naturally available from human being and cattle so there is availability of hydrogen easily. Using an electrolytic approach to produce hydrogen from urine is the most abundant waste on Earth at a fraction of the cost of producing hydrogen from water. The hydrogen gas gives many more application in all the fields such as in cars, vehicle and also used to burned either to provide heat. But it required special arrangement. It is used to drive turbine, in internal combustion engines for motive and electrical power. Urea naturally hydrolyses into ammonia before generating gas phase ammonia emissions. These emissions lead to the formation of ammonium sulphate and nitrate particulates in the air, which cause a variety of health problems including chronic bronchitis, asthma attacks and premature death.

Acknowledgements:-

The present work is just an effort to throw some light on the topic related to **"THE URINE ENGINE"**. The work would not have been possible to come to present shape without the guidance, supervision and help of people. With deep sense of gratitude I convey my heartfelt thanks to all of those people who helped and supported me during the course of completion of my research. Lastly I would like thank all those who helped me any how in any way in my project work. It will be grateful work for me in completion of my research.

References:-

1) Bryan K. Boggs, Rebecca L. King and Gerardine G. Botte "Urea electrolysis: direct hydrogen production from urine" 11th June 2009.
2) Yogendra G. Nandagaoli, Rasika R. Kakade "The Urine Engine" Feb, 2014.
3) C.J. RALLIS, HABBITTS and R.van DlJK "A HYDRAULICALLY CONTROLLED DIAPHRAGM-TYPE HYDROGEN GAS INJECTOR" March, 1997.
4) K.S. VARDE and G.A. FRAME "DEVELOPMENT OF A HIGH-PRESSURE HYDROGEN INJECTION FOR SI ENGINE AND RESULTS OF ENGINE BEHAVIOR" 4 April, 1985.
5) Dr.Neel Sirosh "Hydrogen Composite Tank Program" June, 2002.