Collaborative Learning in Designing and Developing Hydrogen Reinforced Gas for Household and Industry Work

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Abstract: Collaborative learning in implementing engineering projects becomes important when many fields of science and engineering are combined. A product development requires information from mechanical engineering, Chemistry domain, electronics engineering, thermal engineering and material science engineering. The fertilization of ideas from all domains helps in designing the components reliably. Collaborative learning and information exchange over the social media or discussion forums yield diverse ideas and promote lateral thinking. One such project is developed by seeking inputs throughout the globe by web portals and internet for developing a gas torch burner and induction stove which works efficiently on Hydrogen derived from water. Hydrogen-gas torch burner and induction stove offer the promise of significantly reducing the amount of pollutants exhausted into the environment. Furthermore, hydrogen can be generated from any of a number of diverse energy sources, including hydrocarbon, nuclear, solar and wind, thereby helping address energy security as well as environmental concerns. The technology needed to store hydrogen fuel onboard and deliver it to the engine system is different from what consumers, mechanics, fire safety personnel, the public, although these component present new challenges, government, industry, and the public expect that they will not be more hazardous to own and operate than conventional other present gas torch.

The primary components within the hydrogen gas storage subsystem are the compressed-hydrogen gas containers. Because the hydrogen gas has a low energy density per unit volume, storage containers must be designed to supply an adequate amount of hydrogen to achieve realistic welding and cooking ranges. A hydrogen gas container increases weight and cost to the present gas torch and induction stove so its big challenge of achieving desirable welding and cooking ranges. To overcome these limitations in this work by hydrogen gas is produced continuously by electrolysis process the hydrogen gas is generated at cathode end with help of KOH solution and it is directly passes through a series of piping system, valves and filters. This gas flows through the pipe and comes out from the outlet nozzle of induction stove and welding torch. Hydrogen combustion is the process by which hydrogen reacts with an oxidizing agent (a compound that supports or causes combustion of other materials) and burns. Hydrogen combustion is exothermic combustion, which means it releases heat and energy. Hydrogen gas is highly flammable and will burn in air at a very wide range of concentrations between 4% and 75% by volume so which helps to produce the power required to light the gas torch. Benefit of using hydrogen as a fuel is that an ease of availability then the gasoline. This results into increase to make use of the kit and hydrogen gas for household and industry work.

Key Words: *Collaborative Learning, Hydrogen, Water, Welding and Cooking, Discussion Forum, Internet, Social Media.*

I. INTRODUCTION TO HYDROGEN

Hydrogen is the chemical element with atomic number 1. It is represented by the symbol H. With an atomic weight of 1.00794 u (1.007825 u for Hydrogen-1), hydrogen is the lightest and most abundant chemical element, constituting roughly 75 % of the Universe's elemental mass. Stars in the main sequence are mainly composed of hydrogen in its plasma state. Naturally occurring elemental hydrogen is relatively rare on Earth.

The most common isotope of hydrogen is protium (name rarely used, symbol H) with a single proton and no neutrons. In ionic compounds it can take a negative charge (an anion known as a hydride and written as H^-), or as a positively charged species H^+. The latter cation is written as though composed of a bare proton, but in reality, hydrogen cations in ionic compounds always occur as more complex species. Hydrogen forms compounds with most elements and is present in water and most organic compounds. It plays a particularly important role in acid-base chemistry with many reactions exchanging protons between soluble molecules. As the simplest atom known, the hydrogen atom has been of theoretical use. For example, as the only neutral atom with an analytic solution to the Schrödinger equation, the study of the energetic and bonding of the hydrogen atom played a key role in the development of quantum mechanics.

Hydrogen gas (now known to be H_2) was first artificially produced in the early 16th century, via the mixing of metals with strong acids. In 1766–81, Henry Cavendish was the first to recognize that hydrogen gas was a discrete substance, and that it produces water when burned, a property which later gave it its name, which in Greek means "water-former." At standard temperature and pressure, hydrogen is a colorless, odorless, nonmetallic, tasteless, highly combustible diatomic gas with the molecular formula H_2.

Industrial production is mainly from the steam reforming of natural gas, and less often from more energy-intensive hydrogen production methods like the electrolysis of water. Most hydrogen is employed near its production site, with the two largest uses being fossil fuel processing (e.g., hydro cracking) and ammonia production, mostly for the fertilizer market.

Hydrogen is a concern in metallurgy as it can embrittle many metals, complicating the design of pipelines and storage tanks.

A. Physical Properties

Color: colorless
Phase: gas
Density (0 °C, 101.325 kPa) 0.08988 g/L
Liquid density at m.p: 0.07 (0.0763 solid)[2] g·cm^{-3}
Melting point: 14.01 K , -259.14 °C, -434.45 °F
Boiling point: 20.28 K-252.87 ° ,C , -423.17 °F
Triple point13.8033 K (-259°C), 7.042 kPa
Critical point32.97 K, 1.293 MPa
Heat of vaporization (H_2) 0.904 kJ·mol^{-1}
Specific heat capacity (25 °C) (H_2) 28.836 J·mol^{-1}·K^{-1}

B. Hydrogen Cooling

For large turbo-generators, hydrogen is commonly used as a cooling medium in a closed circuit. The following properties of hydrogen make it most suited for this purpose.

1. Hydrogen has a density of 1/14 of that of air at the same temperature and pressure, reducing thereby wind age losses and noise.
2. On an equal weigh basis, the specific heat of hydrogen is 14 times that of air. Therefore, for the same temperature and pressure, the heat-storing capacity/unit volume of hydrogen is the same as that of air.
3. The heat transfer capability of hydrogen is seven times that of air.
4. By use if hydrogen environment, the life of insulation is prolonged and the maintenance cost goes down because of the absence of dirt, moisture and oxygen.
5. The hydrogen air mixture does not explode so long as air content is less than 30%.

To avoid air leaking into the hydrogen circuit, hydrogen pressure is maintained above 1atm. Hydrogen cooling at 1,2 and 3 atm can raise the rating of a machine by 15, 30 and 40% respectively. Hydrogen cooling reduces the temparature and resistance of windings and hence the losses to be dissipated, this fact marginally raise the full-load efficiency of the machine.

The machine and its water cooled heat exchanger for cooling hydrogen are enclosed in a gas-tight envelop; the moset intricate problem being that of sealing the bearings. Oil-filled gas-seals are used for this purpose. Further, the envelop must be explosion-proof.

C. Liquid Petroleum Gases (L.P.G)

This is the name given to those mixtures of commercial butane and propane obtained from crude oil or its derivates, or from natural gas. Table lists the physical and chemical characteristics of butane and propane.

GAS VARIABLES	PROPANE	BUTANE
Chemical formula	C3 H8	C4 H10
Molecular weight	44	58
Specific weight	0.510 Kg/l	0.580 kg/l
Boiling point	- 43 °C	0.5 °C
Low heat value	11070 Kcal/ Kg	10920 Kcal/Kg
Fire point °C	510 °C in air	490 °C in air
Ignition limits as % of volume	2.1 – 9.5	1.5 – 8.5
Burning velocity (cm/sec)	32 in air	32 in air

II. PRODUTCTION OF HYDROGEN

Hydrogen is produced by electrolysis process. Two stainless steel are used which is dipped in the electrolyte solution and the electrolyte used is baking soda (Sodium Bicarbonate).

12V ,10 A current is applied to the electrodes ,as the current is passed to the electrodes ionic transfer takes place from cathode to anode H^+ ions are moved to cathode end and 0- ions are moved to anode . Now at the surface of the container HHO gas gets collected, this gas is taken out from the outlet of the airtight container and is passed through a silica gel filter which absorbs the moisture from the gas and allows only dry HHO gas through it .now this gas is mixed with LPG gas and passed into the intake manifold . As the flame speed of the hydrogen gas is high it improves the combustible properties and hence helps to increase the efficiency of the engine .The engine flywheel is coupled to an alternator which produces alternating current

A. Pressure Reducer Kit

Installing an L.P.G system requires both expertise and a sense of responsibility. Inability, negligence or non compliance with the regulations in force can be EXTREMELY DANGEROUS. It is obviously necessary for the installer to understand the characteristics of L.P.G and to have an in-depth knowledge of the components of the system so as to be able to install it correctly and carry out maintenance. This manual provides the installer with all the information necessary and useful to successfully install the system and keep it in good order.

Objective:

The oxy-acetylene flame has been used very widely in industry for many years and enjoys several positive characteristics including a high combustion temperature, wide availability, trained workforce and process versatility. However, it also has some drawbacks which are becoming more significant with increasing health and safety and environmental concerns; having significant quantities of highly combustible gases is undesirable; dedicated training on safety aspects of handling oxyacetylene; the production and transportation of large quantities of combustible gas is damaging to the environment. In project SafeFlame, an alternative to oxy-acetylene heating will be developed, validated and exploited, particularly for SME fabricators. Oxy-hydrogen flames can be generated by the combustion of oxygen and hydrogen produced locally using an electrochemical cell. This approach has the following advantages over oxy-acetylene heating:

1. The cell is highly portable, reducing transportation costs and increasing the flexibility of the process.

2. The fuel is water which is widely available and low cost.

3. The process requires electricity to generate the gases but is >60% efficient. Storage of combustible gas is eliminated

4. The system can be deployed flexibly and is cost-effective compared with oxy-acetylene.

5. Control over the combustion process will enable reducing or oxidizing conditions to prevail during the heating process.

6. The aim is to develop and validate the use of oxy-hydrogen combustion as an alternative to oxy-acetylene, for applications which could include precision welding, brazing and soldering, cutting, repair and heat treatment. The project will involve the specification of the required heating for a given application, different design(s) of electrolyser, the design of heating torch (including process modeling) tailored to the application, product integration, process trials and validation, the development of case studies, dissemination activities and training.

B. Electrolysis of Water

Electrolysis of water is the decomposition of water (H_2O) into oxygen (O_2) and hydrogen gas (H_2) due to an electric current being passed through the water.

Principle:

An electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum or stainless steel) which are placed in the water. In a properly designed cell, hydrogen will appear at the cathode (the negatively charged electrode, where electrons enter the water), and oxygen will appear at the anode (the positively charged electrode). Assuming ideal faradic efficiency, the amount of hydrogen generated is twice the number of moles of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells competing side reactions dominate, resulting in different products and less than ideal faradic efficiency.

Electrolysis of *pure* water requires excess energy in the form of over potential to overcome various activation barriers. Without the excess energy the electrolysis of *pure* water occurs very slowly or not at all. This is in part due to the limited self-ionization of water. Pure water has an electrical conductivity about one millionth that of seawater. Many electrolytic cells may also lack the requisite electro catalysts. The efficacy of electrolysis is increased through the addition of an electrolyte (such as a salt, an acid or a base) and the use of electro catalysts.

Currently the electrolytic process is rarely used in industrial applications since hydrogen can be produced more affordably from fossil fuels.

C. Equations

In the water at the negatively charged cathode, a reduction reaction takes place, with electrons (e^-) from the cathode being given to hydrogen cations to form hydrogen gas (the half reaction balanced with acid):

Cathode (reduction): $2\ H^+(aq) + 2e^- \rightarrow H_2(g)$

At the positively charged anode, an oxidation reaction occurs, generating oxygen gas and giving electrons to the anode to complete the circuit:

Anode (oxidation): $2\ H_2O(l) \rightarrow O_2(g) + 4\ H^+(aq) + 4e^-$

The same half reactions can also be balanced with base as listed below. Not all half reactions must be balanced with acid or base. Many do like the oxidation or reduction of water listed here. To add half reactions they must both be balanced with either acid or base.

Cathode (reduction): $2\ H_2O(l) + 2e^- \rightarrow H_2(g) + 2\ OH^-(aq)$

Anode (oxidation): $4\ OH^-(aq) \rightarrow O_2(g) + 2\ H_2O(l) + 4\ e^-$

Combining either half reaction pair yields the same overall decomposition of water into oxygen and hydrogen:

Overall reaction: $2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$

The number of hydrogen molecules produced is thus twice the number of oxygen molecules. Assuming equal temperature and pressure for both gases, the produced hydrogen gas has therefore twice the volume of the produced oxygen gas. The number of electrons pushed through the water is twice the number of generated hydrogen molecules and four times the number of generated oxygen molecules.

III. THERMODYNAMICS OF THE PROCESS

Decomposition of pure water into hydrogen and oxygen at standard temperature and pressure is not favorable in thermo dynamical terms.

Anode (oxidation): $2\ H_2O(l) \rightarrow O_2(g) + 4\ H^+(aq) + 4e^-$ Eoox = -1.23 V

Cathode (reduction): $2\ H^+(aq) + 2e^- \rightarrow H_2(g)$ Eored = 0.00 V

Thus, the standard potential of the water electrolysis cell is -1.23 V at 25 °C at pH 0 ($H^+ = 1.0$ M). It is also -1.23 V at 25 °C at pH 7 ($H^+ = 1.0 \times 10^{-7}$ M) based on the Nernst Equation.

The negative voltage indicates the Gibbs free energy for electrolysis of water is greater than zero for these reactions. This can be found using the $G = -nFE$ equation from chemical kinetics, where n is the moles of electrons and F is the Faraday constant. The reaction cannot occur without adding necessary energy, usually supplied by an external electrical power source.

A. Electrolyte Selection

Hoffman voltameter connected to a direct current power supply. If the above described processes occur in pure water, H^+ cations will accumulate at the anode and OH^- anions will accumulate at the cathode. This can be verified by adding a pH indicator to the water: the water near the anode is acidic while the water near the cathode is basic. The negative hydroxyl ions that approach the anode mostly combine with the positive hydronium ions (H_3O^+) to form water. The positive hydronium ions that approach the negative cathode mostly combine with negative hydroxyl ions to form water. Relatively few hydronium (hydroxyl) ions reach the cathode (anode). This can cause a concentration overpotential at both electrodes.

Pure water is a fairly good insulator since it has a low autoionization, $K_w = 10 \times 10^{-14}$ at room temperature and thus pure water conducts current poorly, 0.055 $\mu S \cdot cm^{-1}$. Unless a very large potential is applied to cause an increase in the autoionization of water the electrolysis of pure water proceeds very slowly limited by the overall conductivity.

If a water-soluble electrolyte is added, the conductivity of the water rises considerably. The electrolyte disassociates into cations and anions; the anions rush towards the anode and neutralize the buildup of positively charged H^+ there; similarly, the cations rush towards the cathode and neutralize the buildup of negatively charged OH^- there. This allows the continued flow of electricity.

Care must be taken in choosing an electrolyte, since an anion from the electrolyte is in competition with the hydroxide ions to give up an electron. An electrolyte anion with less standard electrode potential than hydroxide will be oxidized instead of the hydroxide, and no oxygen gas will be produced. A cation with a greater standard electrode potential than a hydrogen ion will be reduced in its stead, and no hydrogen gas will be produced.

The following cations have lower electrode potential than H^+ and are therefore suitable for use as electrolyte cations: Li^+, Rb^+, K^+, Cs^+, Ba^{2+}, Sr^{2+}, Ca^{2+}, Na^+, and Mg^{2+}. Sodium and lithium are frequently used, as they form inexpensive, soluble salts.

If an acid is used as the electrolyte, the cation is H^+, and there is no competitor for the H^+ created by disassociating water. The most commonly used anion is sulfate (SO2−4), as it is very difficult to oxidize, with the standard potential for oxidation of this ion to the peroxodisulfate ion being −2.05 volts.

Strong acids such as sulfuric acid (H_2SO_4), and strong bases such as potassium hydroxide (KOH), and sodium hydroxide (NaOH) are frequently used as electrolytes.

A solid polymer electrolyte can also be used such as NAFION and when applied with a special catalyst on each side of the membrane can efficiently split the water molecule with as little as 1.8 Volts.

IV. FUTURE SCPOE

A. Hydrogen as Future Fuel

Hydrogen is seen as one of the important energy vectors of this century. Hydrogen as an energy carrier, provides the potential for a sustainable development particularly in the transportation sector. A hydrogen fueled engine has the potential for substantially cleaner emissions than other internal combustion engines.. Other benefits arise from the wide flammability limits and the high flame propagation speed, both allowing better efficiency.

Hydrogen is the most plentiful and ubiquitous substance in the universe, representing about half of all matter, and it is everywhere—in the rocks and soil, in the air and especially in the water that covers three quarters of the globe.

Hydrogen is a gas at normal temperatures. It is highly reactive, combining readily with a number ofelements and compounds, the most familiar example being oxygen to form water (H20). The 2H + O = H20 (hydrogen plus oxygen equals water) combustion reaction is highly charged, explosive, producing a great deal of heat as a by product, thus making hydrogen a true competitor with fossil fuels as a source of power. .

The same reactive quality that makes hydrogen a good fuel source, however, also makes free hydrogen rare in nature—it is almost always found bound to other chemicals. One of the challenges, then, of moving to a hydrogen energy regime is to develop economical ways of freeing hydrogen from the chemicals to which it is bonded so it can be used as a fuel, then returned to nature.

While there are many compounds containing hydrogen and, thus, many methods for its extraction—too many to go into here—the ideal, and certainly most universally available source is water itself. Extracting hydrogen from water is simple enough, in principle, through a technique known as electrolysis in which an electrical current is passed through water breaking down its molecules in to their component hydrogen and oxygen ions, both of which can be put to various uses.

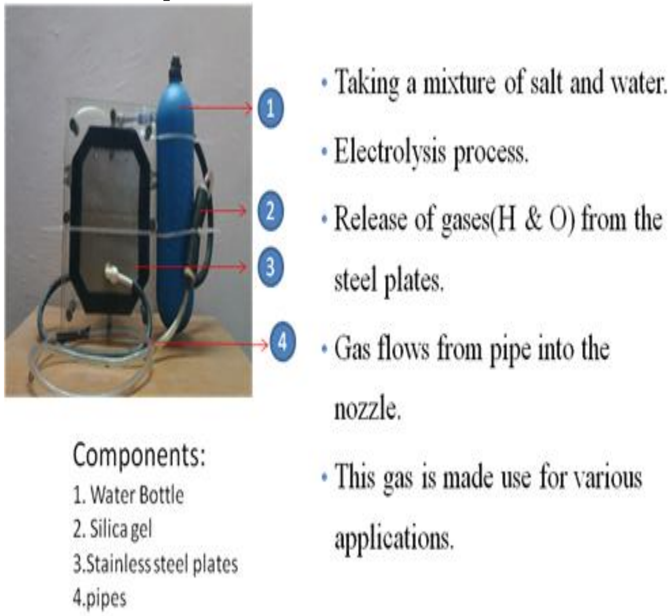

Figure 1: Diagram of the kit

CONCLUSION

Gasoline when blended with Hydrogen efficiency can be improved. Since hydrogen is a highly combustible gas and has got more flame front velocity which helps to burn the unburnt charge.

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