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Investigation on the application of using hydrogen fuel for furnaces

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Abstract. The threat posed by climate change and the striving for security of energy supply are issues high on the political agenda these days. Governments are putting strategic plans in motion to decrease primary energy use, take carbon out of fuels and facilitate modal shifts. Taking a prominent place in these strategic plans is hydrogen and enriched fuel by hydrogen as a future energy for industrial. Now there are a lot of industrial burners that working by fossil fuel. Industrial units and refineries are now using to fossil-fueled burners but there is an idea which hydrogen or enriched fossil fuel by hydrogen are used as an alternative of fossil fuel to decrease local pollution at an affordable cost , saving , capture and storage fossil fuel as a strategic energy. This article offers an overview of hydrogen & enriched fuel as an alternative energy for future. Topics that are discussed include fundamentals of the hydrogen content, effect of blending hydrogen with fossil fuel on their emissions characteristics, a state of the art on increasing power output and efficiency.

Keywords:enriched fossil fuel by hydrogen , hydrogen energy and capture and storage fossil fuel

1. Introduction

In the last years a global process of sensitization about the fundamental problems related to energetic sources and their environmental impact has been observed. Since economies based on alternative energetic sources with respect to fossil fuels are not expected to be competitive in the next decades, many researchers have focused their studies on new technologies for a better utilization of fossil fuels in terms of both thermal process efficiency and environmental impact. The current way of providing the world's energy demand, based primarily on fossil fuel, is becoming increasingly untenable. Fossil fuel reserves, once hardly ever given a second thought, now are clearly exhaustible. Fossil fuel prices have never been more volatile, influenced first by economic acceleration mostly in China and India and subsequently by economic recession. The difficulty of controlling prices and the uncertain reserves are strong incentives for pursuing energy security. Global warming and local pollution hot spots associated with fossil fuel usage are further significant environmental and societal problems. These are strong drivers for research, development and demonstrations of alternative energy sources, energy carriers and energy demanding of industries for their equipments except burners. The use of hydrogen as an energy is one of the options put forward in most governmental strategic plans for a sustainable energy system. The attractiveness of hydrogen lies in the variety of methods to produce hydrogen as well as the long-term viability of some of them (from fossil fuels, from renewable energy: biomass, wind, solar [1], from nuclear power etc.), the variety of methods to produce energy from hydrogen (internal combustion engines, gas turbines, fuel cells, using hydrogen as fuel for industrial burners), virtually zero harmful emissions and potentially high efficiency at the point of its use. Compared to fossil fuels , using hydrogen as an energy is advantageous in terms of volumetric and gravimetric energy storage density and ignition energy. Also, in case of hydrogen-fueled vehicles, care must be taken to ensure that the Well-to-wheel greenhouse gas emission reduction compared to hydrocarbon fuel turns out to be positive [2]. Nevertheless, the advantages offered by hydrogen are significant enough to warrant the exploration of its possibilities[3].

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2. Fundamentals

Hydrogen is by far the most plentiful element in the universe, making up 75% of the mass of all visible matter in stars and galaxies. Hydrogen is the simplest of all elements. You can visualize a hydrogen atom as a dense central nucleus with a single orbiting electron, much like a single planet in orbit around the sun. Scientists prefer to describe the electron as occupying a "probability cloud" that surrounds the nucleus somewhat like a fuzzy, spherical shell [4].

2.1. Physical property

Pure hydrogen is odorless, colorless and tasteless. A stream of hydrogen from a leak is almost invisible in daylight. Compounds such as Mercaptans and Thiophanes that are used to scent natural gas may not be added to hydrogen for fuel cell use as they contain sulfur that would poison ‹the fuel cells. Hydrogen that derives from reforming other fossil fuels by nitrogen, carbon dioxide, carbon monoxide and other trace gases. In general, all of these gases are also odorless, colorless and tasteless. Hydrogen is non-toxic but can act as a simple asphyxiates by displacing the oxygen in the air.

Even as a liquid, hydrogen is not very dense. Ironically, every cubic meter of water (made up of hydrogen and oxygen) contains 111 kg of hydrogen whereas a cubic meter of liquid hydrogen contains only 71 kg of hydrogen. Thus, water packs more mass of hydrogen per unit volume, because of its tight molecular structure, than hydrogen itself. This is true of most other liquid hydrogen-containing compounds as well; a cubic meter of methanol contains 100 kg of hydrogen and a cubic meter of heptane contains 113 kg. Hydrocarbons are compact hydrogen carriers with the added advantage of having higher energy density than pure hydrogen. When used as vehicle fuel, the low density of hydrogen necessitates ‹that a large volume of hydrogen be carried to provide an adequate driving range.

The molecules of hydrogen gas are smaller than all other gases, and it can diffuse through many materials considered airtight or impermeable to other gases. This property makes hydrogen more difficult to contain than other gases. 30 Leaks of liquid hydrogen evaporate very quickly since the boiling point of liquid hydrogen is so extremely low. Hydrogen leaks are dangerous in that they pose a risk of fire where they mix with air . However, the small molecule size that increases the likelihood of a leak also results in very high buoyancy and diffusivity, so leaked hydrogen rises and becomes diluted quickly, especially out-doors. This results in a very localized region of flammability that disperses quickly. As the hydrogen dilutes with distance from the leakage site, the buoyancy declines ‹and the tendency for the hydrogen to continue to rise decreases. Very cold hydrogen, resulting from a liquid hydrogen leak, becomes buoyant soon after is evaporates. In contrast, leaking gasoline or diesel spreads ‹laterally and evaporates slowly resulting in a widespread, lingering ‹fire hazard(risk). Propane gas is denser than air so it accumulates in low spots and disperses slowly, resulting in a protracted fire or explosion hazard. Heavy vapors can also form vapor clouds or plumes that travel as they are pushed by breezes ‹. Methane gas is lighter than air, but not nearly as buoyant as hydrogen, so it disperses rapidly, but not as rapidly as hydrogen. For small hydrogen leaks, buoyancy and diffusion effects in air are often overshadowed by the presence of air currents from a slight ambient wind, very slow vehicle motion or the radiator fan. In general, these currents serve to disperse leaked hydrogen even more quickly with a further reduction of any associated ‹fire hazard. When used as vehicle fuel, the propensity for hydrogen to leak necessitates special care in the design of the fuel system to ensure that any leaks can disperse with minimum hindrance , and the use of dedicated leak detection equipment on the vehicle and within the maintenance facility. Hydrogen leaks pose a potential fire hazard.

2.2. chemical property

High reactivity is characteristic of all chemical fuels. In each case, a chemical reaction occurs when the fuel molecules form bonds with oxygen (from air) so that the final, reacted molecules are at a lower energy state than the initial, un reacted molecules. Chemical reactions of hydrogen combustion often require a small amount of activation energy to get started, but then the energy re- leased by the reaction feeds further reaction in a domino effect. Thus, when a small amount of activation energy in the form of a spark is provided to a mixture of hydrogen and oxygen, the molecules react vigorously, releasing a substantial amount of heat, with water as the final product. We experience this reaction as a fire or explosion, and the resulting water vaporizes and is invisible to us since it is a superheated vapor.

Every fuel can liberate a fixed amount of energy when it reacts completely with oxygen to form water. This energy content is measured experimentally and is quantified by a fuel's higher heating value (HHV) and lower heating value (LHV). The difference between the HHV and the LHV is the "heat of vaporization" and represents the amount of energy required to vaporize a liquid fuel into a gaseous fuel, as well as the energy used to convert water to steam. Although the terms HHV and LHV do not apply to batteries, the energy density of a lead acid battery is approximately 46 Btu/lb (0.108 kJ/g).

Gaseous fuels are already vaporized so no energy is required to convert them to a gas. The water that results from both a combustive reaction and the electrochemical reaction within a fuel cell occurs as steam; therefore the lower heating value represents the amount of energy available to do external work. Both the higher and lower heating values denote the amount of energy (in Btu's or Joules) for a given weight of fuel (in pounds or kilograms). Hydrogen has the highest energy-to-weight ratio of any fuel since hydrogen is the lightest element and has no heavy carbon atoms. It is for this reason that hydrogen has been used extensively in the space program where weight is crucial.

Whereas the energy content denotes the amount of energy for a given weight of fuel, the energy density denotes the amount of energy (in Btu's or Joules) for a given volume (in ft^3 or m^3) of fuel. Thus, energy density is the product of the energy content (LHV in our case) and the density of a given fuel. The energy density is really a measure of how compactly hydrogen atoms are packed in a fuel. It follows that hydrocarbons of increasing complexity (with more and more hydrogen atoms per molecule) have increasing energy density. At the same time, hydrocarbons of increasing complexity have more and more carbon atoms in each molecule so that these fuels are heavier and heavier in absolute terms. On this basis, hydrogen's energy density is poor (since it has such low density) although its energy to weight ratio is the best of all fuels (because it is so light). The energy density of a lead acid battery is approximately 8700 Btu/ft^3 (324,000 kJ/m^3).

Three things are needed for a fire or explosion to occur: a fuel, oxygen (mixed with the fuel in appropriate quantities) and a source of ignition. Hydrogen, as a flammable fuel, mixes with oxygen whenever air is allowed to enter a hydro-gen vessel, or when hydrogen leaks from any vessel into the air. Ignition sources take the form of sparks, flames, or high heat.

The flammability range of a gas is defined in terms of its lower flammability limit (LFL) and its upper flammability limit (UFL). The LFL of a gas is the lowest gas concentration that will support a self-propagating ‹flame when mixed with air and ignited. Below the LFL, there is not enough fuel present to support combustion; the fuel/air mixture is too lean. The UFL of a gas is the highest gas concentration that will support a self-propagating flame when mixed with air and ignited. Above the UFL, there is not enough oxygen present to support combustion; the fuel/air mixture is too rich. Between the two limits is the flammable range in which the gas and air are in the right proportions to burn when ignited. One consequence of the UFL is that stored hydrogen (whether gaseous or liquid) is not flammable while stored due to the absence of oxygen in the cylinders. The fuel only becomes flammable in the peripheral areas of a leak where the fuel mixes with the air in sufficient proportions. Two related concepts are the lower explosive limit (LEL) and the upper explosive limit (UEL). These terms are often used interchangeably with LFL and UFL, although they are not the same. The LEL is the lowest gas concentration that will support an explosion when mixed with air, contained and ignited. Similarly, the UEL is the highest gas concentration that will support an explosion when mixed with air, contained and ignited. An explosion is different from a fire in that for an explosion; the combustion must be contained, allowing the pressure and temperature to rise to levels sufficient to violently destroy the containment. For this reason, it is far more dangerous to release hydrogen into an enclosed area (such as a building) than to release it directly outdoors. Hydrogen is flammable over a very wide range of concentrations in air (4 – 75%) and it is explosive over a wide range of concentrations (15 – 59%) at standard atmospheric temperature. The flammability limits increase with temperature . The flammability limits of comparative fuels are illustrated in Figure 1.

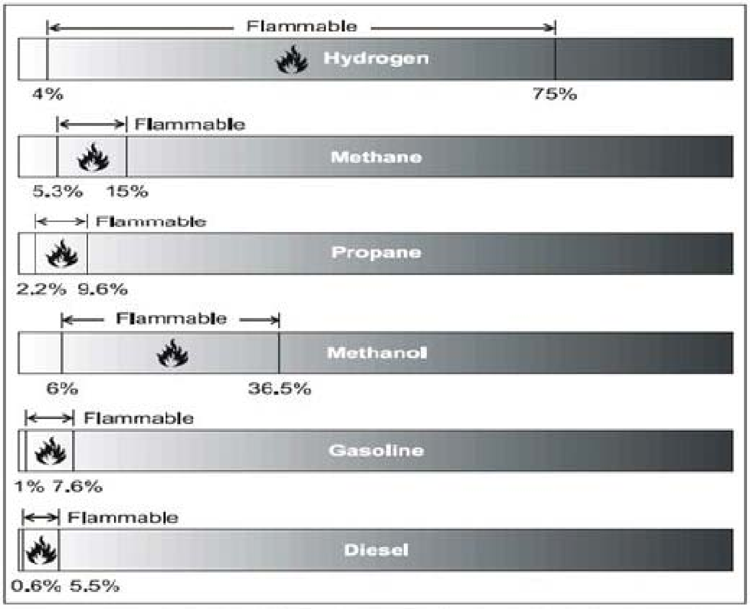

Figure 1 flammability range of comparative fuel

Source: College of the Desert, Palm Desert, CA, USA,” Hydrogen Fuel Cell Engines and Related Technologies,December 2001

Burning speed it the speed at which a flame travels through a combustible gas mixture. Burning speed is different from flame speed. The burning speed indicates the severity of an explosion since high burning velocities have a greater tendency to support the transition from deflagration to detonation in long tunnels or pipes. Flame speed is the sum of burning speed and displacement velocity of the unburned gas mixture. Burning speed varies with gas concentration and drops off at both ends of the flammability range. Below the LFL and above the UFL the burning speed is zero. The burning speed of hydrogen at 8.7–10.7 ft/s (2.65–3.25 m/s) is nearly an order of magnitude higher than that of methane or gasoline (at Stoichiometry conditions). Thus hydrogen fires burn quickly and, as a result, tends to be relatively short-lived.

The quenching gap (or quenching distance) describes the flame extinguishing ‹properties of a fuel when used in an internal combustion engine. Specifically, the quenching gap relates to the distance from the cylinder wall that the flame extinguishes due to heat losses. The quenching gap has no specific relevance for use with fuel cells. The quenching gap of hydrogen (at 0.025 in; 0.064 cm) is approximately 3 times less than that of other fuels, such as gasoline. Thus, hydrogen flames travel closer to the cylinder wall before they are extinguished making them more difficult to quench than gasoline flames. This smaller quenching distance can also increase the tendency for backfire since the flame from a hydrogen-air mixture can more readily ‹get past a nearly closed intake valve than the flame from a hydrocarbon-air mixture.

Hydrogen flames are very pale blue and are almost invisible in daylight due to the absence of soot. Visibility is enhanced by the presence of moisture or impurities (such as sulfur) in the air. Hydrogen flames are readily visible in the dark or subdued light. A hydrogen fire can be indirectly visible by way of emanating “heat ripples‹” and thermal radiation, particularly from large fires. In many instances‹, flames from a hydrogen fire may ignite surrounding materials that do produce smoke and soot during combustion. Hydrogen fires can only exist in the region of a leak where pure hydrogen mixes with air at sufficient concentrations. For turbulent leaks, air reaches the centerline of the leakage jet within about five diameters of a leakage hole, and the hydrogen is diluted to nearly the composition of air within roughly 500 to 1000 diameters. This rapid dilution implies that if the turbulent leak were into open air, the flammability zone would exist relatively close to the leak. Therefore, when the jet is ignited, the flame length is less than 500 diameters from the hole (for example, for a 0.039 in/1 mm diameter leak, the flame length will be less than 19.7 in/0.5 m) [3].

3. Hydrogen Environmental Effect

The lean-premixed combustion in gas turbines could be used for reducing carbon dioxide and nitrogen oxides emissions. A net reduction of CO2 emissions could be achieved using CO2- neutral bio-fuels, hydrogen-enriched fuels, using hydrogen from non-CO2 producing sources, by products of steel and coal industry (hydrogen and/or carbon monoxide). Previous studies showed that adding hydrogen to conventional fuels improves flame stability, yields leaner blowout limits, and reduces CO and NOx emissions. The use of hydrogen-enriched fuels allows operation under fuel-lean conditions where the emission of NOx is strongly reduced. These fuel mixtures could serve as a transition towards the longer term switch to carbon-free energy production [4].

4. Hydrogen Safety

No technology is absolutely safe! What is lightly heard here and there, ‘‘this or that is absolutely safe,’’ cannot, on principle, be justified from an engineering standpoint. Each technology is relatively safe, it has its specific safety standard which, of course, applies also to energy technologies and systems; hydrogen energy is not different. In any case, safety is a consequence of the specific science and engineering attributes of the technology in question, and, thus, its risks under operating conditions. Four categories are particularly interesting for the assessment of hydrogen safety:

(1) The diffusivity of hydrogen in air is very high

(2) The ignition energy of an ignitable hydrogen/oxygen mixture is very low

(3) The ignition range is wide

(4) Carbon compounds in hydrogen as well as radioactivity and radio toxicities are inexistent. Let's discuss: Like many non-hydrogen gas technologies, hydrogen installations need to be tight in order to prevent leaks or at least keep them as small as ever possible. Since hydrogen is the smallest element in the periodic table of elements and its affinity to oxygen is high, leak tightness is of utmost importance. If, however, leakage occurs or in an accident hydrogen is released to the outside, there is a good chance that no ignitable hydrogen/oxygen mixture is built, or that an ignitable mixture lacks a near-by ignition source, because hydrogen quickly disperses vertically upwards into the airy environment; its diffusivity in air is a powerful acceleration source and, thus, a (sort of) safety element. That is the case when hydrogen is handled in open spaces [5].

5. Results and Discussion

5.1. Combustive Properties of Hydrogen

The properties of hydrogen are detailed in Section 1. The properties that contribute to its use as a combustible fuel are its:

- High Energy Content

Specifically, the amount of energy liberated during the reaction of hydrogen, on a mass basis, is about 2.5 times the heat of combustion of common hydrocarbon fuels (gasoline, diesel, methane, propane, etc.) Therefore, for a given load duty, the mass of hydrogen required is only about a third of the mass of hydrocarbon fuel needed. The high energy content of hydrogen also implies that the energy of a hydrogen gas explosion is abou 2.5 times that of common hydrocarbon fuels. Thus, on an equal mass basis, hydrogen gas explosions are more destructive and carry further. However, the duration of a conflagration tends to be inversely proportional to the combustive energy, so that hydrogen fires subside much more quickly than hydrocarbon fires.

- Energy Density

The energy density of a fuel is also affected by whether the fuel is stored as a liquid or as a gas,

and if a gas, at what pressure. To put it into perspective:

• A 132-gal (500-L) diesel tank containing 880 lb (400 kg) of fuel is equivalent on an energy basis to a 2110 gal (8000 L) volume of hydrogen gas at 3600 psi (250 barg). This is a 16 times increase in volume, although the weight of the hydrogen is only 330 lb (150 kg), representing a decrease in fuel weight by a factor of about 2.8.

• The same diesel tank is equivalent to a 550-gal (2100-L) tank of liquid hydrogen. This is a 4.2 times increase in volume.

• If hydrogen is stored as a metal hydride, every kilogram of diesel fuel is replaced by approximately 4.5 kg of metal hydride to maintain the same hydrogen/diesel energy equivalence. Thus the same 132 gal (500 L) diesel tank containing 880 lb (400 kg) of fuel would have to be re-placed with a hydride tank containing 3800 lb (1725 kg) of "fuel" mass.

- Wide Flammability Range

Hydrogen has a wide flammability range in comparison with all other fuels. As a result, hydrogen can be combusted in an internal combustion engine over a wide range of fuel-air mixtures. A significant advantage of this is that hydrogen can run on a lean mixture. A lean mixture is one in which the amount of fuel is less than the theoretical, Stoichiometry or chemically ideal amount needed for combustion with a given amount of air. This is why it is fairly easy to get an engine to start on hydrogen.

Generally, fuel economy is greater and the combustion reaction is more complete when a vehicle is run on a lean mixture. Additionally, the final combustion temperature is generally lower, reducing the amount of pollutants, such as nitrogen oxides, emitted in the exhaust. There is a limit to how lean the engine can be run, as lean operation can significantly reduce the power output due to a reduction in the volumetric heating value of the air/fuel mixture. Hydrogen is flammable over a very wide range of concentrations in air (4 – 75%) and it is explosive over a wide range of concentrations (15 – 59%) at standard atmospheric temperature.it means ,hydrogen can be used over (4-15%) for combustion like a usual fuel. Hydrogen has the ability to burn at extremely lean equivalence rations. Hydrogen will burn at mixtures seven times leaner than gasoline and five times leaner than methane [6]. This lower limit is governed by the Le Chatelier Principle [7].

- low ignition energy

Hydrogen has very low ignition energy. The amount of energy needed to ignite hydrogen is about one order of magnitude less than that required for gasoline. This enables hydrogen engines to ignite lean mixtures and ensures prompt ignition.

- high auto ignition temperature
- high flame speed at Stoichiometry ratios

Hydrogen has high flame speed at Stoichiometry ratios. Under these conditions, the hydrogen flame speed is nearly an order of magnitude higher (faster) than that of gasoline. This means that hydrogen engines can more closely approach the thermodynamically ideal engine cycle. At leaner mixtures, however, the flame velocity decreases significantly. The flame velocity of hydrogen is much faster than other fuels allowing oxidation with less heat transfer to the surroundings. This improves thermal efficiencies. Efficiencies are also improved because hydrogen has a very small gap quenching distance allowing fuel to burn more completely. The only drawback to hydrogen is that even though its lower heat value is greater than other hydrocarbon fuels it is less dense therefore a volume of hydrogen contains less energy [6,8].

- High Diffusivity

Hydrogen has very high diffusivity. This ability to disperse in air is considerably greater than gasoline and is advantageous for two main reasons. Firstly, it facilitates the formation of a uniform mixture of fuel and air. Secondly, if a hydrogen leak develops, the hydrogen disperses rapidly. Thus, unsafe conditions can either be avoided or minimized improving Flame Characteristics. In many respects, hydrogen fires are safer than gasoline fires. Hydrogen gas rises quickly due to its high buoyancy and diffusivity.

5.2. Enviromental effect

- Comparison hydrocarbon and hydrogen effect in environment

All of the atoms present at the start of a reaction are present at the end of the reaction although they may be reorganized into different molecules. Hydrocarbon fuels, in addition to hydrogen and carbon, may contain other impurities such as sulfur. Air, in addition to being a ready source of oxygen, also consists of 78% nitrogen and 1% trace gases. The presence of carbon, nitrogen and sulfur (as well as un reacted hydrocarbons) result in chemical compounds during combustion that cause smog with serious health and environmental consequences:

a) Oxygen reacts with carbon to form carbon monoxide (CO) and carbon dioxide (CO2).

CO2 is benign to human beings and does not produce smog, but is a greenhouse gas and contributes to global warming. CO, on the other hand, is poisonous to humans and severely limits the blood's ability to transport oxygen to body tissues resulting in dizziness, headaches, impaired coordination and death. The formation of CO is favored by lack of air during combustion and therefore leaner running engines emit less CO. Any reduction in CO formation is accompanied by a proportional increase in CO2 formation.

b) Oxygen reacts with nitrogen to form oxides of nitrogen (NOx). Oxides of nitrogen damage lung tissue and act as a precursor to ozone, which irritates the respiratory tract and eyes, decreases the lungs' ability to work, and causes both cough and chest pain. The formation of NOx is favored by high combustion temperatures (2700 ºF; 1480 ºC); thus, advanced ignition and increased pressure ratios tend to increase NOx emissions since these increase the combustion temperature. Lean burning engines typically reduce NOx emissions. Diesel engines, however, generate high NOx emissions when operating lean under low load conditions.

c) Oxygen reacts with sulfur to form oxides of sulfur (SOx). Sulfur also forms the basis for soot, which is a form of particulate matter. Large soot particles are visible and can be filtered out of the air, or coughed out of the respiratory system. Very small soot particles (<2.5 microns) are not visible and can lodge in the lungs and cause cancer.

d) Hydrocarbon emissions pass into the atmosphere through incomplete combustion and evaporation. Hydro-carbons are either volatile organic compounds (VOC's) or reactive hydrocarbons (RHC). The RHC's, such as gasoline, produce photochemical smog (visual pollution). VOC's, such as natural gas, do not produce smog. Unburned hydrocarbons act as precursor to ozone just like NOx emissions.

The type of fuel and the use of post-combustion catalytic converters affect the amount and type of smog pollution. Light hydrocarbons are relatively rich in hydrogen and therefore provide less carbon atoms for CO and CO2 formation. Non sulfur containing fuels eliminate SOx and soot.

Hydrogen is a nearly ideal fuel in terms of smog reduction when combusted. Hydrogen contains no carbon or sulfur, so no CO, CO2 or SOx or soot is produced during combustion (although the combustion of lubricating oil may result in trace amounts). Hydrogen allows for leaner combustion, resulting in lower combustion temperatures and very low NOx emissions. Hydrogen is non toxic so un combusted hydrogen does not pose a direct health risk.

Hydrogen is an ideal fuel in terms of smog reduction when used electrochemically in a fuel cell, rather than combusted. Hydrogen in a fuel cell produces zero harmful emissions. Oxides of nitrogen are completely eliminated due to the low operating temperature (175 ºF; 80 ºC) of the cells. Lubricating oil is not present and is therefore not reacted [4].

5.3. Hydrogen safety

- As the lightest and smallest element in the universe, confining hydrogen is very difficult. Hydrogen is much lighter than air and rises at a speed of almost 20 meters per second — two times faster than helium and six times faster than natural gas — which means that when released, it rises and disperses quickly.
- Combustion cannot occur in a tank or any contained location that contains only hydrogen. An oxidizer, such as oxygen, must be present.
- Hydrogen is odorless, colorless, and tasteless and therefore undetectable by human senses. For these and other reasons, industry designs systems with ventilation and leak detection. Natural gas is also odorless, colorless, and tasteless, but industry adds a sulfur-containing odorant so people can detect it. These odorants are not used with hydrogen, however, because there is no known odorant light enough to "travel with" hydrogen, and at the same dispersion rate. Current odorants also contaminate fuel cells, a popular hydrogen

application.

• Hydrogen burns very quickly. Under optimal combustion conditions, the energy required to initiate hydrogen combustion is significantly lower than that required for other common fuels, such as natural gas or gasoline. At low concentrations of hydrogen fuel in air, the energy required to initiate combustion is similar to that of other fuels.

• Hydrogen flames have low radiant heat. A hydrogen fire has significantly less radiant heat when compared to a hydrocarbon fire. Since low levels of heat are emitted near a hydrogen flame (the flame itself is just as hot), the risk of secondary fires is lower.

• With the exception of oxygen, any gas can cause asphyxiation in high enough concentrations. In most scenarios, however, because hydrogen rises and disperses so rapidly, it is unlikely to be confined where asphyxiation might otherwise occur.

• Hydrogen is non-toxic and non-poisonous. It will not contaminate groundwater (it's a gas under normal atmospheric conditions), and a release of hydrogen is not known to contribute to atmospheric pollution or water pollution [10].

6. Conclusions

Combustion of fossil fuels has caused serious problems to the environment and the geopolitical climate of the world. The main negative effects on the environment by fossil fuel combustion are emissions of NOx, CO, CO2, and unburned hydrocarbons. The main negative effect of burning fossil fuel on the geopolitical climate is the lack in supply of these fuels and the effect pollution has on politics. Introduction of hydrogen into the combustion process using hyadrogen and enriched fuel by hydrogen improve flame stability , Increase thermal efficiency and decrease fuel consumption, Decrease carbon monoxide and unburned hydrocarbon emissions, Increase NOx emissions unless proper timing and mixture adjustments are used when temperature is too high, challenge to using hydrogen as a supplemental fuel is the storage and generation, reduce Nox (at low temperature) &CO2 emission hydrogen and hydrogen enriched by fuel can be an alternative green fuel to reduce pollution, increasing efficiency and saving fossil fuel as a strategic problems.

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