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HYDROGEN: A Backup Fuel for the Next Generation . . .

KEYWORDS

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ABSTRACT *In the present scenario the demands of petroleum products as fuels, are increasing exponentially. Statistics says that the current oil production in the world is about 25 billion barrels of oil per year, the figure that not only shocks but also makes us realize the immense pollution and carbon footprint that are created over the decades. Our huge dependency on the hydrocarbon based gasoline, has not only left us with the fear of hazardous impacts but their predicted decrease would further escalate the petroleum prices and has forced us to look for some alternatives. Out of various alternatives hydrogen has been claimed to be a good one to replace fossil fuel.*

This paper presents an overview about the successes that have been achieved in the recent researches that are making hydrogen an efficient alternate or infact a future fuel for the vehicles. Its most peculiar characteristic is that it is the cleanest fuel of all alternatives. While deriving energy, hydrogen gets oxidized and only produces water molecules which are free from any kind of emissions. As far as the availability is concerned, SunHydro is the world's first chain of privately funded fueling stations that provide hydrogen to fuel cell cars. Discovery of air stable Mg nano composites at Berkely Lab, concept of using hydrogen-methane mixture as a fuel, discovery of CS bacterium and many others are some of the fantastic researches going on in the world of hydrogen economy. As a result of success, many automobile manufacturers like Hyundai , Honda ,Mercedes-Benz and BMW have already demonstrated different models in the market and a lot more are still under research.

INTRODUCTION:

In the present scenario, the demands of petroleum products as fuels are increasing exponentially. Statistics says that the current oil production in the world is about 25 billion barrels per year; and by 2025, annual oil production most likely will be around 18 to 19 billion barrels—less than the annual production during the oil shortages of the 1970's.This descending figure not only astonishes but also throws light on the immense pollution and carbon footprint created over the decades. Fossil fuels have been the largest greenhouse gas emitters in the world, contributing 3/4 of all carbon, methane and other greenhouse gas emissions. While highways, as the experts say, are recognized to act as three-dimensional corridors of air pollution containing many hazardous chemicals, the scientists now believe the nation faces an epidemic of illnesses that are exacerbated by air pollution. Moreover, according to the consumption figures, it is expected to face severe fuel shortages soon after 2025 all around the world, and hence another hike in petroleum prices thereafter.

Our huge dependency on the hydrocarbon based gasoline, has not only left us with the fear of hazardous impacts but their predicted decrease has also forced us to look for some alternatives to carry on the world in general and automobiles industry in particular. As an alternative, cars running on solar energy, ethanol based fuel mixture, hydrogen economy, biodiesel or electric cars are some of the proposals kept so far. Hydrogen which was once claimed to be a good alternative to replace fossil fuel was suppressed due to the Hinderburg airship accident and had kept the idea of using hydrogen fuel far away from the researchers mind.

OVERCOMING HYDROGEN FEAR FACTOR:

When the Hindenburg airship approached its dock in Lakehurst, N.J., on May 6, 1937, the blimp that held the passenger decks aloft was filled with hydrogen. As the Hindenburg was docking that May evening, the blimp's outer skin was exposed to a static spark and in a fraction of seconds Hindenburg burned, and so, too, did the public's opinion of hydrogen. For many decades following the disaster, hydrogen was viewed with skepticism and even alarm. A "hydrogen fear factor" developed regarding the element. But today, as concerns grow about a possibly dwindling global supply of oil, and increasing emissions of pollutants from that oil, energy researchers are reconsidering hydrogen as a source of fuel. It certainly has a tremendous amount of promise: Hydrogen emits little or no greenhouse gases (GHGs). Its major byproducts are water vapour and heat. Hydrogen has the highest energy output by weight of any fuel. And it's plentiful; hydrogen can be produced by a number of sources, from natural gas to water itself. Hydrogen besides producing energy 2.8 times that by gasoline per unit mass has the disadvantage of consuming the volume four times that by gasoline. History reveals that hydrogen's potential has never been realized even partially mainly because of storage and commercial production difficulties.

This paper provides an overview about the success achieved in the recent researches that are trying to solve the storage and production related issues, thus making hydrogen an efficient alternate or in fact a future fuel for the vehicles. Its most peculiar characteristic is that it is a clean fuel of all alternatives. During combustion of hydrogen in the engine, it burns with oxygen producing only water without any other emission. Generally while using hydrogen as vehicle fuel there are two ways to extract the energy contained in hydrogen - by simple combustion in ICE's or turbine engines or by converting it to electricity in a fuel cell.

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HYDROGEN- PRODUCTION, STORAGE & AVAILIBITY:

When it comes to production, the conventional methods were the addition of bacteria to forestry or household waste, using a method analogous to biogas production. A problem with this method is that hydrogen exchange is low, i.e. the raw materials liberate less hydrogen gas. Now, for the first time, researchers have studied a newly discovered bacterium called Caldicellulosiruptor saccharolyticus, that produces twice as much hydrogen gas as the bacteria currently used. But the bacterium could not cope up with high concentrations of salt or hydrogen gas. These affect the signaling molecules in the bacterium and in turn, the metabolism in a manner that it produces less hydrogen gas. But it is possible to direct the process so that salt and hydrogen gas concentrations do not become too high. Adaptability to low energy environment and coping up capability with high temperature changes is its reason for producing hydrogen gas even in difficult conditions.

Another new process of hydrogen production is being tested by chemical engineers of Purdue University to get high hydrogen production at fuel-cell temperature-level with no catalyst use. This research is full of promise for vehicles powered by hydrogen and is officially funded by US Department of Energy. Actually this process is called hydrothermolysis, which a combination of two hydrogen generating methods – hydrolysis and thermolysis. With hydrolysis, a catalyst is required to generate hydrogen when water and ammonia borane are combined, while in thermolysis, it should be heated to a temperature more than 170 degrees Celsius to release the hydrogen. While each process is not individually helpful, the combination releases hydrogen from ammonia borane very efficiently and at fuel-cell temperatures. The benefit of the combined process is that it is working successfully at considerably lower pressures than presently possible in the test cars powered by hydrogen. Hydrogen generated from hydrothermolysis amounted to 14% of total weight used in the process. This is considerably higher than the government's target of 5.5% of total weight; higher than hydrogen yields from the other experimental systems as well.

Soon after when production problems got solved, issues regarding the storage started to pop. The traditional way of fastening hydrogen into solids has not been very successful. Very less volume of hydrogen was absorbed while storing and too convoluted methods like too high heating or cooling was needed for releasing it which did not make it commercially viable. A major step towards a better design has been achieved by the scientists who have been able to design for the first time successfully composite materials that are nano-scale and which are capable of overcoming the barriers that are thermodynamic and kinetic in nature. A team of scientists at Lawrence Berkeley National Laboratory (Berkeley Lab),Department of Energy (DOE), US have discovered a new material called air-stable magnesium nano-composites which can assist in storing hydrogen without complex methodology. This composite material consists of 'nano-particles of magnesium metal sprinkled through a matrix of polymethyl methacrylate – a polymer related to Plexiglas. This nano-composite is a pliable material and it is capable of absorbing and releasing hydrogen at an ordinary temperature without oxidizing the metal. The National Nanotechnology Initiative from DOE has resulted in huge investments for developing the infrastructure of these facilities.

Another investigation regarding hydrogen storage has become a subject of great interest for the lead author and the research scientist Maddury Somayazulu, with his team at Carnegie's Geophysical Laboratory, to talk about a non-reactive noble gas called xenon which when mixed with hydrogen, at massive pressure gives rise to a solid that can be later used to store hydrogen fuel. Xenon as a hydrogen carrier is too heavy and expensive but further research in this direction can definitely lead to lighter alternatives. According to Russell Hemley, director of the Geophysical Laboratory and a co-author, "This hydrogen-rich solid represents a new pathway to forming novel hydrogen storage compounds and the new pressure-induced chemistry opens the possibility of synthesizing new energetic materials."

After the success in production and storage issues, some recent initiations put by Sunhydro has marked a breakthrough in the world of hydrogen economy. This is a matter of hydrogen availability, which has always been an issue next to production and storage. Everyone is excited about hydrogen cars, but there is always the challenge of how are they going to fill up. The challenge is that they can only travel where a single tank will take them. SunHydro, which is expanding its business focuses from hardwood floors to hydrogen fuel and now in partnership with Toyota is trying to change all of that as they are making plans to literally create a hydrogen highway that will enable cars on the East Coast to travel from the tip of Maine to the southern-most point of Florida. All in all, the plan calls for 11 solar refueling stations. To achieve this there will be a need for some public support as the stations are not exactly cheap and need public funding in order to get installed. For this to work efficiently, we will need private investors and companies that have the foresight to invest in something that is obviously the future of motor vehicles.

ONGOING RESEARCHES & IMPLEMENTATIONS:

Many automobile companies are currently researching the feasibility of commercially producing hydrogen cars. Riversimple which is a UK based Car Company and aims to develop highly efficient personal vehicles, is currently working on a 2 seater car project which is powered by hydrogen fuel cells with a novel design and made from advanced composites. The design emphasis is on efficiency and it achieves energy consumption equivalent to 300 miles per gallon on petrol. Other automobile companies like Daimler Chrysler, BMW (2010, BMW 1 Series Fuel-cell hybrid electric) , Toyota (2008 ,Toyota FCHV-adv) , Mitsubishi (2004,Mitsubishi FCV) and Mercedes Benz (2004,Mitsubishi FCV) have developed and tested ICE's fueled with hydrogen and have concluded that hydrogen can be used successfully as a vehicle fuel.

Test run of India's first hydrogen-powered bus was held at Liquid Propulsion System Centre (LPSC), Indian Space Research Organization (ISRO) at Mahendragiriin(Tirunelveli district). The test was carried out for 5 km in the presence of S.Ramakrishnan, director ,VikramSarabhai Space Centre, and some senior authorities from Tata Motors carried out the five-year research project. The bus was operated using an electro-chemical engine working under reverse electrolysis process, V Gnana Gandhi, the brain behind the project, said while explaining the use of liquid hydrogen to propel automobiles. Hydrogen, compressed to 150 bar atmosphere was stored in cylinders on the roof of the bus. The fuel reaching the engine was decompressed to 2 bar atmosphere and thereafter converted by the hydrogen fuel cells into direct current (DC). This power is then converted into an alternating current (AC) to drive the electric engines.

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Similar experiments are being conducted in Germany using PEM-fuel-cell-powered buses. The fuel cells, coupled with electric drive motors, are able to move 18-metric-ton buses efficiently and reliably.

CONCLUSION:

In all, everyone seems to be excited about hydrogen cars. According to the United States Department of Energy, "compared to ICE vehicles using gasoline, fuel cell vehicles using hydrogen produced from natural gas will reduce the greenhouse gas emissions by 60%." Not only have we solved many problems but also have demonstrated many working models today in the market. However there is always a challenge of initial cost. But when it comes to hydrogen economy, things will hopefully change for the good, it is just a matter of who is going to be smart enough to jump on ship and make it happen sooner.

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