ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 2, Issue 10, October 2013

Efficient Use of Hydrogen Made by Splitting Water by Reaction with Aluminum Alloy

Shushant Puranik, Saurabh Gupta

***Abstract*— A new way of improving the country's economy and to decrease the pollution and global warming by the use of hydrogen made by splitting water by reaction with aluminum alloy on demand in cars replacing diesel engine and diesel tank by hydrogen engine and water tank. Today as the need of the petroleum products is increasing with increase in population and industrialization, the depletion of fossil fuels (eg. Petrol, Diesel, Coal etc.) from earth is a harbinger of the energy crisis of the future, so to come out of this problem we find a technology in which we used aluminum which is mixed with some other metals like gallium, indium and tin which splits the water in hydrogen and oxygen. This hydrogen than used as a fuel in vehicles. Now a day's due to fuel depletion the hydrogen produced is used as fuel instead of diesel which will bring the new revolution in the field of this sector. So in future the water will be the only source, which is present abundantly on earth. This technology will help to reduce the usage of fuels and reduce the pollution which also improves the economic condition of the country like India. Solid alloy of aluminum, gallium, indium and tin have been shown to react with water at room temperature to produce hydrogen and aluminum oxide in a exothermic reaction. This aluminum oxide can be recycled into aluminum. Apart from that aluminum metal is abundant on earth. The recycling is less expensive then mining aluminum-containing ore bauxite. After recycling the aluminum oxide back to aluminum 60 times the cost of producing energy would reduce to 10 cents per KW hour or ₹ 6.33 per KW hour.**

***Index Terms*— Aluminum, Combustion, Engine and Hydrogen.**

I. INTRODUCTION

On February 19, 2008 Purdue University engineers have developed a new aluminum-rich alloy that produces hydrogen by splitting water and is economically competitive with conventional fuels for transportation and power generation.

The two major barriers to realizing a viable large-scale hydrogen economy are hydrogen storage and economically viable "green" hydrogen production. This is an economically viable process for producing hydrogen on-demand for vehicles, electrical generating stations and other applications.

The new alloy contains major percentage of aluminum and some percent of an alloy that is made of the metals gallium, indium and tin. Because the new alloy contains significantly less of the more expensive gallium than previous forms of the alloy, hydrogen can be produced less expensively.

. When submerged, the aluminum alloy would instantly split water into its two constituents, and only produce aluminum hydroxide, which can be disposed in a landfill or recycled, to re-extract aluminum. The substance is, however, non-toxic.

The aluminum splits water by reacting with the oxygen atoms in water molecules, liberating hydrogen in the process. The gallium-indium-tin alloy is a critical component because it hinders the formation of a "passivating" aluminum oxide skin normally created on pure aluminum's surface after bonding with oxygen, a process called oxidation. This skin usually acts as a barrier and prevents oxygen from reacting with bulk aluminum. Reducing the skin's protective properties allows the reaction to continue until all of the aluminum is used to generate hydrogen.

$$2Al + 6\ H_2O \rightarrow 3H_2 + 2Al\ (OH)_3$$

Then in june 2011 a thesis on the water splitting by Yizaho Lang is approved by The University of Utah Graduate School. In his thesis he said that among the materials for chemical methods, aluminum could be utilized as an efficient and environmental friendly energy carrier via the production of hydrogen from water. However, it requires the reaction between aluminum and water to be complete, controllable and does not require the involvement of acids and/or alkali. Such direct reaction between aluminum and neutral water, once considered impractical due to the passivation of aluminum surface in water, is enabled with the relatively recent use of catalytic gallium-based liquid alloys. The rate of hydrogen production from each aluminum-water reaction was measured as a function of time. The theoretical ability of one kilogram of aluminum to generate hydrogen is 1245 liter but due to the formation of amorphous oxide layer, whose thickness is several nanometers, forms on surface of aluminum metal which prevents its further reaction with water.

It has been found that Ga-In eutectic alloys can be useful to activate aluminum powders for generating hydrogen. Ga and In are both nontoxic and already widely used in various fields of science and technology. Their eutectic has a melting point lower than room temperature and the alloy is very easy to

***Sushant Puranik, Mechanical Department** SIMS Indore, Indore, India,+919406628463*
***Saurabh Gupta, Mechanical Department,** IIST Indore, Indore, India, +919179266712.,*

generate from Ga metal and In metal. Motivated by those reports we prepared alloys using five metals (Ga, In, Zn, Sn, Bi) and examined their performance as a catalyst in the reaction between water and Aluminum.

This reaction rate depends on the temperature of water and surface area. High temperature water is more reactive due to kinetic reasons. This reaction gives the abundant heat energy and the hydrogen gas which can be used in the cars as a fuel instead of diesel.
Procedure for Paper Submission

II. Literature Review

In early 1780s Alessandro Volta built a toy electric pistol in which an electric spark exploded a mixture of air and hydrogen, firing a cork from the end of the gun.

After that in 1807 Swiss engineer François Isaac de Rivaz built an internal combustion engine powered by a hydrogen and oxygen mixture, and ignited by electric spark.

In 1860 Belgian Jean Joseph Etienne Lenoir (1822–1900) produced a gas-fired internal combustion engine similar in appearance to a horizontal double-acting steam engine, with cylinders, pistons, connecting rods, and flywheel in which the gas essentially took the place of the steam. This was the first internal combustion engine to be produced in numbers.

In 1892 Dr. Rudolf Diesel developed his Carnot heat engine type motor and in 1893 February 23 Rudolf Diesel received a patent for his compression ignition (diesel) engine.

In 1903 Egidius Elling builds a gas turbine using
a centrifugal compressor which runs under its own power. By most definitions, this is the first working gas turbine.

In March, 1937 The Heinkel HeS
1 experimental hydrogen fueled centrifugal jet engine is tested at Hirth.

From 1991 to 2007 Mazda has developed Wankel engines that burn hydrogen.

In 2002 and 2007 BMW tested a supercar named the BMW Hydrogen 7, powered by a hydrogen ICE, which achieved 301 km/h (187 mph) in tests. At least two of these concepts have been manufactured.

Earlier the splitting of water is done by Electrolysis, Photo-electrochemical water splitting, Photo-electrocatalytic water splitting and Photo-biological water splitting.

III. ANALYSIS

We analyze that as the storing of hydrogen is difficult in vehicles, pumps etc. so we find a new way to produce hydrogen on demand in vehicles as per requirement. We mount a system in which the hydrogen is produced which can be collected in different tank. This system contains the aluminum powder with the liquid alloy of gallium indium and tin. When the water falls on the mixture of alloy the water molecules get split into the molecules of the hydrogen and oxygen.

This paper focuses on an innovative idea of making of hydrogen within the vehicle by decomposition of water into H_2 and O_2 by its reaction with aluminum. This will be advantageous in many ways that in future, might be possible that the fuel tanks are replaced by water tanks.

Although the rate of reaction is slow but in presence of gallium, indium and tin, there can be a rapid rise in the rate of reaction. Alternatively this reaction can be catalyzed by presence of zinc also. This can be further become the field of research.

$2Al + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2 + heat$

The energy released in this reaction = 861.1 KJ

And the energy released after burning of H_2 produced = 857.4 kJ

Energy Density-

As hydrogen produce from splitting water,

- **1 Kg H_2: 142 MJ = 39.4 KWh combustible energy**
- **1 Kg Al makes 111g H_2 from 2 Kg of H_2O = 4.4 KWh**
- **1 gal(10 Kg) Al makes 44 KWh as Hydrogen**
- **1 gal diesel makes 37.5 KWh**
- **1 gal liquid hydrogen makes 10 KWh.**

As heat from splitting water,

- **1 Kg Al : 4.4 KWh**

Therefore, total energy obtained from 1 Kg Aluminum : 8.8 KWh (1Kg coal : 6.7 KWh)

Further the rate of reaction can be greatly enhanced by the use of hot water substituting the cold one. Although it looks costlier but it will be of no cost if we design the engine in such a manner that at first the water can be used as a coolant for engine and afterwards it can be used as a working fluid for producing hydrogen. So we have hot water at no cost. From the analysis we found that water of temperature greater than 70^oC is highly reactive. The efficiency of aluminum to

produce H_2 increases as temperature of water increases. The efficiency observed at different temperature is given as follow by a graph:

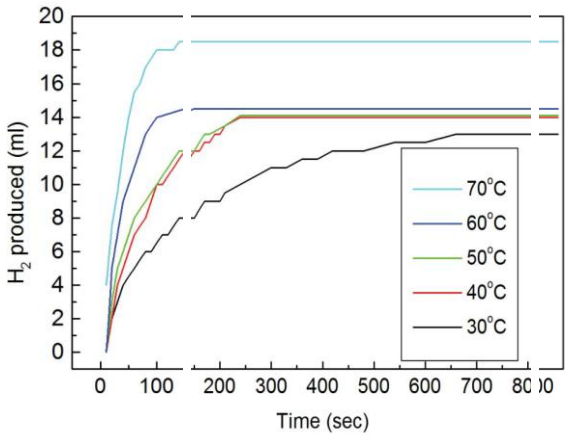

Fig.1.1

Variation of Mass of hydrogen produced at different temperature with respect to time.

Theoretical efficiency of Al is 1245 Liter of hydrogen but practically due to formation of aluminum hydroxide it decreases. At 70° C the efficiency of Al is 58% of the theoretical value and as the temperature of water increases the efficiency increases.

The aluminum hydroxide [Al (OH_3)] produced is totally non toxic, non ignitable, non explosive solid and harmless. So it can be used as a land fill and also can be recycled. The cost of recycle is less than the cost of Al extraction from the ore.

IV. CONCLUSIVE REMARKS

Most of the industrial equipments and transportation media use fossil fuels as a source of energy. Their depletion rate is very high and this created a need for any alternative fuel.

Our study suggests a very efficient substitute i.e. Hydrogen derived from water aluminum. The paper suggests the use of H_2O and Al in a very efficient manner. The inbuilt (Al & water) looks very attractive option for future. The use of alloying elements and hot water is suggested in paper which will increase the rate of H_2 generation when the vehicle is idle. The H_2 is continue to produce and get stored in its chamber and can be utilized during running condition.

REFERENCES

[1] "The History of the Automobile". About.com. 2009-09-11. Retrieved 2009-10-19.

[2] Zeleznik, F. J.; Mcbride, B. J. "Modeling the Internal Combustion Engine". *NASA Reference Publication*. NASA Technical Reports Server. Retrieved 18 October 2011.

[3] Go Choi; Ziebarth, J.T.; Woodall, J.M.; Kramer, R.; Sherman, D.; Allen, C.R., "Mechanism of Hydrogen Generation via Water Reaction with Aluminum Alloys," *Micro/Nano Symposium (UGIM), 2010 18th Biennial University/Government/Industry* , vol., no., pp.1,4, June 28 2010-July 1 2010 doi: 10.1109/UGIM.2010.5508911

[4] United States patent application 20080056986 [20].The binary Al-Ga alloys,however,displayed.

[5] NOVEL METHODS OF HYDROGEN PRODUCTION by Yizhao Lang

Sushant Puranik

Education

- Bachelor of engineering in Industrial Production Engineering, from S.G.S.I.T.S., Indore, affiliated to R.G.P.V. in December 2010 with a degree of 77.8%.

Experience

- At present working in the S.I.M.S.(Indore)
- Worked as Assistant professor in Medicaps institute of technology & management engineering college from 1/2/2012 to 15/6/2012.
- Worked as a lecturer in Indore institute of science & technology (I.I.S.T.) from 17/2/2011 to 31/1/2012

Special Achievements

- Achieved All India rank 5th in GATE 2010 in Industrial production engineering with 99.8 percentile.
- Achieved All India rank 54th in GATE 2011 in Mechanical engineering with 99.93 percentile.
- Achieved 1st rank in diploma.
- Throughout all clear
- Successfully cleared the written exam of I.E.S.2010 with Mechanical branch. .
- Successfully cleared the written exam of N.T.P.C. with Mechanical branch. .
- Successfully published a research paper named "Experimental analysis of entransy dissipation number as performance parameter for heat exchanger" in International conference on "advances in mechanical, automobile and aerospace engineering" (AMAAE-2013) Organized by "krishi sanskriti" On 21st – 22nd September 2011Jawaharlal Nehru university.

Saurabh Gupta

Education

- Pursuing Bachelor of engineering in Mechanical Engineering from IIST[final year]