Generation of Electric Energy Converted Into Fuel Cell for Operating Grass Cutter Mechanism.

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Abstract: The research intends the need for an alternative source of energy based on fuel cell. The purpose of the work is to generate electricity from hydrogen fuel cell using H₂ gas. The stored energy in form of fuel cell can be further used to operate the automatic grass cutter. The hydrogen, oxygen fuel cell formed from electric energy storage can be obtained by combining aluminium and water. H₂ has the highest energy density from all common fuels by weight so that's why it can be one of the promising substitute energy sources. The hydrogen must be incorporated in a small, less heavy system so that unnecessary weight of the device should be avoided. For cutting the grass, manually handled devices are commonly used, efforts required are more. Also, the old grass cutters are getting obsolete and requires replacement by automatic one, where system will work for guidance and obstacle detection using battery as power source. In these days' problems like pollution, power cut problem etc. appearing. To deal with such trouble and the help of technology device can be made, which can do its function without stimulating any harmful exhaust, the project will be operated by generating an energy, which can perform operation by using the renewable source of energy like alternate hydrogen fuel. Hence an attempt has been made by combining aluminium and water into some usable form which can absolutely be an alternative for various power generating fuels.

1. Introduction

At the latest, a significant attentiveness can be seen towards fuel cell technology, as it can be one of the most eminent prime mover, also frequency of climate alterations and different environmental impacts, need for an alternative power sources have increased enormously. Less thermal processes, noiseless operating feature, less weight and relatively greater efficiency tends to make Proton exchange membrane fuel cell as a coming energy resource for stationary usage. The need for power is tremendously increasing due to high level technology incorporation. In addition to cut down the dependency on the fossil fuel and discover sources of power which should be environmental friendly, can results in extensive search for energy sources and alternative fuels and substitute findings. For the
Prime mover one the best choice for future fuel can be the hydrogen which has superior energy reaction of 142.9 MJ/Kg (HHV) eminent heating value which is about thrice greater than HC fuels and combined product with air is non-polluting and non-toxic. Starting from mixture of water, the hydrogen is produced locally with scrap Al and sodium hydroxide. Hydrolysis of Al or alloys of Al for the production of H$_2$ gas to power the fuel cells. Due to great reaction rate, Nano-aluminium powder is good to use. But the cheaper micro aluminium is unable to give required chemical reaction rate. Due to formation of coherent and adherent oxide layer on aluminium surface, aluminium and water reaction system affected from self-restraining problem. The passivation layer gets damaged by adding hydroxide, selected salts or metal oxide. Low melting point metals consuming alloying aluminium has proven an effective approach for preventing the coherent passivation layer formation. The easiest and effective deal for promoting aluminium and water reaction is addition of hydroxides such as NaOH. The igneous alkali mixture of KOH and NaOH are efficient. In today’s world, pollution is the dangerous factor increasing day by day in universe and if in lawn mower if fuel such petrol or diesel is used, it would create the emission of harmful gases, confining to the world energy survey, approximately 80% of energy is obtained from fossil fuels, viz oil (36%), natural gas (21%) and coal (23%). Evidence has proved that there is limited life of such sources and hence there is utmost need of alternate options. At present, there are numerous choices starting from the basic, simpler and advanced types of grass cutting mechanism, So, in context with future, alternative sources should be used to avoid energy crisis and so initiation of hydrogen fuel cells can be thought of for working of machines. Automated Solar Grass Cutter uses solar energy, it is automatic robotic vehicle which works for a cutting grass, also avoids obstacles without any kind of human interactions. So manually handled grass cutter can be thought to be replaced by such robotic grass cutter. In similar way grass cutting mechanism operated using fuel cell can give the best results.

Combining Al and H$_2$O (Production of hydrogen)

When powder of Al mixed with the tap water at room temperature, it generates small amount of hydrogen. However, we can generate hydrogen effectively by the two of processes such as using deionized water over 35°C or metal oxides Nano crystals get differentiate in tap water at room temperature. Hydrogen generated from Al and NaOH reaction in aqueous solution has been studied:

$$2\text{Al} + 6\text{H}_2\text{O} + 2\text{NaOH} \rightarrow \text{NaAl} (\text{OH})_4 + 3\text{H}_2 \quad (1)$$

$$\text{NaAl} (\text{OH})_4 \rightarrow \text{NaOH} + \text{Al(OH)}_3 \quad (2)$$

The consumed NaOH can be regenerated in reaction. The process is shown below:

$$2\text{Al} + 6\text{H}_2\text{O} \rightarrow 2\text{Al} (\text{OH})_3 + 3\text{H}_2 \quad (3)$$

To establish the capability of the investigation, for an arrangement or device to work, study of the range Pressure, temperature, acceleration capability of IC engine automobile can be analysed observing the result. Thus, the analysis and estimation of the performance, cost and efficiency of the fuel cells, and the vehicles powered by this system are all important part of the research. H$_2$ is playing prominent part in the advancement of new energy technologies. It is not a primary fuel, nor mined from our planet, but the potential possibilities have vast range of conversion into other energy forms owing to combustion in atmosphere, through fuel cells, or by other things. The hydrogen fuel cells work with an efficiency of 40%, and possibly it can increase with 10% coming future, while petrol and diesel have 25-30% of efficiency. The hydrogen generation process is production of gas using H$_2$O and Al. Aluminium is mostly used for structural design purposes because of its small weight and maximum strength but it is potentially used as an energy carrier this is the important advantage of it.
The strength and fact that availability of Al is enormous obtained from metal earth’s crust, it has high energy density of 29MJ/Kg. Its principal feature of Excellency as a reducing agent when it comes in contact with water, capable of producing hydrogen gas which does not involve production of CO₂ in a corrosion process. For the production of Al the main material alumina (Al₂O₃) is used it is found in natural mineral in large number. By the Bayer process of refining bauxite to 98% of metallurgical alumina i.e Al₂O₃ is produced a mineral generates 50 - 80% of hydrous alumina i.e Al and oxy-hydroxides In an solved interpretation of the chemistry an electric automobile generated by fuel cell using 4Kg of hydrogen can run about 400km which is obtained after reaction of H₂O from 36 kg of aluminium, this is the example for high energy density of aluminium. There are 3 main stages of extraction of aluminium, bauxite mining, alumina production by bayer process, and alumina electrolysis. Bauxite is mined by open casting method in which upper layer of soil is removed by scrapers, having the fact is the principal core of aluminium, consisting of Al₂O₃, more or less hydrated and containing various impurities, such as iron oxide, aluminium silicate, titanium dioxide, quartz, and compounds of phosphorus and vanadium. Commercially in all operations extraction of alumina is done by bayer method, taking advantage of the solubility equilibrium of the alumina hydrates in caustic soda solution, in accordance with one or the other of the following equations:

\[
\text{AlO-OH} + \text{NaOH} \rightarrow \text{NaAlO}_2
\]

\[
\text{Al (OH)}_3 + \text{NaOH} \rightarrow \text{NaAlO}_2 + \text{H}_2\text{O}
\]

The Bayer process consists of four stages.

**Electrolysis**

The Hall-Heroult process shows the aluminium production in which the electrolysis process separates Al and O₂ in the alumina. This made up of electric current passes through liquefied alumina and natural/synthetic cryolite. For the production of Al the main material alumina (Al₂O₃) is used it is found in natural mineral in large number. By the Bayer process 98% of metallurgical alumina is produced starting from bauxite, a mineral generates 50% - 80% of hydrous alumina (Al hydroxides and oxy-hydroxides). A solved interpretation of the chemistry under the Bayer process is given by:

\[
\text{Al}_2\text{O}_3 \cdot n\text{H}_2\text{O} + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + (n + 1) \text{H}_2\text{O}
\]

The 2Kg of alumina produces 1Kg of aluminium, which is derived from 4Kg of bauxite. Aluminium should easily react with water due to its highly negative redox potential, generating Al (OH)₃ and hydrogen gas according to the equation:

\[
2\text{Al} + 3\text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{Al}_2\text{O}_3
\]

Practically, Generation of aluminium have adhering layer of surface film, When exposed to air, the Al surface is speedily oxidized to form a tight layer of aluminium oxide, which saves further penetration of oxygen, thus protecting the under metal from further oxidation.

**Experimental Procedure.**

In the chemical formation of Aluminium in sodium hydroxide aqueous alkaline solutions rate of production was calculated using standardised and specific equipment. Take Al sample in the flask (glass) with a volume of 100cm³ of 0.1el g was placed containing alkaline solutions from 2 to 30cm³. The practical investigational procedure was done at 20°C, supplied with a 1Litre volume of water bath. When taken 1g of aluminium with water produces approximately 15.5KJ of thermal energy. hence cooling of reaction is necessary. For experiments only small part is consumed and therefore the water bath can keep an invariable average reaction temperature without any type of stimulation even in the small amount of solutions. But there was no guarantee of uniform local temperature close to the reaction surface. When aluminium and aqueous alkaline solution come in contact with each other then, hydrogen generation starts and is moved out via silicon tube measured by burette.
system, it calculated the experimental data of hydrogen yield in time(t), whereas by the differentiation procedure the function $Q_s(t)$ was obtained. From the reaction of Aluminium and Water the Hydrogen is produced, the produced $H_2$ supply to the fuel cell where Hydrogen reacted with oxygen and electricity generated and the by-product obtained is pure water. The generated power is can be stored in the battery which is rechargeable the device can run by using hydrogen fuel cell. Now 6V is required supply to operate the proposed lawn cutter. Ultrasonic sensor is incorporated at the eyes of lawn cutter which is trans receiver for detection of any obstacles present in front of it, it is signalled by eco signals taking deviation unless and until the obstacle is removed. The grass cutter and vehicle motor are interfaced to a device called microcontroller which controls the working of all motors. It can be designed in such a way if any obstacle occurs the vanes/blades should stop rotating whereas when obstacle is removed, it should continue rotating. Right deviation command should be given because instruction set for motor 1 will make the forward direct and motor2 2 will move in reverse direction. The RF module as the name indicates which operates radio frequency. It varies from 30 KHz and 300GHz. The digital data represented varies in the amplitude of wave, this modulation is known as amplitude shift keying. The receiver or transmitter payer which is operated at a frequency of 434MHz. And RF transmitter receives serial data which further transmits it wireless through RF its antenna connected to pin 4. The rate of transmission is 1Kbps-10Kbps.

**Storage:**

Hydrogen is a clean fuel, when consumed in a fuel cell produces zero emission, main issue about hydrogen is high risk of leakage, due to its gaseous nature. Recently various methods and technologies have been seen for its storage. Pressurized gas, hydrogen in liquid form and metal hydrides are the three hydrogen storing methods. The storage of liquid hydrogen is done in cryogenic tanks 3-6 weight % hydrogen made under pressurized hydrogen tanks to 200-700 bar. Metal and hydrogen compound is being offered by the metal hydride for storage. Heating or pressure reduction leads to release hydrogen from compound. Solid metal hydrides is safe and compact method for storing hydrogen and currently it is being used in different applications and forms. For storing hydrogen, compression hydrogen tanks are also used. Fuel cell used for any operation, high pressurized storage becomes viable option many variables must be considered which include weight, volume, safety and cost and therefore the kind of material used for the storage should be able to resist the possibility of brittlement with hydrogen. In addition to being light weight, easy to handle and less costly, Vessels originally made from aluminium which has high thermal conductivity. Comparatively the material having more strength and safety parameter such as fibre/epoxy composite is used and not Al having the drawback of not being strong material. If $H_2$ would have been liquid form then, It must maintain boiling point of 20K., hence forth heat intrusion must be kept at down level. To do this, original $H_2$ tanks were metallic double-walled vessels. Inner lay is consists of multilayer insulation which is composed of several metallic foil layers which is separated by glass wool, the space between outer and inner vessels was evacuated to create vacuum. This storage system is known as vacuum super insulation. In the latest, for safety purpose pressure release valves have been added.

**Application of fuel cell for Automatic Grass Cutter**

The proper selection and calculation of the correct alternative propulsion technology is to be brought and fossil fuel should be replaced which will propagate high evolution of environmental impact, and also which will be matter of high societal importance of technology. Relatively arguments are around that the devices operated by batteries can become bridge towards the final execution of fuel cell. Each fuel type has its own advantages and disadvantages but the decision confining less drawback should be considered and therefore fact about better fuel should be analyzed. The state of the art for automotive applications are membrane electrode assemblies consisting, of a proton-conducting polymer membrane (Proton Exchange Membrane) PEM which is based on Ployperfluorosulsonic (PFSA) and carbon supported platinum nanoparticles act as catalyst (Pt/C). The relative high conductivity of proton of PFSA membranes under automotive operated conditions (60 and 80ºC) with the high Pt-catalyst activity which ask fuel cell to complete target performance of automotive. The introduction of $H_2$ series of automatic grass cutter by Opel and GM, the fuel cell and electric fraction systems were packaged so that they must fit into the same volume as an internal combustion engine.
(ICE) module. This type of highly integrated power cube will allows a simple and cost-efficient type automatic grass cutter with provision of manufacturing installations. Therefore approach can be made towards the technology scenario for the introduction of smart grass cutter can be done. There is no principal technical restriction that rule out a different configuration of fuel cell components, of power train on the board of automatic grass cutter. Fuel cells mostly consists hydrogen as a fuel. Due to problems of hydrogen storage in a portable mode, micro fuel cell have been developed for the use of portable electronic device. Two additives sodium hydroxide and calcium oxide both are utilized for flow control of $H_2$ generation in electrical wire, aluminium foil or metal hydride which are the variegated sources produces hydrogen. All this experiment conducted by Jung et al where they feed the reactor with NaOH solution at $0.2 \times 10^{-6}$ m$^3$/min rate through micro pump at 1500 kgf cm$^2$ pressure with 5%, 10%, 20% concentrations. It gives $2.65 \times 10^{-3}$ m$^3$ hydrogen production 15% NaOH and the best performance gained at 2000 kgf/cm$^2$. Based on Al-H$_2$O reaction shkolnikov et al. presented 2W cell phone having micro fuel cell 1.2 to 1.8 WH electrical energy is produced by each gram of Al.Al-Bi-NaCl charged by a portable generator of 2050 ml capacity, which includes aluminium and bismuth in powder form (13 microns) combined with NaCl particles. The original mixture containing Al by 10 weight% Bi and 1, 3, 5 or 10 weight % NaCl gives the best yield of hydrogen (1063 ml/g Al) further in experiment with the addition of zinc, it gives a highest rate of $H_2$ production (i.e. 1026 ml/g Al), which can be received, when the mixture is at Al 10 weight%, Bi 1 weight%, Zn 2 weight% NaCl. With this data it can be observed that the hydrogen fuel cells are suitable used with the generator and can operate smart grass cutter too.

Methodology

**STUDY OF PROBLEM IDENTIFICATION**

**EXAMINE THE REACTION OF ALUMINIUM & WATER**

**GENERATION OF HYDROGEN GAS**

**STORAGE OF HYDROGEN GAS INTO CYLINDER**

**CONVERT IT INTO ELECTRIC ENERGY USING FUEL CELL**

**DESIGN OF AUTOMATIC GRASS CUTTER**
Working Of Automatic Grass Cutter

The grass cutter operated by hydrogen fuel cell uses few electronics gadgets such as, rechargeable batteries, geared DC motor, cutting blades, comparator, relay, temperature sensor, and finally hydrogen fuel cell etc. Its main work is to provide high speed solution to the blades and the blades will perform their work of grass cutting. One can use electric grass cutter in any type of garden, grass fields and lawn. It can beautify the home lawn maintaining proper grasses grass cutter can cut the grasses with even length with rotating cutting blades the battery used in their systems get change through hydrogen fuel cells. DC motor have been used for the blade to cut the grass in grass cutter they use electrical energy which gets converted into mechanical energy, thereof magnetic field and conductor are interacted with each other carrying current, where voltage is the input of DC motor and torque is the output used to drive the blade.

Proposed Diagram

Here, after reaction of aluminium with water the hydrogen gas is generated. After generation of hydrogen gas it is stored into the cylinder for the further process. Then hydrogen gas send to the hydrogen fuel cell so that the hydrogen molecules combine with the oxygen and the electricity produced with the pure water. Then electric energy stored into the battery. Batteries are connected by the motor through connecting wires the working of the motor can be handled by the driver which is held between their two motors. The blade is being rotated after supplying power to the mechanism and
then after rotating blade it start to cut the grasses. So the sensors attached will detect the direction for cutting. We are using arduino kit with motor controller for that purpose. Mowing is achieved by the D.C motor which provides the required.

Figure 3. Arduino UNO Kit

Figure 4. Motor Controller

Figure 5. Hydrogen Fuel Cell
Outcome and Discussion

Under different conditions, some practical investigations was done to obtain the H\textsubscript{2} gas. In an aqueous solution, by using one hydrolyser and always start from 1g of Al, 1.5g of sodium hydroxide and 0.675 g of distilled water added at the different rates. When pure Al powder is immersed in tap water at room temperature little hydrogen can be generated, it is well known that from the use of deionized water at temperature over 35\,°C or various metal oxide Nano crystal modifiers in tap water at room temperature, we were able to produce hydrogen in an effective way. Different size, shape and thickness of aluminium foils were prepared. By hydrochloric acid some Al sample was pretreated for 1.5 min. Experiment says that there was great change in the specific H\textsubscript{2} production rate Qs from 0.2-1 L/m\textsuperscript{2} min. The lowest rate was with long foil crumpled until a small ball which is formed emerged into a small amount of solution. The highest hydrogen production rate was arrived when aluminum foil deals with hydrochloric acid. In experiment the result found for single piece of 180 mm foil of 2.2 cm\textsuperscript{2} square for four similar pieces of Total Square of 9 cm\textsuperscript{2} in 2ml volume of solution were some within the error of 5%. The different structure, mass, shape and geometry of the sample the results as well as data were obtained and explained by various experimental condition. Aluminium could be preliminarily activated or coated by the oxide film of various porosity and thickness. So fixed solution molarity the quantity of aqueous alkaline solution was also different. With the use of Al in sheet form and NaOH in pellet form, the fastest evolution of hydrogen gas is observed, but all the variants of the presentation of Al metal and NaOH.

The Al- H\textsubscript{2}O reaction is as follows:

\[ \text{Al} + 3\text{H}_2\text{O} \rightarrow \text{Al(OH)}_3 + \frac{3}{2}\text{H}_2 \]

10% hydrogen related to aluminium is produced by stoichiometric reaction theoretically. It is nearly equals to 1.24 litre hydrogen- 1 gram aluminium and Al and H\textsubscript{2}O available easily. It is very safe and easy for the work as well as one can store it for long time. Low specific energy and energy density are the main problems for storing electric energy. The batteries consist of electric energy. There are two types of batteries primary (non-rechargeable) and secondary (rechargeable) batteries.

According to the chemical reaction for PEM fuel cells as follows:

\[ \text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O} \]

Water is the only by-product of the operation (liquid or vapour form), quiet and operates at low temperature (which typically varies from 20-100\,°C. PEM fuel cells exhibit about 50% efficiency of generation of electric energy as compared to the HHV of the chemical reaction. sOne must consider, when applying hydrogen production method for the storage of electric energy, a number of scenarios.
with relation to specific energy density according to the Aluminum-Water reaction and hydrogen-oxygen reaction in the fuel cell. When applying our hydrogen production method for electric energy storage, one may consider a number of scenarios with relation to specific energy or energy density according to the aluminum-water reaction and the hydrogen-oxygen reaction in the fuel cell. Typically, for land devices (e.g., emergency electric generators) aluminum has to be provided, water is usually available, and oxygen is obtained from the ambient air. The PEM fuel cell produced electric energy which is equal to 19.8 kWh per kg hydrogen, considering that high heating value (HHV) is 142.9 MJ/kg and that PEM fuel cell efficiency is 50%. In 1 Kg of aluminium one ninth (0.11) kg of hydrogen is produced in reaction between Al and water. This says that by the combination of the activated aluminium-water reaction the specific electric energy (per unit mass of aluminium) produced and a PEM fuel cell is 2.2 kWh per kg aluminium. The advantages in long duration applications such as electricity supply for remote communication posts and long duration Unmanned underwater vehicles and Unmanned aerial vehicles .NaOH and water used in these experiment, named as 1:1:1 the stoichiometry cannot hold. Rather, the equation which best describes the chemical processes which took place in these trials would be

$$\text{Al} + \text{NaOH} + \text{H}_2\text{O} \rightarrow \text{NaAlO}_2 + 3/2\text{H}_2$$

(3)

Which accounts for consumption of the three ingredients in a 1:1:1 molar ratio, and still agrees with the ratio of 1.5mol of gaseous hydrogen produced per mole of input aluminium, as observed in the experiments. The tractor driven motor cannot be used for cutting residential grasses therefore lawn mower have been develop capacity of lawn mower is sufficient for that. IR sensors have been used for sensing any type of obstacles and it will protect it from them. It is environment friendly consumes low cost.

**Summary**

Fuel cells uses hydrogen gas to power an electric motor. Fuel cell mowers combine hydrogen and oxygen to produce electricity, which runs a motor. It combines the range and refuelling of conventional mowers with the recreational and environmental benefits of driving on electricity. Also automatic grass cutter will run without any human effort. So it consumes human effort as well as has the best alternative of fuel as per the future requirements. Refuelling a fuel cell mower is comparable to refuelling a conventional mower; pressurised hydrogen is sold at hydrogen refuelling stations which are like petrol stations. The important fact of hydrogen is it is highly flammable even if mixed with small amount of ordinary air, hydrogen has no rating for toxicity and any rate of hazardous reactivity, though storage of H\(_2\) Poses unique challenges, due to the reason of ease in leakage being a gaseous fuel. Any machine in form of Robots has large field formed for innovation of new systems. Automated guided vehicle is example of it. For the safe, undeviating, operating with accuracy, Navigational systems and motion control are the essential and influential elements and can be incorporated in the device which can be done the best future work to be done. The device can be remote controlled too. The RC operations can be safe and reliable because the human operator can directly view both the robot device and environment general out view.

**Future scope**

Possibilities of GPRS and high navigational operations in RC can be inculcated. Use of heavy materials tends variations in dynamics of the system with decreased efficiency, hence light cut material can be used. Design of blade have to be made in respective to the type of grass which will be used to cut. Furthermore innovation more work can be done on the adjustable blades.

**Conclusion**

The reaction of powdered aluminium and water results in generation of hydrogen. Proceeding further to convert the output into battery form of H\(_2\) and O\(_2\) fuel cell for harmless electric energy formation is tested and analyzed. The 10% weight of generated hydrogen from Al and H\(_2\)O compared to the weight
of aluminium gives production of adequate amount of power 2100Wh/Kg. The hydrogen generation process by reaction of Al and KOH aqueous alkaline solutions is also studied. The specific hydrogen generation rate was analysed by the effect of various physical factors. It is proved that corrosion factor less during the reaction process is at the initial phase. The invariance of practical result stimulates depending upon numerous reasons such as the rate of removing the reaction product from surface of metal and the local temperature. Hydrogen storage study has been significantly done in the research. General category of gas storage discussed in this paper includes mechanical techniques such as compressing and cooling of the gas, chemical hydrides which containing H$_2$ chemically bonded to non-H$_2$ atoms and absorption materials, with metal organic frameworks, carbon and other nanostructures. The proposed smart lawn grass cutter using hydrogen fuel cell for minimum working time, cost effectiveness and energy consumptions with higher efficiency with minimum efforts can be achieved.

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