Forecasting of Biomass Energy to Hydrogen Generator as Green Thermal Fuel Experience, Development and Future Aspects

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Abstract - *A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. However, the fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge. Hydrogen fuel can be produced from methane by electrolysis As of 2018, the majority of hydrogen is produced from fossil fuels or partial oxidation of methane and biomass gasification or electrolysis of water Fuel cells are a promising technology for use as a source of heat and electricity for buildings, and as an electrical power source for electric motors propelling vehicles. Fuel cells operate best on pure hydrogen. But fuels like natural gas, methanol, or even gasoline can be reformed to produce the hydrogen required for fuel cells. Some fuel cells even can be fueled directly with methanol, without using a reformer. In the future, hydrogen could also join electricity as an important energy carrier. An energy carrier moves and delivers energy in a usable form to consumers. Renewable energy sources, like the sun and wind, can't produce energy all the time. But they could, for example, produce electric energy and hydrogen, which can be stored until it's needed. Hydrogen can also be transported (like electricity) to locations where it is needed.*

Key Words: fuel cell, electricity, Renewable energy, power source, Biomass.

1.1 INTRODUCTION

As human population, new technologies, and infrastructures continue to grow, there is a proportional increase in the demand for energy need. Currently, most energy in the India is produced by fossil fuels. For the last century, petroleum, natural gas, and coal had accounted for at least 80% of the total Indian energy consumption.

However, burning fossil fuels produces pollutants and heat-trapping gases that increase global atmospheric temperatures. Global carbon emissions in 2018 were estimated at 9776 million metric tons, which represents a 1.4% increase over global carbon emissions in 2017. Continued use of fossil fuels increases global pollutants and poses environmental threats. Renewable energy sources such as wind and solar energy are potential alternatives to fossil fuels in which many businesses and governments have already invested. The whole system produces zero emissions and therefore is considered a renewable energy solution.

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic, or indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic converts light into electric current using the electrolyte effect. Hydrogen is a colorless, odorless, tasteless, flammable gas. It is found in water, organic compounds, biomass, and hydrocarbons such as petrol, natural gas, methanol, and propane. Hydrogen is high in energy content as it contains 120.7 kilojoules/gram. This is the highest energy content per unit mass among known fuels. However, its energy content per unit volume is rather low. Thus, challenges are greater in the storage of hydrogen for civilian applications, as compared to storage of liquid fossil fuels. When burnt, hydrogen produces water as a by-product and is therefore not only an efficient energy carrier but a clean, environmentally benign fuel as well. Hydrogen can be used for power generation and also for transport applications. It is possible to use hydrogen in internal combustion (IC) engines, directly or mixed with diesel and compressed natural gas (CNG) or hydrogen can also be used directly as a fuel in fuel cells to produce electricity. Hydrogen energy is often mentioned as a potential solution for several challenges that the global energy system is facing. The advantages are the fact that hydrogen use results in nearly zero emissions at end-use, and that hydrogen opens up the possibility of decentralized production on the basis of a variety of fuels. But it is found that hydrogen will not play a major role in India without considerable research, technology innovations and cost reductions, mainly in fuel cell technology. This section provides inputs on the status of hydrogen energy in India.

Innovative inexhaustible courses are conceivably ready to support the change to a decarbonized vitality economy. Green engineered fills, including hydrogen and petroleum gas, are viewed as reasonable options in contrast to non-renewable energy sources. For sure, they assume a basic job in those segments that are hard to jolt (e.g., street portability or high-heat mechanical procedures), are fit for moderating issues identified with adaptability and immediate parity of the electric network, are appropriate for enormous size and long haul stockpiling and can be moved through the gas organize. This article is a diagram of the general inventory network, including creation, transport, stockpiling and end employments. Accessible fuel change advancements utilize sustainable power source for the synergist transformation of non-fossil feed stocks into hydrogen and syngas. We will show how pertinent advances include thermochemical, electrochemical and photochemical procedures. The syngas quality can be improved by reactant CO what's more, CO2 meth nation responses for the age of manufactured flammable gas. At long last, the delivered vaporous energizes could follow a few pathways for transport and lead to various last employments. Hence, capacity choices and gas compatibility prerequisites for the sheltered infusion of green energizes in the flammable gas system and power modules are laid out. By the by, the impacts of gas quality on burning emanations and wellbeing are considered.

1.2 LITERATURE REVIEW

Mandal et al. (2013) revealed that on increasing the flow rate of hydrogen from 3.84 cc/min to 15.5 cc/min into a polymer electrolyte membrane fuel cell (PEMFC) operated at 30oC using a 25 cm2 self-humidifying nafion membrane, the maximum voltage output increased from 0.813 to 0.993V DC. The steady state voltage output was almost independent of hydrogen flow rate. The time required to achieve the maximum voltage was longer for lower flow rate. After cutting off the hydrogen flow rate, the PEMFC continued to provide the output voltage and current up to 3 minutes and afterwards in a decreasing order up to 3-5 minutes. The cell was able to show a persistent voltage of about 0.0733V for long time. Li et al. (2014) reported that the photo catalytic water splitting was a promising approach for hydrogen production, but the unsatisfactory efficiency of current photo reactors limited its widespread exploitation and commercialization. Recent innovations in opt fluidic micro reactors showed a window for advancing photo catalytic water splitting technology. Nevertheless, existing opt fluidic micro reactors with the planar design showed the low active surface area and rate of mass transport, thereby restricted the hydrogen production performance. In the work, they proposed an opt fluidic micro reactor with staggered micro-pillars in the reaction micro-chamber. Such design not only enlarged the surface area to load catalyst but also induced perturbation to the liquid flow and shortened the transport length which increased the active surface area and enhanced the mass transfer and eventually boosted the hydrogen production rate. To evaluate the performance of this new opt fluidic micro reactor, a redox mediated water splitting reaction was implemented. Results showed that the developed micro reactor with micro-pillar structure exhibited a higher reaction rate. As compared to the conventional planar opt fluidic micro reactor, the maximal increment of the reaction rate could reach up to 56%. 34 The studies on the electrolysis of water using renewable energy inputs were being actively pursued as a route to sustainable hydrogen production by Benjamin et al. (2014). They introduced a redox mediator (silicotungstic acid) that enabled coupling of low-pressure production of oxygen via water oxidation to a separate catalytic hydrogen production step outside the electrolyze that required no post-electrolysis energy input. That approaches sidestepped the production of high-pressure gases inside the electrolytic cell (a major cause of membrane degradation) and essentially eliminated the hazardous issue of product gas crossover at the low current densities that characterized renewable driven water-splitting devices. They demonstrated that a platinum-catalyzed system could produce pure hydrogen over 30 times faster than the state-of-the-art proton exchange membrane electrolyzes at equivalent platinum loading.

Kaveh et al. (2012) reported that the electrical impedance of an electrolysis cell caused a fraction of the applied energy to be wasted as heat while the electric current passed through it. In the report, several internal and external variables were pointed out having an influence on the electrical behavior of such cells. The work provided an insight to these factors in regards to minimize the energy loss of the process of water electrolysis, generally operated using concentrated solutions of KOH (25–30%), at temperature ranging from 30 to 90o C and 1 atm pressure with working current densities of the order of 159 mA/cm 2 and the practical voltage efficiency of the system around 65–70%. The principal causes for the efficiency losses were the cathodic and anodic over potentials dependent strongly on electrode materials, temperature and pressure.

1.3 METHODOLOGY

1. Open Fuel *Cell model*

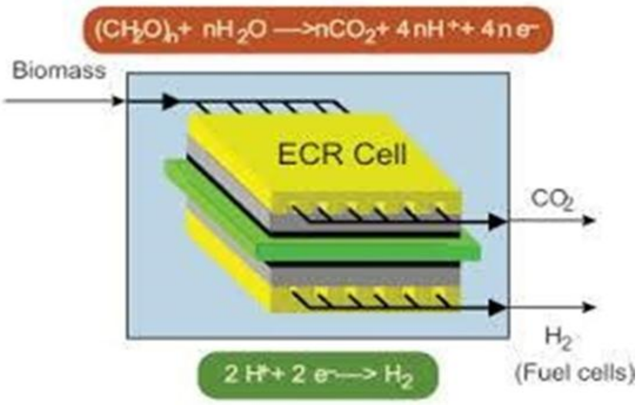
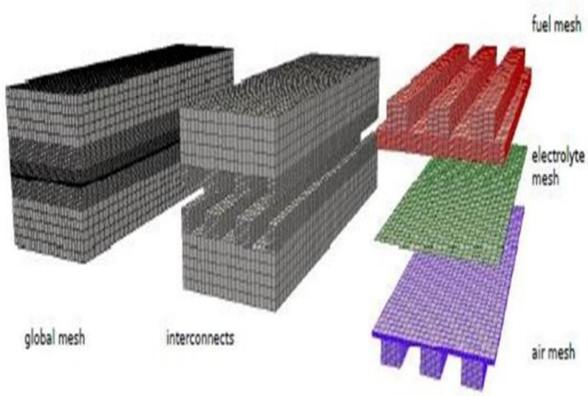


Figure-1 Fuel cell

2. Mesh

Physical phenomena in fuel cells occur throughout the whole cell body and are not restricted to single region: fuel ofc through channels and enters the micro-porous electrode while opposite stands for reactants; heat is released by electrochemical reaction in electrode-electrolyte assembly, but is transferred to channels and supporting structures; potential eldest are present in solids, but not in insulating channels, etc. Choice of regions included in model depends on the idea behind it, as well as on what phenomena wants to be simulated or ignored, but generally includes air and channels, anode and cathode, electrolyte and some kind of support structure which serves for electricity conduction and heat dissipation. .is problem with region decomposition in numerical modeling of fuel cells, which are multi-physics, multi-scale devices, can be approached in several ways Single global mesh can be made for whole fuel cell, with solving governing equations for whole domain and disabling appropriate eldest in parts where needed. .is approach is perhaps simpler because of only one mesh, but is rather computationally indecent due to all equations being unnecessarily solved on the whole mesh. Furthermore, Open FOAM code does not permit internal boundary conditions on single mesh, which creates problem with this approach.

Integrated cell concept is approach where single global mesh is created and then separated in several" child" meshes. Energy equation is solved for on the global mesh, while the rest of eldest are enabled on child meshes as needed. Mapping from global to component meshes and vice versa is possible, and boundaries are incorporated as



internal surfaces between meshes

Figure2: Open Fuel Cell mesh for cow case decomposed in region meshes. Bo.om to top: interconnect, air, electrolyte fuel, interconnect.

their third solution is applied in open Fuel Cell code, although the coupled mesh has been considered as well. Its main drawbacks were being unsuitable with overlapping sub regions and efficiency when dealing with large stacks due to increased data transfer for many coupled regions. .is way fuel cell model in open Fuel Cell consists out of global mesh for entire fuel cell with sub regions for air, fuel, electrolyte and interconnects. Fuel and air mesh are further divided into zones to enable distinction between, e.g. air channels and porous cathode inside air mesh is used only for defining properties such as diversity, but the equations are solved over the whole child mesh. So, computational approach was to have a multiple-region model that solves for region-specific fields for every distinct region.

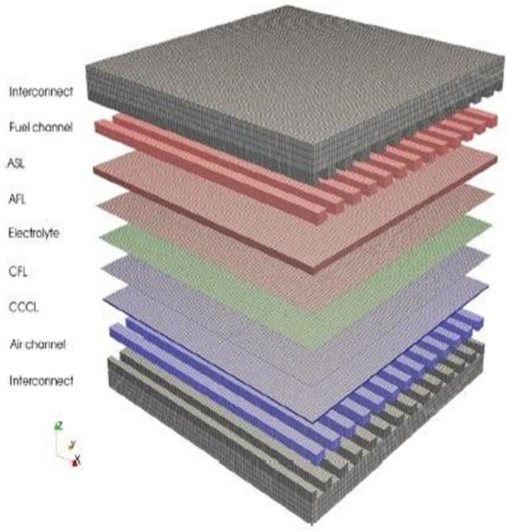


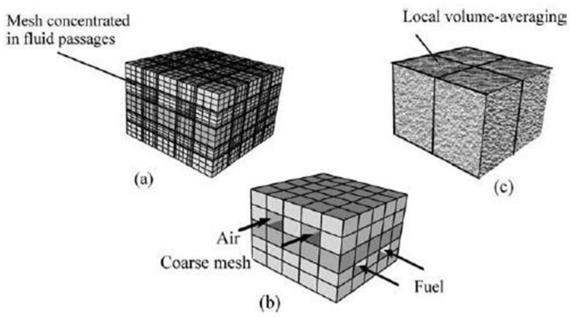
Figure3: Regional and zonal decomposition of a mesh. It can be seen that regions (child meshes) from Figure are further divided into zones of uniform physical properties.

However, equations are solved on the mesh levels.

Open FOAM provides modern automatic meshing techniques with unstructured polyhedral mesh support for capturing the complex geometry of SOFC. Depending on the model and the phenomena wanted to be captured, computational grid can be inner or coarser, as well as structured or unstructured. Mesh can be concentrated in the near of boundary regions of humid channels to capture details of diffusion terms, as shown in Figure a. On the other hand, rate-equations can be used, and with-it coarser body mesh in Figure or locally volume-averaged mesh in Figure 4.2.1.c.

Radiation heat transfer present in fuel and air channels was

$$-\Gamma \frac{\partial \Phi}{\partial y}\bigg|_w = g\Delta\Phi$$



not yet implemented in all releases heat model.

3. Two Potential Model Overview

An addition to the open Fuel Cell model presented in this thesis tackles the issue of modeling potential yields in solid oxide fuel cells. To account for potentials, present in a fuel cell, electrochemical model had to be adjusted, just as additional mesh decomposition had to be added

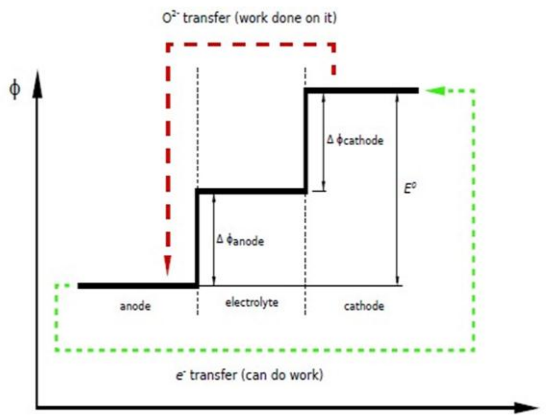


Figure 4: Charge transfer in electrode-electrolyte assembly of a SOFC.

1.4 ELECTROCHEMISTRY CALCULATION FOR THE TWO POTENTIAL MODELS

Electrochemistry model and equations are changed compared to open Fuel Cell, in order to take into account potential distributions. Since only anode is the active electrode, there is a discontinuity in the potential yield on its surface. As stated, this jump coincides with the boundary between two new region meshes. Two potential model is posed as potentiation problem, with potential on the anode side (top) set to zero, while on the bo.om a prescribed voltage V is applied. Hence, voltage drop on the anode boundary can be calculated as a difference between surfaces of electrolyte and anode. Or, if described in terms of two potential model decomposition—voltage drop is the deference between adjacent cell faces on top and om mesh. .is way the equation for potential jump DF simply becomes:

$$\Delta\Phi = \Phi_{bottom} - \Phi_{top}.$$

Ideal potential is obtained from the same equation as in the regular open Fuel Cell, equation, and the anode over potential is calculated as follows

$$\eta = E - \Delta\Phi.$$

Since thin electrode assumption was used, these parameters are defined as localized, surface values on the interface between top and bo.om region mesh.

The equation above is valid for a case with only one jump across the fuel cell. It is a modified version of a Kirchhoff. -Ohm relation and when rearranged shows that ideal cell voltage is equal to all potential decreasegence in the cell: E = DF+ h is can be seen in Figure 4.3.1 where the solid line represents open circuit voltage with no current drawn and no over potential. When the circuit is closed, current is drawn and losses in solids become present (they cause slopes in the graph—they are ohmic losses due to conducting charge, see section 4.3.4 below), just as over potential h further reduces output voltage when compared to the ideal case.

Another simplification, the use of the Tafel equation (equation (2.7.7)), provides current density values that are function of exchange current density and over potential is equation valid for high current densities and high over potential values, which has been taken as an acceptable assumption [16] for SOFCs:

$$i = i_0 e^{\alpha n F \eta_a/(RT)}.$$

this equation calculates current density on the boundary between anode and electrolyte, and is a simplification when compared to the open Fuel Cell model boundary values are used in the same way as was before to set the mass and species boundary conditions. the decreasegence is that in this model mapping top region to the air/fuel is needed. Furthermore, current density is used for seeing boundary conditions on top and bo.om region potential yields. Neumann boundary conditions (fixed gradient) are defined on the boundary corresponding to the anode-electrolyte interface as:

$$\frac{\partial\Phi}{\partial n} = -\frac{i}{\sigma}. \quad (4.3.4)$$

In this equation σ is the region's electrical conductivity. It is calculated for both regions as function of temperature according to[17] :

$$\begin{aligned} &\text{Anode} && \sigma = \left(2.98e{-5}\exp^{-1392/T}\right)^{-1} \\ &\text{Cathode} && \sigma = \left(8.11e{-5}\exp^{600/T}\right)^{-1} \end{aligned} \quad (4.3.5)$$

Region that contains electrolyte within it (in present case that is the bo.om) causes another discrepancy with reality because equations for s used for conductivity calculation are obtained for anode and cathode material do not represent conductivity in electrolyte accurately.

However, due to the thinness of electrolyte when compared to electrode sizes, this was presumed to be a valid assumption is also true for metallic interconnects.

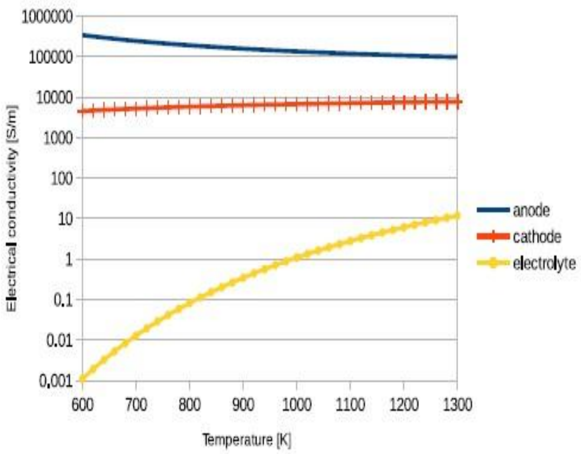


Figure 5: Electrical conductivity for SOFC anode, cathode and electrolyte although the decrease is substantial, electrolyte thickness is significantly smaller than one of the electrodes.

Finally, with top and bottom mesh having fixed values prescribed on one side (set at the beginning of a calculation) and having prescribed gradient (function of current density) on the side corresponding to anode-electrolyte interface, potential yields can be solved for. Since there are no volumetric source terms for potential yields in top and bo.om region, just as there are no potential jumps or discontinuities, distribution can be calculated by solving Laplace.

Equations for each yield,

$$\nabla \cdot (\sigma \nabla \Phi) = 0.$$

Laplace equation solutions for potential yields provide the distributions across two new meshes, and calculate values on boundaries that are needed for determining jump values on the interface. Conductivity s shows how well the material conducts charged particles (it is the inverse of resistivity). When potential distribution is calculated this way, it substitutes the ohmic over potential ohm or the usage of term Ri in the Kirchhoff -Ohm relation equation.

1.5 RESEARCH PROBLEM AND OBJECTIVES

The hydrogen fuel cell is a device that has been designed to convert chemical energy into electricity. It is supposed to be a safe and clean alternative to burning fossil fuels to power, amongst other things, our cars, since its waste products, rather than huge amounts of carbon dioxide and even sulfur particles, the hydrogen fuel cell releases carbon dioxide in smaller amounts and water. The basic mechanism behind these sorts of fuel cells is that energy is created from a reacting of positively hydrogen ions and an oxidizing agent, which is often oxygen. Unlike batteries, hydrogen fuel cells need a continuous source of oxygen or other fuel in order to keep the chemical reaction happening, which means that they can run continuously as long as they are supplied with the essential inputs.

Hydrogen is the most common element available on planet Earth. An atom of hydrogen consists of only one proton and one electron. Though it is available in plenty, it doesn't occur as a gas on the Earth. Water, for example, contains two atoms of hydrogen and one atom of oxygen bonded together. A process called electrolysis is required to separate water into its components of oxygen and hydrogen.

A hydrogen fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. As hydrogen is high in energy and produces almost no pollution, it is used as fuel to propel space shuttle and rockets into the orbit. These cells power the shuttle's electrical systems and produce clean water as a byproduct. It provides DC (direct current) voltage that can be used to power motors and run any number of electrical appliances.

1.6 BENEFITS OR IMPACT OF HYDROGEN FUEL CELLS

1. More Efficient

Compared to traditional means of powering cars and heating homes, for instance – such as using fossil fuels like coal and gas – hydrogen fuel cells are a lot more efficient. They produce a lot more energy for the number of components that are used. This makes them a lot cleaner than fossil fuels as more of them need to be burned and more chemicals and carbon dioxide needs to be released into the atmosphere in order to achieve the same amount of energy.

2. Hydrogen Fuel Cells are Quiet

Whereas mining for, transporting and refining fossil fuels is a messy and noisy affair, hydrogen fuel cells actually operate silently. Compared to internal combustion engines in, for instance, cars, which are very noisy, hydrogen fuel cells, do not make any sound. (If these were to be used for cars, therefore, artificial engine sounds would need to be added for the safety of pedestrians and animals.)

3. Elimination of Pollution

By switching from burning of fossil fuels for energy to using hydrogen fuel cells, we would effectively be switching from one of the worst pollutants to a power source that causes no pollution whatsoever. Besides tiny amounts of carbon dioxide and water, there are no byproducts or waste products when using hydrogen fuel cells.

4. Longer Operating Time

Hydrogen fuel cells tend to last a lot longer than other normal batteries that use chemicals to produce energy. Because doubling the operation time of the hydrogen fuel cell means doubling the amount of fuel rather than doubling the capacity of the unit (as with a battery), it is much easier to make the fuel cells run for longer periods of time without extra effort, money or stress.

1.7 NO NEED FOR GRIDS

Fossil fuels are distributed via energy grids to ensure that everyone who needs energy gets it. Hydrogen fuel cells can be grid-independent because they can be used anywhere that has a source of power as well as a source of water. This, in turn, means that the generation of fuel by hydrogen fuel cells can be distributed equally without the need for a centralized grid.

1.8 CONCLUSION

In this research article it is our aim to assess numerous physicochemical parameters generation of hydrogen with the help of previously completed work that improve our knowledge and enhance our vision of aim to establish hydrogen fuel cell with the various incorporation techniques. An analogical review paper can be make an approach that help to make research prospective vast and improved to create the hydrogen generation

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