MODELLING AND SIMULATION OF PEM FUEL CELL USING MATLAB

ASHWIN K[1] , JOTHIRAJ K[2] , SAIRAM B R[3] ,RAJA T [4]

[1,2,3] Student, Department of Automobile Engineering, Bannari Amman Institute of Technology, Sathyamangalam

[4]Assistant Professor, Department of Automobile Engineering, Bannari Amman Institute of Technology, Sathyamangalam

[1] ashwin.au19@bitsathy.ac.in

[2] jothiraj.au19@bitsathy.ac.in

[3] sairam.au18@bitsathy.ac.in

[4] raja@bitsathy.ac.in

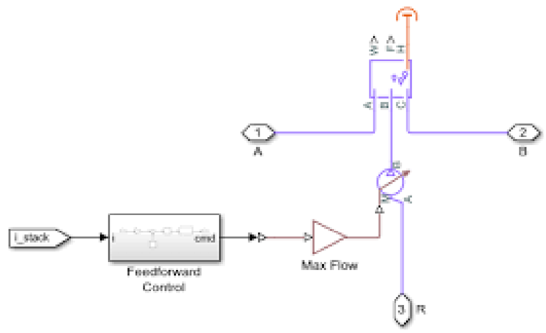
ABSTRACT

The studies pastime aimed to analyse and model gasoline cell structures for stationary applications. Mainly , PEM and SOFC models had been evolved and installation within the Matlab-Simulink environment. In the paper, the steady nation and dynamical operation of PEM and SOFC technology had been analysed, and their essential characteristics had been as compared .The reaction to the air and hydrogen flow rate and stress law. The studies hobby aimed to analyse and version fuel cell structures for stationary programs in particular, PEM and SOFC fashions were advanced and installation inside the Matlab-Simulink environment. Inside the paper, the steady state and dynamical operation of PEM and SOFC technology had been analysed, and their predominant characteristics had been compared, e.g. the reaction to the air and hydrogen growth the flow fee and pressure regulation.

INTRODUCTION

Fuel cells are set to turn out to
be the electricity supply of the future.
The activity in gas cells has extended for the
duration of the previous decade due to
the reality that the use of fossil fuels
for electricity has resulted in
many poor consequences. Some of
these encompass extreme pollution, considerabl
e mining of the world's resources, and
political manipulate and domination
of international locations that
have enormous resources. A
new energy supply is wanted that
is electricity efficient, has low pollutant
emissions, and has an limitless grant of fuel.
Fuel cells are now nearer to commercialization
than ever, and they have the capacity to fulfil all
of
the world electricity wants whilst assembly the
efficacy and environmental expectations.
Polymer electrolyte membrane
(PEM) gasoline cells are the
most famous kind of gas cell, and typical use
hydrogen as the fuel.
PEM gas cells additionally have
many different gas options, which vary from
hydrogen to ethanol to biomass-derived
materials. These fuels can both be at once fed
into the gasoline cell, or despatched to a
reformer to extract pure hydrogen, which is

then immediately fed to the gasoline cell. There are solely 30 extra years left of the furnish of fossil fuels for strength use. Changing the gasoline infrastructure is going to be costly, however steps need to be taken now to make certain that the new infrastructure is applied when needed. Since it is not possible to convert to a new economic system overnight, tivate Windows the alternate need to start slowly and have to be stimulated through countrywide govern to Settings juadreals.



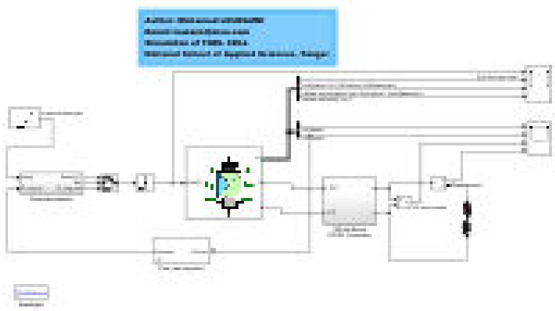
PEM Fuel Cell Modeling and Simulation Using MATLAB

- What's a PEM energy cell?
- Why do we need energy cells?
- The history of energy cells
- Mathematical models in the literature
- Creating fine models

These introductory energy cell motifs are bandied to help the anthology to appreciate the applicability that energy cell modeling has in addressing the global power requirements.

What's a gasoline cell?

A gasoline cell consists of a negatively charged electrode (anode), a definitely charged electrode (cathode), and an electrolyte membrane. Hydrogen is oxidized on the anode and oxygen is decreased at the cathode. Protons are transported from the anode to the cathode through the electrolyte membrane, and the electrons are carried to the cathode over the outside circuit. In nature, molecules can't stay in an ionic kingdom, therefore they immediately recombine with other molecules with a purpose to go back to the impartial state. Hydrogen protons in gas cells live within the ionic state by using traveling from molecule to molecule via the use of special substances. The protons travel through a polymer membrane made of persulfonic acid agencies with a tell on backbone. The electrons are attracted to conductive substances and tour to the burden whilst wanted. At the cathode, oxygen reacts with protons and electrons, forming water and generating warmness. Each the anode and cathode include a catalyst to hurry up the electrochemical approaches, as shown in discern 1-1. A normal pem gasoline cell (proton alternate membrane fuel mobile) has the



following reactions:

anode: h2 (g) → 2h+ (aq) + 2e−

cathode: 1/2o2 (g) + 2h+(aq) + 2e− → h2o (l)

overall: h2 (g) + 1/2o2 (g) → h2o (l) + electric strength + waste heat reactants are transported via diffusion and/or convection to the catalysed electrode surfaces wherein the electrochemical reactions take region. The water and waste heat generated by means of the fuel cell ought to be continuously eliminated and might gift crucial issues for pem fuel cells. The fundamental pem gasoline mobile stack consists of a proton alternate membrane (pem), catalyst and fuel diffusion layers, flow field plates, gaskets and quit plates as proven in desk the real fuel cell layers are the pem, gasoline diffusion and catalyst layers. Those layers are "sandwiched" together the use numerous procedures, and are referred to as the membrane electrode assembly A stack with many cells has means "sandwiched" between bipolar flow field plates and handiest one set of stop plates.

A few benefits of gasoline cell structures are as follows:

• gasoline cells have the capability for a high operating efficiency.

• there are many types of gasoline resources, and techniques of offering gas to a gas cell.

• gas cells have a highly scalable design.

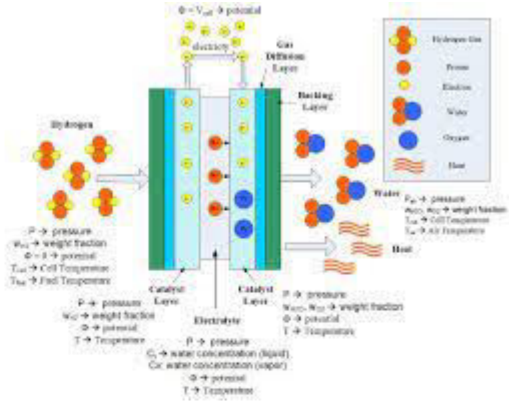
• fuel cells produce no pollutants

• gasoline cells are low renovation due to the fact they don't have any transferring components.

• gas cells do now not need to be recharged, and that they offer energy instantly when provided with gasoline.

A few limitations not unusual to all gas mobile systems consist of the following:

• gasoline cells are presently steeply-priced due to the need for substances with specific properties. There may be an trouble with finding low-cost replacements. This consists of the want for platinum and nafion cloth.



Why Do We Need Fuel Cells?

They produce large amounts of pollutants, they're of restrained deliver, and (three) they motive international conflict between areas. Fuel cells can energy anything from a house to a automobile to a cellular telephone. They're specifically advantageous for programs which can be electricity-restricted. For example, strength for transportable gadgets is restrained, therefore, consistent recharging is essential to hold a device operating. This is especially nice for portable power machine. Future markets for gasoline cells consist of the portable, transportation and desk bound sectors . Each market needs gasoline cells for varying motives, as defined in phase.

HISTORY OF FUEL CELL

William Grove is credited with creating the first power device in 18391. Fuel cells were not researched a lot during the 1800s and the vast majority of the 1900s.Broad power device research started during the 1960s at NASA. During the past decade, power devices have been widely explored and are finally approaching commercialization. A rundown of power device history is given in Figure 1-2.The most common way of utilizing power to break water into hydrogen and oxygen (electrolysis) was first depicted in 1800 by William Nicholson furthermore Anthony Carlisle2. William Grove created the first power device in 1839, utilizing the thought from Nicholson and Carlisle to "recompose water. "He achieved this by joining anodes in a series circuit, with separate platinum anodes in oxygen and hydrogen lowered in a weaken sulphuric corrosive electrolyte arrangement.

membrane for the production of electricity is g below:

Anode reaction $H_2 \Rightarrow 2H^+ + 2e^-$

Cathode reaction $\frac{1}{2}O_2 + 2H^+ + 2e^- \Rightarrow H_2O$

Overall reaction $H_2 + \frac{1}{2}O_2 \Rightarrow H_2O$

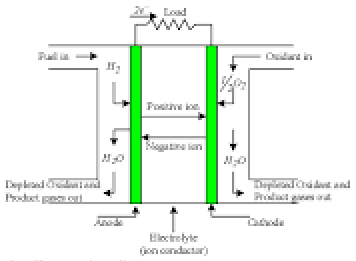
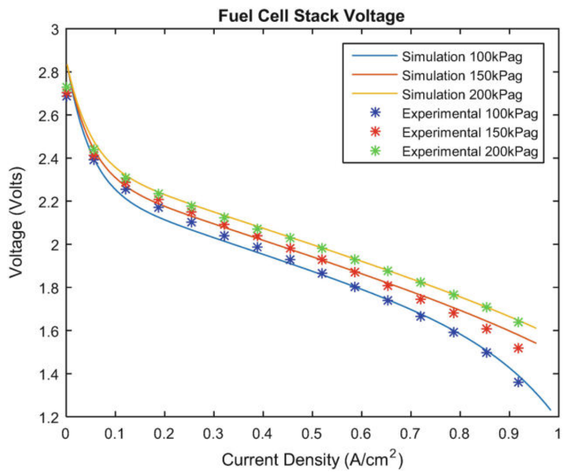


Fig. 1. Fuel cell operation diagram.

The gas battery, or "Forest cell," produced 12 amps of current at around 1.8 volts3. PEM Fuel is made more negative than the harmony potential, the response will structure more Re. In the event that the capability of the anode is more certain than the harmony potential, it will make more Ox5. The forward and in reverse responses occur all the while. The reactant utilization is relative to the surface concentration. For the forward response, the flux is jf = kfCOx



where kf is the forward response rate coefficient, and COx is the surface grouping of the reactant species. The regressive response of the flux is depicted by,

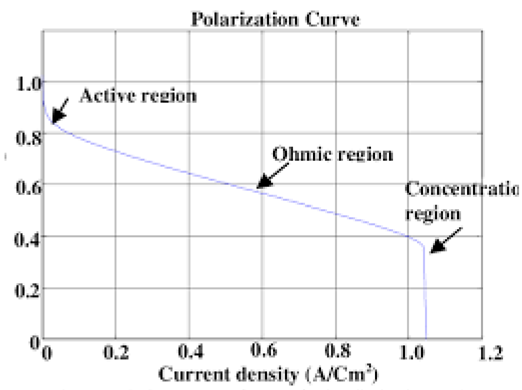
jB = kbCRd

where kb is the retrogressive response rate coefficient, and CRd is the surface centralization of the reactant species .These responses either devour or discharge electrons. The net current created is the contrast between the electrons delivered and burned-through

i = nF(kfCOx − kbCRd)

The net contemporary must same zero at equilibrium due to the fact the response will proceed in each directions simultaneously at the identical rate8. This reaction price at equilibrium is known as the alternate current density, that can be expressed as

K=kf/kb =cb/ca



I-V Characteristics curve of PEM fuel cell single stack

Ordinary voltage losses seen in a gasoline cellular are illustrated in discern 3-8. The single fuel cellular provides a voltage depending on running situations such as temperature, implemented load, and gas/oxidant waft rates. The same old degree of overall performance for fuel cellular systems is thepolarization curve, which represents the cellular voltage conduct towards working modern density.While electric electricity is drawn from the fuel cellular, the real mobile voltage drops from the theoretical voltage due to several irreversible loss mechanisms. The loss is defined because the deviation of the cellular potential (Virrev) from the theoretical ability (Vrev)

CONCLUSION

A steady-country version that simulates a PEM gas cellular stack to calculate output electricity and overall device efficiency with various external load turned into offered and as compared with experiments in a check bench. In popular, a great settlement among version and experiments become located for all results acquired. The stack polarisation curve, stack current and voltage version with external load confirmed maximum discrepancies between version and experiments of 3.1%, four.2% and 3.1%, respectively. The stack output strength variant with load resistance provided a most discrepancy between model and experiments of 5.7%. each model and experiments showed a linear dependence of hydrogen intake with stack modern, with a most discrepancy of eight.7%. model and experiments revealed the maximum overall device performance of around forty 7.5% at 50% of the rated strength. The maximum discrepancy of the gadget efficiency variation with output power determined via version and experiments become 4.6%. future applications of the version consist of the research of running parameters, together with stack temperature, with aim to optimise the device for elevated average efficiency via reducing fuel consumption and losses.

References

- Renewable 2019 Global Status Report; Renewable Energy Policy Network for the 21st Century; REN21: Paris, France, 2019.
- 2. Larminie, J.; Dicks, A. Fuel Cell Systems Explained, 2nd ed.; John Willey & Sons Ltd.: Hoboken, NJ, USA, 2003.
- 3. Ioannou, S.G. Discrete Linear Constrained Multivariate Optimization for Power Sources of Mobile Systems; University of South Florida:
- Tampa, FL, USA, 2008.
- 4. Ioannou, S.; Dalamagkidis, K.; Valavanis, K.P.; Stefanakos, E.K.; Wiley, P.H. On Improving Endurance of Unmanned Ground Vehicles:
- The ATRV-Jr Case Study. In Proceedings of the 2006 14th Mediterranean Conference on Control and Automation, Ancona, Italy, 28–30 June 2006; pp. 1–6.
- [1] Yan, Q., H. Toghiani, and J. Wu. Investigation of water transport through
- membrane in a PEM fuel cell by water balance experiments. J. Power Sources.
- Vol. 158, 2006, pp. 316–325.
- [2] Fabian, T., J.D. Posner, R. O'Hayre, S.-W. Cha, J.K. Eaton, F.B. Prinz, and J.G.
- Santiago. The role of ambient conditions on the performance of a planar,
- air-breathing hydrogen PEM fuel cell. J. Power Sources. Vol. 161, 2006, pp.
- 168–182.
- [3] Spiegel, C.S. Designing and Building Fuel Cells. 2007. New York: McGrawHill.
- [4] Ibid.

- [5] Lin, B. 1999. Conceptual design and modeling of a fuel cell scooter for urban
- Asia. Princeton University, master's thesis.
- [6] Lee, Analyses of the fuel cell stack assembly pressure.
- [7] Ibid.
- [8] Lee, S.-J., C.-D. Hsu, and C.-H. Huang. Analyses of the fuel cell stack assembly pressure. J. Power Sources. Vol. 145, 2005, pp. 353–361.
- [9] Lee, Analyses of the fuel cell stack assembly pressure.
- [10] Li, X. 2006. Principles of Fuel Cells. New York: Taylor & Francis Group.
- [11] Song, R.-H., and D.R. Shin. Infl uence of CO concentration and reactant gas
- pressure on cell performance in PAFC. Int. J. Hydrogen Energy. Vol. 26, 2001,
- pp. 1259–1262..