Research on Solid Oxide Fuel Cell(SOFC)

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ABSTRACT

Solid oxide fuel cells (SOFC) are an emerging technology for production of electricity through processing of different fuels such as contemporary diesel or gasoline fuel, natural gas (NG) and hydrogen. SOFC are advantageous over other fuel cells due to their high efficiency (up to 65%), the usage of a cheap catalysts and the low requirements towards the purity of the fuel when hydrogen is utilized. Additionally, SOFC can be combined with an internal combustion engine (ICE) or a gas turbine (GT) to work in combined cycles. The heat engine (HE) utilizes the residual anode-off hydrocarbon-containing gases of the SOFC to guarantee even better efficiencies and higher versatility of the power system over standalone-SOFC and standalone-ICE layouts. Such combined systems can successfully be applied in stationary power or combined heat and power (CHP) generation for remote regions, or where the electricity from the grid is too expensive. They are also a promising concept in the transportation sector, particularly for heavy-duty transport means such as trains, trucks and airplanes. One of the greatest advantages of hybrid cycle systems is that they generate very low amounts of harmful gases, which makes them viable in the context of contemporary strict emission regulations. Namely the basics of the SOFC technology, its possible applications, and the approaches and possible layouts for building.

INTRODUCTION: -

Rising fuel prices with increased consumption of electricity will make necessary to implement much more efficient systems for its production than today. Fuel cells convert chemical energy of fuel directly in electricity through electrochemical processes, so they are not limited by maximum cycle thermal efficiency. In addition, high-temperature fuel cells can be used as a heat source for traditional thermal cycles, thereby creating hybrid systems with a potential ultra-high efficiency (70%). Currently, dynamic models of individual components of the power plants are based mainly on zero-dimensional models, where apart from the static characteristics of the equipment, the corresponding dynamic characteristics are considered (accumulation of heat and matter, rotating inertia, etc.). In order to choose an optimal control system and the operation parameters of both fuel cells and elements cooperating with them, a suitable dynamic model of SOFC cells congruent with other components of the system is needed.

In the past decades, a great number of researchers had investigated in SOFC modelling and the internal process simulation based on physical principles. By using physical and analytical equations, they translated successfully the electrochemical reactions, the electronic and ionic properties materials as well as gas flow process to detailed physical models. These models range from zero-dimensional (0-D) to three-dimensional (3-D) with different features and point to different research objectives. From the viewpoint of model function, 2-D and 3-D modelling is typically concerned with the cell and stack design issues while 0-D and 1-D modelling is aimed at control purposes (on system-level) such as prediction of both the transient and steady-state performance of fuel cell/stack and establishing the optimal operating conditions. For the research target of setting up an online diagnostic tool, low dimensional models (0- and 1-D) are more appropriate due to the less computational time in comparison with the high dimensional ones (2- and 3-D). Moreover, high dimensional models require information about material properties or electrochemical parameters that are not always available or might be difficult to determine.

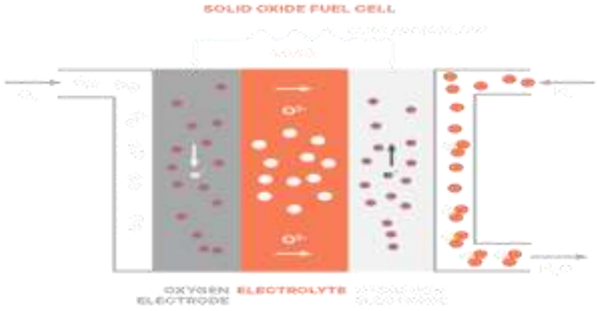
Even so, high dimensional models are still helpful to learn the operation behavior of fuel cells of different geometry design and very useful for creating training data for black-box modelling which will be introduced in the fifth section. Another method is AC impendence modelling. It is based on electrochemical impedance spectroscopy (EIS) measurements. The electrochemical information on an operating fuel cell system can be obtained from the measured EIS data and interpreted by fitting this data to an impedance model. Recently, specific applications of EIS in SOFCs have appeared frequently in the literature. The obtained results demonstrate that this technique is an effective modelling approach. It is worth noting that EIS is a tool used to acquire electro-chemical parameters. It is also known as AC impedance technique. When a perturbation signal (voltage or current) is imposed on a SOFC, a corresponding output signal (current or voltage) can be obtained.

HISTORY AND BACKGROUND: -

Water electrolysis to produce hydrogen and oxygen gases is a well-known established process. Basically, the principle of a water electrolyser is to convert water and DC electricity into gaseous hydrogen and oxygen, that is to say the reverse of a hydrogen fuel cell.

Year of research	***Name of researcher***	***Research work***
1800	**Nicholson and charlisle**	**First who introduced the concept of SOFC.**
1820	**Faraday and team**	**Introduction to principles of Solid oxide fuel cell(SOFC).**
1934	**Faraday and team**	**Introduction to new concept of dzelectrolysisdz of Solid oxide fuel cell(SOFC).**
1951	**Lurgi**	**First commercial high pressure.**
1980	**Dontiz and Edle**	**Worked on Hot-Elly project, using electrolyte support tubular SOEC.**

METHODOLOGY: -



A solid oxide fuel cell utilizes the energy produced by a chemical reaction to Supply a Voltage that can be used to power other devices. This direct conversion process increases the efficiency of power generation by removing mechanical steps required for example, traditional turbine plants. Additionally, the combination of higher efficiency and electrochemical processes results in an environmentally favorable product. This Fuel cells generate significantly less NO, and negligible quantities of carbon dioxide compared to internal combustion engines.

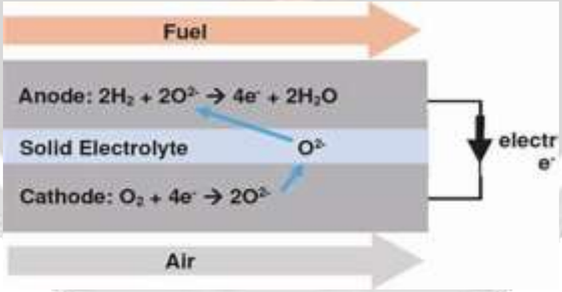
A fuel cell powered vehicle, for example, may generate one ten-thousandth the quantity of NO and non-detectable quantities of CO. The solid oxide fuel cell (SOFC)possesses three basic parts: An anode that produces electrons, a cathode that consumes electrons, and an electrolyte that conducts ions but prevents electrons from passing. Using hydrogen gas as the fuel passed to the anode and oxygen gas as the oxidant passed to the cathode, a current of oxygen anion charge carriers is produced according to the following reactions:

$H_2O \rightarrow H_2 + 1/2O_2$. (FINAL REACTION)

The reactions in the cathode and anode sides are

$H_2O + 2e^- \rightarrow H_2 + O^{2-}$

$O^{2-} \rightarrow 1/2\ O_2 + 2e^-$



Making a SOFC is a simple process but our aim is to make it in large scale, by this we may acquire electricity on a large scale.

A solid oxide fuel cell (SOFC) directly converts the chemical energy in fossil fuels into electrical power via an electrochemical reaction. A SOFC (Figure) has three basic functional elements: cathode, electrolyte, and anode. The cathode reduces oxygen (in the form of O2) in the air supplied to it into O2–. The electrolyte transports oxygen continuously, in the form of O2–, from the cathode to the anode under a gradient of oxygen chemical potential. At the anode, or fuel supply electrode, the O2– delivered by the electrolyte reacts with hydrogen or a hydrocarbon fuel to produce H2O, CO2, and electrons. The electrons required for the cathode reaction are released by the anode and arrive at the cathode via an external load that produces electricity.

MATERIALS: -

A SOFC is mainly composed of two electrodes (the anode and the cathode), and a solid electrolyte. The fuel is also important as the principal parameter but independent of the other as it is most of the time converted into hydrogen. The SOFC, which relies on O2- oxygen ion transport, also works with high purity hydrogen, but it does not rely upon this fuel, which is expensive to produce and difficult to handle. The main function of the electrode is to bring about reaction between the reactant (fuel or oxygen) and the electrolyte, without itself being consumed or corroded. It must also bring into contact the three phases, i.e., the gaseous fuel, the solid electrolyte, and the electrode itself. The anode, used as the negative post of the fuel cell, disperses the hydrogen gas equally over its whole surface and conducts the electrons, that are freed from hydrogen molecule, to be used as a useful power in the external circuit. The cathode, the positive post of the fuel cell, distributes the oxygen fed to it onto its surface and conducts the electrons back from the external circuit where they can recombine with oxygen ions, passed across the electrolyte, and hydrogen to form water. The electrolyte determines the operating temperature of the fuel cell and is used to prevent the two electrodes to come into electronic contact by blocking the electrons. It also allows the flow of charged ions from one electrode to the other to maintain the overall electrical charge balance. It can either be an oxygen ion conductor or a hydrogen ion (proton) conductor, the major difference between the two types is the side in the fuel cell in which the water is produced: the oxidant side in proton– conductor fuel cells and the fuel side in oxygen-ion-conductor ones.

APPLICATIONS OF SOFC: -

1)High power reliability: computer facilities, call centers, communication facilities, data processing centers high technology manufacturing facilities.
2)Emission minimization or elimination: urban areas, industrial facilities, airports, zones with strict emissions standards.
3)Limited access to utility grid: rural or remote areas, maximum grid capacity.
4)Biological waste gases are available: waste treatment plants, SOFC can convert waste gases (methanol from biomass) to electricity and heat with minimal environment intrusion.
5)Large and small stationary power generation Co-generation application
6)Spin a gas turbine, generating second source of energy.

ADVANTAGE OF SOFC: -

1)High efficiency

2)Long term stability

3)Fuel flexibility

4)Low emission

5)Relative low cost.

DISADVANTAGES OF SOFC: -

1)Complex manufacturing

2)Fuel handling and utilization

3)High operating temperature which results in longer start-up times and mechanical and chemical compactability

CONCLUSION: -

Energy exploitation of fossil fuels is reaching its limits. Future alternatives must therefore be developed for long term and environmental-friendly energy supply needed by a constantly growing world population. SOFCs provide highly efficient, pollution free power generation. Their performance has been confirmed by successful operation power generation systems throughout the world. Electrical-generation efficiencies of 70% are possible nowadays, along with a heat recovery possibility. SOFCs appear to be an important technology for the future as they `a variety of fuels, from solar hydrogen to methanol, from biomass to gasified coal. As the technology develops, and if the cost of fossil fuels continues to rise, this clean, efficient alternative will stimulate the thermo-mechanical engineers, despite their Carnot and Rankine limitations, to even greater efforts for the SOFCs to find more and more practical uses issues.

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