A Novel Solar Driven Micro-CHP System: A State of the Art Review

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ABSTRACT: The state-of-the-art solar power system technologies are presented. With ever increasing global energy demand and high oil prices and as well current environmental problems as result of usage of fossil fuels, there is a high interest in renewable energy technologies. The sun radiates enormous amounts of energy to the earth due to its surface temperature of about 6,000°C. About 40-50% of this temperature can be captured and utilised for power generation. Many developing countries have an abundance of solar energy. Thus solar energy as a means of power generation from renewable source presents an attractive and promising solution to the future energy needs of both the developing and developed countries. Various methods of capturing solar energy using solar collectors such as parabolic trough collectors and dish collectors are reviewed. Combined heat and power (CHP) systems driven by concentrating solar collectors are proving to be the most promising methods of domestic power generation. This paper also reviews past work on solar driven CHP technologies. Despite huge potential market for micro scale solar powered CHP systems, the systems are yet to be seen available on commercial market. Hence the authors of this paper are currently developing such type of CHP system with electricity production being of prime importance.

Keywords: concentrator, solar collector, solar driven CHP, turbine, biomass

1. Introduction

Solar energy is the world's largest energy source, while biomass is the world's oldest non fossil-fuel which currently contributes to about 14% of world energy needs. The reduction of fossil-fuel based power production by using solar power technology combined with biomass is one important step in the international commitment towards reduction of carbon emissions.

The two main technologies used for utilisation of solar energy are photovoltaic and solar collector. The photovoltaic technology has low efficiency and high capital cost [2]. Solar collectors transform solar radiation into thermal energy. Various high-temperature solar thermal power systems have been suggested and developed. Existing large-scale solar power plants are usually located far away from centres of population. This results in grid transmission and distribution losses [11]. Hence this has lead to the development of

Characteristics of Pore Structure in Filtering Layer of High Strength Reaction Bonded Silicon Carbide Hot Gas Filter for IGCC

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ABSTRACT: The high strength reaction bonded SiC(RBSC) hot gas filter was newly developed for IGCC. The RBSC hot gas filter was consisting of RBSC porous support and clay bonded SiC filtering layer which were separately fabricated. The clay bonded SiC filtering layer on RBSC support was fabricated by spray coating process and subsequently sintering process using SiC powder and feldspar powder. In this study, the pore structure including porosity and pore size of clay bonded SiC filtering layer was controlled by changing amounts of feldspar. With increasing the amounts of feldspar in filtering layer, the porosity and pore sizes in the filtering layer was decreased. The maximum porosity and average pore size of clay bonded SiC filtering layer fabricated in this study were 41% and 8 μm, respectively. The pore structure of filtering layer of hot gas filter for IGCC was optimized by controlling amounts of feldspar.

Keywords: SiC hot gas filter, IGCC, filtering layer, porous SiC

1. INTRODUCTION

Integrated Gasification Combined Cycle(IGCC) technology is less polluting and more efficient than any other coal power generation technology. It's high efficiency yield much less CO_2 gas emission than those of coal power plants. The recently developed reaction bonded SiC(RBSC) hot gas filters with high flexural strength seems to have the best potential for particulate collection in IGCC[1], [2], [3]. The RBSC hot gas filter developed in this study was consisting of RBSC porous support and clay bonded SiC filtering layer. The porous reaction bonded silicon carbide with high strength was used to support the filtering layer. The pore structure of filtering layer including pore size and porosity mainly determines the filtration properties of RBSC hot gas filter operating under high temperature and high pressure. Therefore, to develop multilayered filtering structure of hot gas filter which has excellent properties on filtration and cleaning process of hot particulates from gasfier, it is necessary to control the porosity and the pore size of filtering layer in the hot gas filter. There are some essential factors to affect the pore structure of filtering layer such as the size of particle used, neck composition, sintering temperature, and sintering time, etc. In this

Numerical Simulation of PEM Fuel Cell Performance

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ABSTRACT: An improved proton exchange membrane (PEM) fuel cell model including two finite-thickness catalysts and a partially hydrated membrane is described and employed in this study. After validation against available experimental results, the model is used to predict the PEM fuel cell performance corresponding to a series of operating conditions and material properties. The outcome of this study reveals some effective heat and water management strategies leading to improved performance of PEM fuel cells.

Keywords: proton exchange membrane fuel cell, numerical simulation

1. INTRODUCTION

Fossil-fuel powered vehicles are found to be responsible for emitting various hazardous pollutants into the atmosphere, resulting in numerous environmental problems such as worsening air quality and global warming. This has prompted research and development into energy conversion technologies using alternative fuels that are inherently clean, efficient, and compatible with renewable energy sources. Fuel cell technology meets all these criteria. Among various fuel cell systems, the proton exchange membrane (PEM) fuel cell appears more attractive owing to its simplicity in design, high power density, proven long operating life, and great potential for transport applications.

During the PEM fuel cell operation, critical properties, such as the fluid flow pattern, species concentration variation, temperature distribution, and local current densities, are often fairly difficult to achieve by *in-situ* measurements. Fortunately, the development of digital computers enables fuel cell researchers to investigate, through numerical solution of mathematical modelling equations, sophisticated flow features and complex transport mechanisms that might be experimentally unobservable, greatly helping obtain insight for the PEM fuel cell design and performance optimization.

A number of modelling studies have been conducted to better understand how the water and thermal management affects the operation of PEM fuel cells. In [1], a general PEM fuel cell model was presented that considered all components into a unified domain for computation. On the other hand, a partially hydrated membrane was studied in [2] that evaluated the effect of membrane water variation on the PEM fuel cell performance. Built upon these two studies, a new PEM fuel cell model is developed in this paper that features: (1) allowing the thin catalysts to physically appear in the computational model instead of simply using them as nil-thickness interfaces; and (2) accounting for variable water content in the membrane instead of replying on the fully hydrated membrane assumption. The numerical results obtained in this study are shown in good agreement with the experimental data. Also, a systematic study

Compact Reformer for Treatment of Liquid and Gaseous Fuels

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ABSTRACT: We have designed a small scale reformer to maintain a reaction of partial oxidation. It contains a fuel and air supply part, a reforming mixture preparation, a reaction initiation part, and the reformation part. An important parameter for the quality of reformation is a liquid fuels atomization on the inlet of the reformer. We designed a diesel evaporating system which gives a perfect atomization. The fuel steam is mixing later on with a hot air in a mixing pipe, and then passes throw a flame blocking media and get into an initiation chamber, where the sparking plug ignites the oxidation reaction. No catalyst was used in the reaction. The reformer used a new labyrinth structure of reformer thereby increasing the effective burning surface by turning the flame front. The reformer consumes less then 200 watts without a heat recirculation, it happens in a cold start. At the steady work the power consumption can be even less.

Keywords: hydrogen production, waste treatment, small scale reformer.

1. INTRODUCTION

For an application in automobile a small scale production of hydrogen or carbon monoxide is necessary. For example a catalytic cleaning of the exhaust gas of diesel vehicles in some cases needs a supply of a reduction reagent. Other applications for a small fuel reformer may be found in using fuel cells systems without hydrogen cylinders, in utilization of wasting oils and gases. Fuel comes into the reformation system, and after, in a gaseous state containing carbon monoxide, hydrogen, and light hydrocarbons, the reformed fuel is getting to a consuming device like a catalyst.

An application of plasmatron for the fuel reformation gave us knowledge about the burning mixture behaviour [1, 2]. The plasmatron geometry is principally not perfect for atomization, because the air and fuel mixture are forced to go throw parts with decreasing cross-sections. But one important feature was noticed during experiments: the reformation process "likes" the hot equipment, especially when the reformation pipe becomes red hot. We could reach that condition by lowering fuel concentration. An excessive air makes reaction more complete and additional reaction energy heat the pipe making conversion deeper.

Another conclusion was made about the continuity of reaction. Quite often the reaction switched to the chains of detonations following with a frequency of 1-10 Hz. The sound was always loud. A probable explanation for these phenomena is that the reformation doesn't happen in full measures in the area of plasma and technologic mixture interaction. Spatial and temporal limitations for the inflammation process cause periodical detonations. Flame propagation velocity becomes an important

CFD Simulation on the 2nd Discharge-Path Line in Hydrogen Reciprocating Compressor

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ABSTRACT: The reciprocating compressor is widely used in the industry field, because it has simple principle and high efficiency. In this work, in order to improve design of discharge-path line in hydrogen compression system, Numerical analysis has been conducted. It is a useful tool to observe the flow quickly and clearly. General information about an internal gas flow is presented by numerical analysis approach. Flow characteristic analysis, including velocity, pressure and turbulence kinetic energy distribution of hydrogen gas going out from the cylinder to discharge-path line are presented in this paper. Discharge-path model is designed based on real model of hydrogen compressor. Pressure boundary conditions are applied considering the real condition of operating system. The result shows velocity, pressure and turbulent kinetic energy are not distributed uniformly along the discharge-path of the Hydrogen system. Particles track helps to demonstrate flow characteristics inside the discharge-path. The existence of vortices and flow direction can be precisely predicted. Based on this result, the design improvement will be done.

Keywords: CFD simulation, Hydrogen Reciprocating Compressor, Discharge-Path Line, Velocity, Pressure, Turbulence Kinetic Energy

1. INTRODUCTION

Hydrogen can be produced from a variety of sources, including fossil fuels; renewable sources such as wind, solar, or biomass; nuclear or solar heat-powered thermo chemical reactions; and solar photolysis or biological method [1]. It is considered to be a prime fuel in supply and security, transition to hydrogen economy, environmental betterment, and social, societal, technological, industrial, economical and governmental sustain abilities in a country. Thus, green energy based hydrogen system can be one of the best solutions for accelerating and ensuring global stability and sustainability. Therefore, the production of hydrogen from non-fossil fuel sources and the development and application of green energy technologies become crucial in this century for better transition to hydrogen economy [2].

The assertion of "hydrogen is considered a promising future fuel for vehicles" is based on three main arguments: the potential reducing greenhouse gases from the transport sector, greater energy supply security, i.e. hydrogen can be produced from many energy sources and hence the risk of shortage of supply may be reduced; the potential of zero local emissions with the use of fuel cells.

Hydrogen Gas Pulsation Damping in Snubber of Reciprocating Hydrogen Compressor

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ABSTRACT: Hydrogen compressing system is the most important part of hydrogen economy. There develop inherently pressure pulsation in reciprocating hydrogen compressing system. Snubber unit has been employed then to decrease it. An experiment has been conducted to investigate the performance of snubber used in reciprocating compression system. CFD analysis is applied to get the pressure values at different sections of this system. Regression models are also developed for amplitude at input and output of the snubber. A comparative study of pressure and amplitude by experiment, regrssion model and CFD model are performed for 35, 40 and 45hz motor frequency. These models results are varied by 0.844%, 0.117% and 0.475% from the experiment for those motor frequencies. The pressure losses in the snubber are also found almost similar values by the model i.e. 0.024%, 0.030% and 0.016% deviations.

Keywords: hydrogen gas, pulsation, damping, snubber, reciprocating compressor

1. INTRODUCTION

Today, the use of energy brings a lot of benefits but it has unwanted effects of one kind or another. Enormous scale of modern energy use has sharply increased concerns about unwanted environmental effects. Emissions of greenhouse gases are carbon dioxide, methane, nitrous oxide, and others. They alter the earth's climate which is inhospitable to life. The recent hikes in the price of fossil fuel have added impetus to the movement towards hydrogen and other alternative fuels [1]. The physical and chemical properties of hydrogen make its utilization superior to fossil fuels. It is a simple, non-toxic molecule that generates power cleanly and efficiently, even silently and without combustion, if desired. If generated from renewable energy, hydrogen becomes the crucial link in an inexhaustible global fuel cycle based on the cleanest, most abundant, natural, and elementary substances: H_2, O_2 and H_2O [2]. In integrating production planning and reactive scheduling for the optimization of a hydrogen supply network, compressor is an essential part. Reciprocating compressor is used in hydrogen compression more for its higher pressure increasing capacity. But pressure fluctuation is inherent and resulted from reciprocating back and forth movement of piston inside the cylinder. It gives several various problems for the equipment related to the system and acting gas in it like inaccurate metering, unwanted vibrations, noises, explosions, shorten life of equipment, poor performance etc. Therefore, it should be lessened this pressure pulsations. Snubber or dampers are

Application of Proton Exchange Membrane Fuel Cell (PMFC) for Hydrogen Based Electricity Generator Alternative

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ABSTRACT: In this paper, hydrogen based sustainable electricity generator alternative utilizing Proton Exchange Membrane Fuel Cell (PMFC) is presented. Hydrogen and oxygen, with suitable operating condition are flowed to anode and cathode of fuel cell respectively to produce electricity, heat and water. Hence, the energy conversion process from chemical to electricity is clean, without combustion process that produces harmful carbon dioxide gas, and with higher efficiency as well. Based on fuel cell capacity and specification, process analysis is performed to get overall process parameters that are very critical and substantially affect the performance of the power generation. Instrumentation and control of this system are also designed and implemented to enable the direction of the system operation to achieve its better performance as well as to enable the evaluation of the system performance through continuous monitoring of overall system parameters. Some experimental results will also be shown in this paper to give illustration of the performance of the zero carbon emission and green energy conversion system.

Keywords: fuel cell, electricity generator, energy conversion, zero carbon, higher efficiency

1. INTRODUCTION

A fuel cell is electrochemical device that converts the energy of a chemical reaction directly into electrical energy, with water and heat as its by-product. The inputs of the fuel cell are hydrogen and oxygen gases that will react to each other to enable the production of electricity. The different between fuel cell and battery is mainly in the mode of operation where for battery, energy conversion is limited by the amount of energy stored internally while for the fuel cell, it is possible to operate the fuel cell continuously as long as the supply of fuel is maintained. By using fuel reformer, fuel cell system can be supplied with any kind of hydrocarbon fuel, not only gases such as hydrogen and methane but also liquid fuels such as gasoline, biodiesel, methanol and ethanol as well as solid fuels such as carbon. As the basis of energy conversion in fuel cell is electrochemical process which does not involve any combustion anymore, there are some potential advantageous of the utilization of fuel cell including clean process, quiet and more efficient than that of fuel burning and cutting the GHG effect. Consequently, fuel cell has attracted researchers to develop wide spread applications of fuel cell for stationery as well as mobile applications including power generation. However, some challenges are still under investigation to bring fuel cell achieves its targeted applications. These problems include catalyst material to obtain higher density of energy conversion, reliability and stability of fuel system as well as instrumentation and control to get better performance of the fuel cell system

Theoretical and experimental investigation into using a PEM fuel cell to supply combined heat and power in a solar-hydrogen system

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ABSTRACT: Solar-hydrogen systems are approaching competitiveness for remote area power supply. One option for improving the economics of such systems compared to conventional systems such as diesel generators is to use the fuel cell to supply both electricity and low temperature heat for domestic water heating. A theoretical investigation has been conducted into a solar-hydrogen system employing a PEM fuel cell to supply both power and heat to a remote household. Simulation modeling of a standalone system of this kind to supply a household in south-eastern Australia with a 5 kWh daily electricity demand has revealed that harnessing the heat generated by the fuel cell increases the average annual efficiency of the fuel cell from about 33% for power generation alone, to about 63% in the combined heat and power application. The economic gain of this heat recovery is equivalent to about 9% of the capital cost of the system over an assessment period of 30 years if the recovered heat is assumed to save LPG consumption used for hot water supply. An experimental investigation into the performance of a 500 W PEM fuel cell system used to supply both electricity and heat is reported. The results agree closely with the predictions of the theoretical model for both electrical power and heat production. It is also found that relatively small deviations from ideal values for key parameters of the fuel cell such as temperature, air pressure and air stoichiometry could lead to reductions in electrical output of about 25%.

Keywords: solar-hydrogen system, PEM fuel cell, combined heat and power, simulation, remote power supply

1. INTRODUCTION

Solar-hydrogen systems promise to have a strong potential for remote area power supply or other standalone applications with poor to no access to grid electricity. Such a system comprises photovoltaic panels for directly supplying the electrical demand and

Exergoeconomic and exergoenvironmental analyses of the AZEP concept, a combined cycle power plant with CO_2 capture

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ABSTRACT: CO_2 capture and storage from energy conversion systems is widely known as a potential method to reduce CO_2 emissions to the atmosphere and to limit the impact of energy use on the climate.
This study provides an evaluation from an economic and environmental point of view of the Advanced Zero Emission Plant (AZEP), an oxy-fuel concept. The plant is evaluated and compared to a reference plant that includes no CO_2 capture. The concept appears to have relatively lower cost and exergy expenditures than competitive alternatives, like CO_2 capture with post-combustion technology.
Two exergy-based methods, the exergoeconomic and the exergoenvironmental analyses, are used to determine the environmental and economic impacts, respectively, and options to improve the overall effectiveness of the plant. The results of the detailed exergoeconomic and exergoenvironmental analyses are compared to those of the reference case. The exergoeconomic analysis shows a high increase in the costs due to the introduction of the new technology used in the AZEP. On the other hand, the additional cost is counter-balanced by the reduced environmental impact of the plant with CO_2 capture. The applied exergy-based methods provide a way to suggest changes to the structure and the operation of the plants.

Keywords: AZEP, CO_2 capture, exergy analysis, exergoeconomics, exergoenvironmental analysis

NOMENCLATURE

b	environmental impact per unit of exergy (€/GJ)
$\dot{B}$	environmental impact rate associated with an exergy stream (€/h)
c	cost per unit of exergy (€/GJ)
$\dot{C}$	cost rate associated with an exergy stream (€/h)
$\dot{E}$	exergy rate (MW)
f	exergoeconomic factor (%)
f_b	exergoenvironmental factor (%)
M	mass flow rate (kg/s)
p	pressure (bar)
r	relative cost difference
r_b	relative environment impact difference
T	temperature (°C)
Y	component related environmental impact (mPts/s)
$\dot{Z}$	cost rate associated with capital investment (€/h)

Subscripts

D	exergy destruction
F	fuel (exergy)