Solid Oxide Fuel Cell Balance Of Plant And Stack Component

As recognized, adventure as without difficulty as experience not quite lesson, amusement, as competently as bargain can be gotten by just checking out a book Solid Oxide Fuel Cell Balance Of Plant And Stack Component furthermore it is not directly done, you could resign yourself to even more just about this life, roughly the world.

We give you this proper as competently as simple way to get those all. We allow Solid Oxide Fuel Cell Balance Of Plant And Stack Component and numerous book collections from fictions to scientific research in any way. along with them is this Solid Oxide Fuel Cell Balance Of Plant And Stack Component that can be your partner.

High Temperature Oxidation Resistance of Welded Ferritic, Austenitic and Nickel Alloys for Balance of Plant (BOP) in Solid Oxide Fuel Cell (SOFC) Systems Rick D. Wilson 2005

Cost Analysis and Balance-of-plant of a Solid Oxide Fuel Cell/gas Turbine Combined Cycle Mary Elizabeth Douglas 2003

Solid Oxide Fuel Cell Technology Stationary Power Application Project 2009 The objectives of this program were to: (1) Develop a reliable, cost-effective, and production-friendly technique to apply the power-enhancing layer at the interface of the air electrode and electrolyte of the Siemens SOFC; (2) Design, build, install, and operate in the field two 5 kWe SOFC systems fabricated with the state-of-the-art cylindrical, tubular cell and bundle technology and incorporating advanced module design features. Siemens successfully demonstrated, first in a number of single cell tests and subsequently in a 48-cell bundle test, a significant power enhancement by employing a power-enhancing composite interlayer at the interface between the air electrode and electrolyte. While successful from a cell power enhancement perspective, the interlayer application process was not suitable for mass manufacturing. The application process was of inconsistent quality, labor intensive, and did not have an acceptable yield. This program evaluated the technical feasibility of four interlayer application techniques. The candidate techniques were selected based on their potential to achieve the technical requirements of the interlayer, to minimize costs (both labor and material), and suitably for large-scale manufacturing. Preliminary screening, utilizing lessons learned in manufacturing tubular cells, narrowed the candidate processes to two, ink-roller coating (IRC) and dip coating (DC). Prototype fixtures were successfully built and utilized to further evaluate the two candidate processes for applying the interlayer to the high power density Delta8 cell geometry. The electrical performance of interlayer cells manufactured via the candidate processes was validated. Dip coating was eventually selected as the application technique of choice for applying the interlayer to the high power Delta8 cell. The technical readiness of the DC process and product quality was successfully and repeatedly demonstrated, and its throughput and cost are amenable to large scale manufacturing. Two 5 kWe-class SOFC power systems were built and installed for the purpose of testing and evaluating state-of-the-art tubular cell and bundle technologies, advanced generator and module design features, balance-of-plant components, and cost reduction measures. Installed at the Phipps Conservatory and Botanical Gardens, a system operated for more than 17,500 hrs, delivering electrical power to the on-site grid and thermal energy in form of hot water for onsite utilization. Operation was typically autonomous, requiring minimal operator intervention, and achieved an overall availability of greater than 85%. Outages were primarily due to an unstable local grid, two weather related outages were experienced, and very few reliability issues were encountered despite harsh operating conditions. No repairs to the stack, module, or balance-of-plant were required. A second system was designed, built, delivered, and installed at a Siemens facility in Charlotte, North Carolina. Operational issues associated with the balance-of-plant were encountered during startup and prevented the system from operating.

Advances in Medium and High Temperature Solid Oxide Fuel Cell Technology Marta Boaro 2016-11-24 In this book well-known experts highlight cutting-edge research priorities and discuss the state of the art in the field of solid oxide fuel cells giving an update on specific subjects such as protonic conductors, interconnects, electrocatalytic and catalytic processes and modelling approaches.Fundamentals and advances in this field are illustrated to help young researchers address issues in the characterization of materials and in the analysis of processes, not often tackled in scholarly books.

Fuel Cell 655 Success Secrets - 655 Most Asked Questions on Fuel Cell - What You Need to Know Ronald Alston 2014 There has never been a Fuel Cell Guide like this. It contains 655 answers, much more than you can imagine; comprehensive answers and extensive details and references, with insights that have never before been offered in print. Get the information you need--fast! This all-embracing guide offers a thorough view of key knowledge and detailed insight. This Guide introduces what you want to know about Fuel Cell. A quick look inside of some of the subjects covered: Glossary of fuel cell terms - Direct carbon fuel cell, Glossary of fuel cell terms - Ion, Glossary of fuel cell terms - Boiling point, Molten Carbonate Fuel Cell - MTU fuel cell, List of fuel cell vehicles - Automobiles, Glossary of fuel cell terms - Engine, Glossary of fuel cell terms - Potential difference, Glossary of fuel cell terms - Liquid-liquid extraction, Glossary of fuel cell terms - Density, Glossary of fuel cell terms - Carbon dioxide sensor, Glossary of fuel cell terms - Terbium, Glossary of fuel cell terms - Flammability limit, Microbial fuel cell - History, Glossary of fuel cell terms - Borax, Glossary of fuel cell terms - Liquefaction, List of fuel cell vehicles - Trucks/buses, Fuel cell - Phosphoric acid fuel cell (PAFC), Glossary of fuel cell terms - Anion, Glossary of fuel cell terms - Thermal efficiency, Enzymatic Biofuel Cells, Glossary of fuel cell terms - Solubility, Hybrid cars - Fuel cell, electric hybrid, Glossary of fuel cell terms - Voltage, Stationary fuel cell applications - Applications, Glossary of fuel cell terms - Carbon black, Glossary of fuel cell terms - Service life, Glossary of fuel cell terms - Electrical efficiency, Direct-methanol fuel cell - Reaction, Hydrogen fuel cell - Power, Tubular solid oxide fuel cell - Balance of plant, List of fuel cell vehicles - Trains/Locomotives, and much more...

Volkswirtschaftslehre 1 Werner Lachmann 1993-12-01

Advances in Solid Oxide Fuel Cells X Mihails Kusnezoff 2014-12-19 This issue contains 13 papers from The American CeramicSociety's 38th International Conference on Advanced Ceramicsand Composites, held in Daytona Beach, Florida, January 26-31, 2014presented in Symposium 3 - 12th International Symposium on SolidOxide Fuel Cells: Materials, Science, and Technology.

Development of a Novel Efficient Solid-Oxide Hybrid for Co-generation of Hydrogen and Electricity Using Nearby Resources for Local Application 2009 Developing safe, reliable, cost-effective, and efficient hydrogen-electricity co-generation systems is an important step in the quest for national energy security and minimized reliance on foreign oil. This project aimed to, through materials research, develop a cost-effective advanced technology cogenerating hydrogen and electricity directly from distributed natural gas and/or coal-derived fuels. This advanced technology was built upon a novel hybrid module composed of solid-oxide fuel-assisted electrolysis cells (SOFECs) and solid-oxide fuel cells (SOFCs), both of which were in planar, anode-supported designs. A SOFEC is an electrochemical device, in which an oxidizable fuel and steam are fed to the anode and cathode, respectively. Steam on the cathode is split into oxygen ions that are transported through an oxygen ion-conducting electrolyte (i.e. YSZ) to oxidize the anode fuel. The dissociated hydrogen and residual steam are exhausted from the SOFEC cathode and then separated by condensation of the steam to produce pure hydrogen. The rationale was that in such an approach fuel provides a chemical potential replacing the external power conventionally used to drive electrolysis cells (i.e. solid oxide electrolysis cells). A SOFC is similar to the SOFEC by replacing cathode steam with air for power generation. To fulfill the cogeneration objective, a hybrid module comprising reversible SOFEC stacks and SOFC stacks was designed that planar SOFECs and SOFCs were manifolded in such a way that the anodes of both the SOFCs and the SOFECs were fed the same fuel, (i.e. natural gas or coal-derived fuel). Hydrogen was produced by SOFECs and electricity was generated by SOFCs within the same hybrid system. A stand-alone 5 kW system comprising three SOFEC-SOFC hybrid modules and three dedicated SOFC stacks, balance-of-plant components (including a tailgas-fired steam generator and tailgas-fired process heaters), and electronic controls was designed, though an overall integrated system assembly was not completed because of limited resources. An inexpensive metallic interconnects fabrication process was developed in-house. BOP components were fabricated and evaluated under the forecasted operating conditions. Proof-of-concept demonstration of cogenerating hydrogen and electricity was performed, and demonstrated SOFEC operational stability over 360 hours with no significant degradation. Cost analysis was performed for providing an economic assessment of the cost of hydrogen production using the targeted hybrid technology, and for guiding future research and development.

Electrochemical and Partial Oxidation of Rahul Singh 2008 Hydrogen has been the most common fuel used for the fuel cell research but there remains challenging technological hurdles and storage issues with hydrogen fuel. The direct electrochemical oxidation of CH_4 (a major component of natural gas) in a solid oxide fuel cell (SOFC) to generate electricity has a potential of commercialization in the area of auxiliary and portable power units and battery chargers. They offer significant advantages over an external reformer based SOFC, namely, (i) simplicity in the overall system architecture and balance of plant, (ii) more efficient and (iii) availability of constant concentration of fuel in the anode compartment of SOFC providing stability factor. The extreme operational temperature of a SOFC at 700-1000 °C provides a thermodynamically favorable pathway to deposit carbon on the most commonly used Ni anode from CH_4

according to the following reaction ($CH_4 = C + 2H_2$), thus deteriorating the cell performance, stability and durability. The coking problem on the anode has been a serious and challenging issue faced by the catalyst research community worldwide. This dissertation presents (i) a novel fabricated bi-metallic Cu-Ni anode by electroless plating of Cu on Ni anode demonstrating significantly reduced or negligible coke deposition on the anode for CH_4 and natural gas fuel after long term exposure, (ii) a thorough microstructural examination of Ni and Cu-Ni anode exposed to H_2, CH_4 and natural gas after long term exposure at 750 °C by scanning electron microscopy, energy dispersive X-ray spectroscopy and X-ray diffraction and (iii) in situ electrochemical analysis of Ni and Cu-Ni for H_2, CH_4 and natural gas during long term exposure at 750 °C by impedance spectroscopy. A careful investigation of variation in the microstructure and performance characteristics (voltage-current curve and impedance) of Ni and Cu-Ni anode before and after a long term exposure of CH_4 and natural gas would allow us to test the validation of a negligible coke formation on the novel fabricated anode by electroless plating process. Hydrogen is an environmentally cleaner source of energy. The recent increase in the demand of hydrogen as fuel for all types of fuel cells and petroleum refining process has boosted the need of production of hydrogen. Methane, a major component of natural gas is the major feedstock for production of hydrogen. The route of partial oxidation of methane to produce syngas ($CO + H_2$) offers significant advantages over commercialized steam reforming process for higher efficiency and lower energy requirements. Partial oxidation of methane was studied by pulsing O_2 into a CH_4 flow over Rh/Al_2O_3 in a sequence of in situ infrared (IR) cell and fixed bed reactor at 773 K. The results obtained from the sequence of an IR cell followed by a fixed bed reactor show that (i) adsorbed CO produced possesses a long residence time, indicating that adsorbed oxygen leading to the formation of CO is significantly different from those leading to CO_2 and (ii) CO_2 is not an intermediate species for the formation of CO. In situ IR of pulse reaction coupled with alternating reactor sequence is an effective approach to study the primary and secondary reactions as well as the nature of their adsorbed species. As reported earlier, hydrogen remains to be the most effective fuel for fuel cells, the production of high purity hydrogen from naturally available resources such as coal, petroleum, and natural gas requires a number of energy-intensive steps, making fuel cell processes for stationary electric power generation prohibitively uneconomic. Direct use of coal or coal gas as the feed is a promising approach for low cost electricity generation. Coal gas solid oxide fuel cell was studied by pyrolyzing Ohio #5 coal to coal gas and transporting to a Cu anode solid oxide fuel cell to generate power. The study of coal-gas solid oxide fuel cell is divided into two sections, i.e., (i) understanding the composition of coal gas by in situ infrared spectroscopy combined with mass spectrometry and (ii) evaluating the performance of coal gas for power generation based on the composition on a Cu-SOFC. The voltage-current performance curve for coal gas suggests that hydrogen and methane rich coal gas performed better than CO_2 or D_2O concentrated coal gas. A slow rate of reforming reaction of D_2O than CO_2 with coal and coal gas was observed during pyrolysis reaction. The coal and coke (by-product of pyrolysis) were characterized by Raman spectrometer to reveal the effect of pyrolysis on the structural properties of coal.

Solid Oxide Fuel Cells Radenka Maric 2020-12-09 Solid Oxide Fuel Cells: From Fundamental Principles to Complete Systems is as a valuable resource for beginners, experienced researchers, and developers of solid oxide fuel cells. It provides a fundamental understanding of SOFCs by covering the present state-of-the-art as well as ongoing research and future challenges to be solved. It discusses current and future materials and provides an overview of development activities with a more general system approach toward fuel cell plant technology, including plant design and economics, industrial data and advances in technology. Provides an understanding of the operating principles of SOFCs Discusses state-of-the-art materials, technologies and processes Includes a review of current industry and lessons learned Offers a more general system approach toward fuel cell plant technology, including plant design and economics of SOFC manufacture Covers significant technical challenges that remain to be solved Presents the status of government activities, industry and market This book is aimed at electrochemists, batteries and fuel cell engineers, alternative energy scientists, and professionals in materials science.

SOLID STATE ENERGY CONVERSION ALLIANCE DELPHI SOLID OXIDE FUEL CELL. Gail Geiger 2003 The objective of Phase I under this project is to develop a 5 kW Solid Oxide Fuel Cell power system for a range of fuels and applications. During Phase I, the following will be accomplished: Develop and demonstrate technology transfer efforts on a 5 kW stationary distributed power generation system that incorporates steam reforming of natural gas with the option of piped-in water (Demonstration System A). Initiate development of a 5 kW system for later mass-market automotive auxiliary power unit application, which will incorporate Catalytic Partial Oxidation (CPO) reforming of gasoline, with anode exhaust gas injected into an ultra-lean burn internal combustion engine. This technical progress report covers work performed by Delphi from January 1, 2003 to June 30, 2003, under Department of Energy Cooperative Agreement DE-FC-02NT41246. This report highlights technical results of the work performed under the following tasks: Task 1 System Design and Integration; Task 2 Solid Oxide Fuel Cell Stack Developments; Task 3 Reformer Developments; Task 4 Development of Balance of Plant (BOP) Components; Task 5 Manufacturing Development (Privately Funded); Task 6 System Fabrication; Task 7 System Testing; Task 8 Program Management; and Task 9 Stack Testing with Coal-Based Reformate.

Solid Oxide Fuel Cells VIII Subhash C. Singhal 2003

Five Kilowatt Fuel Cell Demonstration for Remote Power Applications 2008 While most areas of the US are serviced by inexpensive, dependable grid connected electrical power, many areas of Alaska are not. In these areas, electrical power is provided with Diesel Electric Generators (DEGs), at much higher cost than in grid connected areas. The reasons for the high cost of power are many, including the high relative cost of diesel fuel delivered to the villages, the high operational effort required to maintain DEGs, and the reverse benefits of scale for small utilities. Recent progress in fuel cell technologies have lead to the hope that the DEGs could be replaced with a more efficient, reliable, environmentally friendly source of power in the form of fuel cells. To this end, the University of Alaska Fairbanks has been engaged in testing early fuel cell systems since 1998. Early tests were conducted on PEM fuel cells, but since 2001, the focus has been on Solid Oxide Fuel Cells. In this work, a 5 kW fuel cell was delivered to UAF from Fuel Cell Technologies of Kingston, Ontario. The cell stack is of a tubular design, and was built by Siemens Westinghouse Fuel Cell division. This stack achieved a run of more than 1 year while delivering grid quality electricity from natural gas with virtually no degradation and at an electrical efficiency of nearly 40%. The project was ended after two control system failures resulted in system damage. While this demonstration was successful, considerable additional product development is required before this technology is able to provide electrical energy in remote Alaska. The major issue is cost, and the largest component of system cost currently is the fuel cell stack cost, although the cost of the balance of plant is not insignificant. While several manufactures are working on schemes for significant cost reduction, these systems do not as yet provide the same level of performance and reliability as the larger scale Siemens systems, or levels that would justify commercial deployment.

High Temperature Solid Oxide Fuel Cells Subhash C. Singhal 2003 The growing interest in fuel cells as a sustainable source of energy is pulling with it the need for new books which provide comprehensive and practical information on specific types of fuel cell and their application. This landmark volume on solid oxide fuel cells contains contributions from experts of international repute, and provides a single source of the latest knowledge on this topic.

Solid oxide fuel cell balance of plant test rig P. A. Martin 1997

Solid Oxide Fuel Cells Meng Ni 2013-08-16 Solid oxide fuel cells (SOFCs) are promising electrochemical power generation devices that can convert chemical energy of a fuel into electricity in an efficient, environmental-friendly, and quiet manner. Due to their high operating temperature, SOFCs feature fuel flexibility as internal reforming of hydrocarbon fuels and ammonia thermal cracking can be realized in SOFC anode. This book presents an overview of the SOFC technology with a focus on the recent developments in new technologies and new ideas for addressing the key issues of SOFC development. This book first introduces the fundamental principles of SOFCs and compares SOFC technology with conventional heat engines as well as low temperature fuel cells. Then the latest developments in SOFC R&D are reviewed and future directions are discussed. Key issues related to SOFC performance improvement, long-term stability, mathematical modelling, as well as system integration/control are addressed, including material development, infiltration technique for nano-structured electrode fabrication, focused ion beam – scanning electron microscopy (FIB-SEM) technique for microstructure reconstruction, the Lattice Boltzmann Method (LBM) simulation at pore scale, multi-scale modelling, SOFC integration with buildings and other cycles for stationary applications.

Solid Oxide Fuel Cells IX S. C. Singhal 2005

Intermediate Temperature Solid Oxide Fuel Cell Development 2008 Solid oxide fuel cells (SOFCs) are high efficiency energy conversion devices. Present materials set, using yttria stabilized zirconia (YSZ) electrolyte, limit the cell operating temperatures to 800 C or higher. It has become increasingly evident however that lowering the operating temperature would provide a more expeditious route to commercialization. The advantages of intermediate temperature (600 to 800 C) operation are related to both economic and materials issues. Lower operating temperature allows the use of low cost materials for the balance of plant and limits degradation arising from materials interactions. When the SOFC operating temperature is in the range of 600 to 700 C, it is also possible to partially reform hydrocarbon fuels within the stack providing additional system cost savings by reducing the air preheat heat-exchanger and blower size. The promise of Sr and Mg doped lanthanum gallate (LSGM) electrolyte materials, based on their high ionic conductivity and oxygen transference number at the intermediate temperature is well recognized. The focus of the present project was two-fold: (a) Identify a cell fabrication technique to achieve the benefits of lanthanum gallate material, and (b) Investigate alternative cathode materials that demonstrate low cathode polarization losses at the intermediate temperature. A porous matrix supported, thin film cell configuration was fabricated. The electrode material precursor was infiltrated into the porous matrix and the counter electrode was screen printed. Both anode and cathode infiltration produced high performance cells. Comparison of the two approaches showed that an infiltrated cathode cells may have advantages in high fuel utilization operations. Two new cathode materials were evaluated. Northwestern University investigated LSGM-ceria composite cathode while Caltech evaluated Ba-Sr-Co-Fe (BSCF) based pervoskite cathode. Both cathode materials showed lower

polarization losses at temperatures as low as 600 C than conventional manganite or cobaltite cathodes.
Simulation of Solid Oxide Fuel Cell - Based Power Generation Processes with CO2 Capture [electronic Resource] Zhang, Wei 2006
Degradation of Solid Oxide Fuel Cell Metallic Interconnects in Fuels Containing Sulfur 2005 Hydrogen is the main fuel for all types of fuel cells except direct methanol fuel cells. Hydrogen can be generated from all manner of fossil fuels, including coal, natural gas, diesel, gasoline, other hydrocarbons, and oxygenates (e.g., methanol, ethanol, butanol, etc.). Impurities in the fuel can cause significant performance problems and sulfur, in particular, can decrease the cell performance of fuel cells, including solid oxide fuel cells (SOFC). In the SOFC, the high (800-1000°C) operating temperature yields advantages (e.g., internal fuel reforming) and disadvantages (e.g., material selection and degradation problems). Significant progress in reducing the operating temperature of the SOFC from ~1000 oC to ~750 oC may allow less expensive metallic materials to be used for interconnects and as balance of plant (BOP) materials. This paper provides insight on the material performance of nickel, ferritic steels, and nickel-based alloys in fuels containing sulfur, primarily in the form of H2S, and seeks to quantify the extent of possible degradation due to sulfur in the gas stream.
Solid Oxide Fuel Cells S. C. Singhal 1999
Klubben Social-Demokraten 1956
Advances in Solid Oxide Fuel Cells II Andrew Wereszczak 2009-09-29 Due to its many potential benefits, including high electrical efficiency and low environmental emissions, solid oxide fuel cell (SOFC) technology is the subject of extensive research and development efforts by national laboratories, universities, and private industries. In these proceedings, international scientists and engineers present recent technical progress on materials-related aspects of fuel cells including SOFC component materials, materials processing, and cell/stack design, performance, and stability. Emerging trends in electrochemical materials, electrodics, interface engineering, long-term chemical interactions, and more are included. This book is compiled of papers presented at the Proceedings of the 30th International Conference on Advanced Ceramics and Composites, January 22-27, 2006, Cocoa Beach, Florida. Organized and sponsored by The American Ceramic Society and The American Ceramic Society's Engineering Ceramics Division in conjunction with the Nuclear and Environmental Technology Division.
Perovskite Oxide for Solid Oxide Fuel Cells Tatsumi Ishihara 2009-06-12 Fuel cell technology is quite promising for conversion of chemical energy of hydrocarbon fuels into electricity without forming air pollutants. There are several types of fuel cells: polymer electrolyte fuel cell (PEFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC), solid oxide fuel cell (SOFC), and alkaline fuel cell (AFC). Among these, SOFCs are the most efficient and have various advantages such as flexibility in fuel, high reliability, simple balance of plant (BOP), and a long history. Therefore, SOFC technology is attracting much attention as a power plant and is now close to marketing as a combined heat and power generation system. From the beginning of SOFC development, many perovskite oxides have been used for SOFC components; for example, LaMnO -based oxide for the cathode and 3 LaCrO for the interconnect are the most well known materials for SOFCs. The 3 current SOFCs operate at temperatures higher than 1073 K. However, lowering the operating temperature of SOFCs is an important goal for further SOFC development. Reliability, durability, and stability of the SOFCs could be greatly improved by decreasing their operating temperature. In addition, a lower operating temperature is also beneficial for shortening the startup time and decreasing energy loss from heat radiation. For this purpose, faster oxide ion conductors are required to replace the conventional Y O -stabilized ZrO 2 3 2 electrolyte. A new class of electrolytes such as LaGaO is considered to be 3 highly useful for intermediate-temperature SOFCs.
Advances in Solid Oxide Fuel Cells Narottam P. Bansal 2009-09-28 Due to its many potential benefits, including high electrical efficiency and low environmental emissions, solid oxide fuel cell (SOFC) technology is the subject of extensive research and development efforts by national laboratories, universities, and private industries. This collection of papers provides valuable insights on materials-related aspects of fuel cells such as SOFC component materials, materials processing, and cell/stack design, performance, and stability. Emerging trends in electrochemical materials, electrodics, interface engineering, long-term chemical interactions are also covered.
Multivariable Robust Control of a Simulated Hybrid Solid Oxide Fuel Cell Gas Turbine Plant 2010 This work presents a systematic approach to the multivariable robust control of a hybrid fuel cell gas turbine plant. The hybrid configuration under investigation built by the National Energy Technology Laboratory comprises a physical simulation of a 300kW fuel cell coupled to a 120kW auxiliary power unit single spool gas turbine. The public facility provides for the testing and simulation of different fuel cell models that in turn help identify the key difficulties encountered in the transient operation of such systems. An empirical model of the built facility comprising a simulated fuel cell cathode volume and balance of plant components is derived via frequency response data. Through the modulation of various airflow bypass valves within the hybrid configuration, Bode plots are used to derive key input/output interactions in transfer function format. A multivariate system is then built from individual transfer functions, creating a matrix that serves as the nominal plant in an H{sub ?} robust control algorithm. The controller's main objective is to track and maintain hybrid operational constraints in the fuel cell's cathode airflow, and the turbo machinery states of temperature and speed, under transient disturbances. This algorithm is then tested on a Simulink/MatLab platform for various perturbations of load and fuel cell heat effluence. As a complementary tool to the aforementioned empirical plant, a nonlinear analytical model faithful to the existing process and instrumentation arrangement is evaluated and designed in the Simulink environment. This parallel task intends to serve as a building block to scalable hybrid configurations that might require a more detailed nonlinear representation for a wide variety of controller schemes and hardware implementations.
Chromium Evaporation of Metallic Component Materials in Solid Oxide Fuel Cell (sofc). Le Ge 2014 Recent developments of planar intermediate temperature solid oxide fuel cells (IT-SOFCs) make metallic alloys attractive candidates as interconnects as well as balance of plant (BoP) materials at operating temperatures below 900 oC. The resistance of alloys against oxidation and corrosion is one of the critical criteria for selecting candidate alloys for SOFC applications. The oxidation and corrosion resistance of the alloys service at high temperature depends on the formation of a protective oxide scale (chromia. silica, alumina). Among these, chromia forming alloys are often used in SOFCs. At higher temperature, the evaporation of chromium containing species from chromia in humid air limits the applications of chromia forming alloys. SOFCs are susceptible to chromium evaporation (known as chromium poisoning) as it can lead to severe degradation of SOFC performance. In this study, the transpiration method was used to measure the chromium evaporation rates from chromium evaporation of chromia and alumina forming nickel and iron base alloys. The effects of the temperature and water vapor content on the chromium evaporation rates were also investigated. The measured chromium evaporation rates were used to predict the degradation rates of the SOFCs under those conditions. The oxidation behavior of candidate alloys in air with different water vapor contents was studied. The effects of the temperature and water vapor content on physicochemical characteristics of the oxide scales formed on the surface of metallic components were also examined.
Intermediate-Temperature Solid Oxide Fuel Cells Zongping Shao 2016-09-12 This book discusses recent advances in intermediate-temperature solid oxide fuel cells (IT-SOFCs), focusing on material development and design, mechanism study, reaction kinetics and practical applications. It consists of five chapters presenting different types of reactions and materials employed in electrolytes, cathodes, anodes, interconnects and sealants for IT-SOFCs. It also includes two chapters highlighting new aspects of these solid oxide fuel cells and exploring their practical applications. This insightful and useful book appeals to a wide readership in various fields, including solid oxide fuel cells, electrochemistry, membranes and ceramics. Zongping Shao is a Professor at the State Key Laboratory of Materials-Oriented Chemical Engineering and the College of Energy, Nanjing University of Technology, China. Moses O. Tade is a Professor at the Department of Chemical Engineering, Curtin University, Australia.
High-temperature Solid Oxide Fuel Cells for the 21st Century Kevin Kendall 2015-11-21 High-temperature Solid Oxide Fuel Cells, Second Edition, explores the growing interest in fuel cells as a sustainable source of energy. The text brings the topic of green energy front and center, illustrating the need for new books that provide comprehensive and practical information on specific types of fuel cells and their applications. This landmark volume on solid oxide fuel cells contains contributions from experts of international repute, and provides a single source of the latest knowledge on this topic. A single source for all the latest information on solid oxide fuel cells and their applications Illustrates the need for new, more comprehensive books and study on the topic Explores the growing interest in fuel cells as viable, sustainable sources of energy
Control of Balance of Plant Components for Solid Oxide Fuel Cell Systems with Sensitivity to Carbon Formation Matthew J. Kupilik 2012
Advances in Solid Oxide Fuel Cells VIII Prabhakar Singh 2012-11-27 The Ninth International Symposium on Solid Oxide Fuel Cells: Materials, Science, and Technology was held in January 2012 as part of the 36th International Conference on Advanced Ceramics and Composites (ICACC). This symposium provided an international forum for scientists, engineers, and technologists from around the world to present and discuss the latest advances in solid oxide fuel cells. This issue features fourteen papers selected from the symposium, offering readers a broad panorama of the current status of solid oxide fuel cells technology, as well as emerging issues and future directions in the field.
??? ??? ???? 1752
Engineering High Performance Intermediate Temperature Solid Oxide Fuel Cells Jin Soo Ahn 2009 ABSTRACT: Solid oxide fuel cells (SOFCs) are an efficient, fuel flexible energy conversion device, capable of operating on fuels ranging from natural gas to gasoline, diesel, and biofuels, as well as hydrogen. However, to this point the marketability of SOFCs has been limited by their high operating temperatures. Achieving high power at intermediate temperatures

(IT, 500 - 700 °C) would be a significant breakthrough, as low temperature operation would result in better stability and allow for a broader range of material options for the SOFC components as well as the balance of plant, such as stainless steel interconnects (which are only viable at

Solid Oxide Fuel Cell Lifetime and Reliability Nigel Brandon 2017-05-23 Solid Oxide Fuel Cell Lifetime and Reliability: Critical Challenges in Fuel Cells presents in one volume the most recent research that aims at solving key issues for the deployment of SOFC at a commercial scale and for a wider range of applications. To achieve that, authors from different regions and backgrounds address topics such as electrolytes, contaminants, redox cycling, gas-tight seals, and electrode microstructure. Lifetime issues for particular elements of the fuel cells, like cathodes, interconnects, and fuel processors, are covered as well as new materials. They also examine the balance of SOFC plants, correlations between structure and electrochemical performance, methods for analysis of performance and degradation assessment, and computational and statistical approaches to quantify degradation. For its holistic approach, this book can be used both as an introduction to these issues and a reference resource for all involved in research and application of solid oxide fuel cells, especially those developing understanding in industrial applications of the lifetime issues. This includes researchers in academia and industrial R&D, graduate students and professionals in energy engineering, electrochemistry, and materials sciences for energy applications. It might also be of particular interest to analysts who are looking into integrating SOFCs into energy systems. Brings together in a single volume leading research and expert thinking around the broad topic of SOFC lifetime and durability Explores issues that affect solid oxide fuel cells elements, materials, and systems with a holistic approach Provides a practical reference for overcoming some of the common failure mechanisms of SOFCs Features coverage of integrating SOFCs into energy systems

Fuel Cell Science and Engineering, 2 Volume Set Detlef Stolten 2012-10-22 Fuel cells are expected to play a major role in the future power supply that will transform to renewable, decentralized and fluctuating primary energies. At the same time the share of electric power will continually increase at the expense of thermal and mechanical energy not just in transportation, but also in households. Hydrogen as a perfect fuel for fuel cells and an outstanding and efficient means of bulk storage for renewable energy will spearhead this development together with fuel cells. Moreover, small fuel cells hold great potential for portable devices such as gadgets and medical applications such as pacemakers. This handbook will explore specific fuel cells within and beyond the mainstream development and focuses on materials and production processes for both SOFC and lowtemperature fuel cells, analytics and diagnostics for fuel cells, modeling and simulation as well as balance of plant design and components. As fuel cells are getting increasingly sophisticated and industrially developed the issues of quality assurance and methodology of development are included in this handbook. The contributions to this book come from an international panel of experts from academia, industry, institutions and government. This handbook is oriented toward people looking for detailed information on specific fuel cell types, their materials, production processes, modeling and analytics. Overview information on the contrary on mainstream fuel cells and applications are provided in the book 'Hydrogen and Fuel Cells', published in 2010.

Performance Simulation of Planar Solid Oxide Fuel Cells Siamak Farhad 2011 The performance of solid oxide fuel cells (SOFCs) at the cell and system levels is studied using computer simulation. At the cell level, a new model combining the cell micro and macro models is developed. Using this model, the microstructural variables of porous composite electrodes can be linked to the cell performance. In this approach, the electrochemical performance of porous composite electrodes is predicted using a micro-model. In the micro-model, the random-packing sphere method is used to estimate the microstructural properties of porous composite electrodes from the independent microstructural variables. These variables are the electrode porosity, thickness, particle size ratio, and size and volume fraction of electron-conducting particles. Then, the complex interdependency among the multi-component mass transport, electron and ion transports, and the electrochemical and chemical reactions in the microstructure of electrodes is taken into account to predict the electrochemical performance of electrodes. The temperature distribution in the solid structure of the cell and the temperature and species partial pressure distributions in the bulk fuel and air streams are predicted using the cell macro-model. In the macro-model, the energy transport is considered for the cell solid structure and the mass and energy transports are considered for the fuel and air streams. To demonstrate the application of the cell level model developed, entitled the combined micro- and micro-model, several anode-supported co-flow planar cells with a range of microstructures of porous composite electrodes are simulated. The mean total polarization resistance, the mean total power density, and the temperature distribution in the cells are predicted. The results of this study reveal that there is an optimum value for most of the microstructural variables of the electrodes at which the mean total polarization resistance of the cell is minimized. There is also an optimum value for most of the microstructural variables of the electrodes at which the mean total power density of the cell is maximized. The microstructure of porous composite electrodes also plays a significant role in the mean temperature, the temperature difference between the hottest and coldest spots, and the maximum temperature gradient in the solid structure of the cell. Overall, using the combined micro- and micro-model, an appropriate microstructure for porous composite electrodes to enhance the cell performance can be designed. At the system level, the full load operation of two SOFC systems is studied. To model these systems, the basic cell model is used for SOFCs at the cell level, the repeated-cell stack model is used for SOFCs at the stack level, and the thermodynamic model is used for the balance of plant components of the system. In addition to these models, a carbon deposition model based on the thermodynamic equilibrium assumption is employed. For the system level model, the first SOFC system considered is a combined heat and power (CHP) system that operates with biogas fuel. The performance of this system at three different configurations is evaluated. These configurations are different in the fuel processing method to prevent carbon deposition on the anode catalyst. The fuel processing methods considered in these configurations are the anode gas recirculation (AGR), steam reforming (SR), and partial oxidation reformer (POX) methods. The application of this system is studied for operation in a wastewater treatment plant (WWTP) and in single-family detached dwellings. The evaluation of this system for operation in a WWTP indicates that if the entire biogas produced in the WWTP is used in the system with AGR or SR fuel processors, the electric power and heat required to operate the plant can be completely supplied and the extra electric power generated can be sold to the electrical grid. The evaluation of this system for operation in single-family detached dwellings indicates that, depending on the size, location, and building type and design, this system with all configurations studied is suitable to provide the domestic hot water and electric power demands. The second SOFC system is a novel portable electric power generation system that operates with liquid ammonia fuel. Size, simplicity, and high electrical efficiency are the main advantages of this environmentally friendly system. Using a sensitivity analysis, the effects of the cell voltage at several fuel utilization ratios on the number of cells required for the SOFC stack, system efficiency and voltage, and excess air required for thermal management of the SOFC stack are studied.

Investigation and Development of Electro Catalysts for Solid Oxide Fuel Cells Nandita Lakshminarayanan 2010 Abstract: Solid Oxide Fuels Cells (SOFCs) have tremendous potential as efficient and clean energy conversion devices. They are the most desirable fuel cells for stationary power generation and as auxiliary power sources in transport applications. The fuel flexibility and higher efficiency of the SOFC make it a favorable choice over conventional combustion systems. However, there are some major roadblocks to the effective commercialization of SOFC technology. High operating temperatures are required due to low activity of the cathode catalysts, thus dictating the use of more expensive materials for the SOFC components as well as balance of plant. Moreover, the state-of-the-art Nickel -Yttria Stabilized Zirconia (Ni-YSZ) cermet anode catalysts are extremely susceptible to poisoning by sulfur in the fuel, as well as coking on operation with carbonaceous fuels. Ni also tends to sinter at elevated temperatures. Since these fuel cells are envisioned to be used with Coal and Natural Gas as fuels, stable and active anode catalysts are required.

Proceedings of the Fifth International Symposium on Solid Oxide Fuel Cells (SOFC-V) U. Stimming 1997

INTEGRATED GASIFICATION COMBINED CYCLE PROJECT 2 MW FUEL CELL DEMONSTRATION. FuelCell Energy 2005 With about 50% of power generation in the United States derived from coal and projections indicating that coal will continue to be the primary fuel for power generation in the next two decades, the Department of Energy (DOE) Clean Coal Technology Demonstration Program (CCTDP) has been conducted since 1985 to develop innovative, environmentally friendly processes for the world energy market place. The 2 MW Fuel Cell Demonstration was part of the Kentucky Pioneer Energy (KPE) Integrated Gasification Combined Cycle (IGCC) project selected by DOE under Round Five of the Clean Coal Technology Demonstration Program. The participant in the CCTDP V Project was Kentucky Pioneer Energy for the IGCC plant. FuelCell Energy, Inc. (FCE), under subcontract to KPE, was responsible for the design, construction and operation of the 2 MW fuel cell power plant. Duke Fluor Daniel provided engineering design and procurement support for the balance-of-plant skids. Colt Engineering Corporation provided engineering design, fabrication and procurement of the syngas processing skids. Jacobs Applied Technology provided the fabrication of the fuel cell module vessels. Wabash River Energy Ltd (WREL) provided the test site. The 2 MW fuel cell power plant utilizes FuelCell Energy's Direct Fuel Cell (DFC) technology, which is based on the internally reforming carbonate fuel cell. This plant is capable of operating on coal-derived syngas as well as natural gas. Prior testing (1992) of a subscale 20 kW carbonate fuel cell stack at the Louisiana Gasification Technology Inc. (LGTI) site using the Dow/Destec gasification plant indicated that operation on coal derived gas provided normal performance and stable operation. Duke Fluor Daniel and FuelCell Energy developed a commercial plant design for the 2 MW fuel cell. The plant was designed to be modular, factory assembled and truck shippable to the site. Five balance-of-plant skids incorporating fuel processing, anode gas oxidation, heat recovery, water treatment/instrument air, and power conditioning/controls were built and shipped to the site. The two fuel cell modules, each rated at 1 MW on natural gas, were fabricated by FuelCell Energy in its Torrington, CT manufacturing facility. The fuel cell modules were conditioned and tested at FuelCell Energy in Danbury and shipped to the site. Installation of the power plant and connection to all required utilities and syngas was completed. Pre-operation checkout of the entire power plant was conducted and the plant was ready to operate in July 2004. However, fuel gas (natural gas or syngas) was not available at the

WREL site due to technical difficulties with the gasifier and other issues. The fuel cell power plant was therefore not operated, and subsequently removed by October of 2005. The WREL fuel cell site was restored to the satisfaction of WREL. FuelCell Energy continues to market carbonate fuel cells for natural gas and digester gas applications. A fuel cell/turbine hybrid is being developed and tested that provides higher efficiency with potential to reach the DOE goal of 60% HHV on coal gas. A system study was conducted for a 40 MW direct fuel cell/turbine hybrid (DFC/T) with potential for future coal gas applications. In addition, FCE is developing Solid Oxide Fuel Cell (SOFC) power plants with Versa Power Systems (VPS) as part of the Solid State Energy Conversion Alliance (SECA) program and has an on-going program for co-production of hydrogen. Future development in these technologies can lead to future coal gas fuel cell applications.

Solid Oxide Fuel Cells 12 (SOFC-XII) S. C. Singhal 2011-04-25 This issue of ECS Transactions contains papers from the Twelfth International Symposium on Solid Oxide Fuel Cells (SOFC-XII),a continuing biennial series of symposia. The papers deal with materials for cell components and fabrication methods for components and complete cells. Also contained are papers on cell electrochemical performance and its modelling, stacks and systems, and prototype testing of SOFC demonstration units for different applications.