Modeling Of Biomass Char Gasification Combustion And

????:Coal combustion and gasification

This book is part of a two-volume work that offers a unique blend of information on realistic evaluations of catalyst-based synthesis processes using green chemistry principles and the environmental sustainability applications of such processes for biomass conversion, refining, and petrochemical production. The volumes provide a comprehensive resource of state-of-the-art technologies and green chemistry methodologies from researchers, academics, and chemical and manufacturing industrial scientists. The work will be of interest to professors, researchers, and practitioners in clean energy catalysis, green chemistry, chemical engineering and manufacturing, and environmental sustainability. This volume focuses on catalyst synthesis and green chemistry applications for petrochemical and refining processes. While most books on the subject focus on catalyst use for conventional crude, fuel-oriented refineries, this book emphasizes recent transitions to petrochemical refineries with the goal of evaluating how green chemistry applications can produce clean energy through petrochemical industrial means. The majority of the chapters are contributed by industrial researchers and technicians and address various petrochemical processes, including hydrotreating, hydrocracking, flue gas treatment and isomerization catalysts.

This book highlights the processes of biomass thermochemical conversion, covering topics from combustion and gasification, to pyrolysis and liquefaction. Heat, power, biofuels and green chemicals can all be produced by these thermochemical processes. The different scales of investigation are presented: from the bioenergy chains, to the reactors and molecular mechanisms. The author uses current research and data to present bioenergy chains from forest to final use, including the biomass supply chains, as well as the life cycle assessment of different process chains. Biomass conversion reactors are also presented, detailing their technologies for combustion, gasification and syngas up-grading systems, pyrolysis and bio-oil upgrading. The physical-chemical mechanisms occurring in all these reactors are presented highlighting the main pathways for gas, char and bio-oil formation from biomass. This book offers an overview of biomass valorization for students, engineers or developers in chemistry, chemical, environmental or mechanical engineering.

The overall objective of the current project was to investigate the high pressure gasification characteristics of a feed containing both coal and biomass. The two feed types differ in their ash contents and ash composition, particularly the alkali content. Gasification of a combined feed of coal and biomass has the potential for considerable synergies that might lead to a dramatic improvement in process economics and flexibility. The proposed study aimed to develop a detailed understanding of the chemistry, kinetics, and transport effects during high pressure gasification of coal-biomass blend feed. Specifically, we studied to develop: (a) an understanding of the catalytic effect of alkali and other inorganic species present in the biomass and coal, (b) an understanding of processing conditions under which synergistic effects of the blending of coal and biomass might be observed. This included the role of particle size, residence time, and proximity of the two feed types, (c) kinetics of high pressure gasification of individual feeds as well as the blends, and (d) development of mathematical models that incorporate kinetics and transport models to enable prediction of gasification rate at a given set of operating conditions, and (e) protocols to extend the results to other feed resources. The goal was to provide a fundamental understanding of the gasification process and guide in optimizing the configurations and design of the next generation of gasifiers. The approach undertaken was centered on two basic premises: (1) the gasification for small particles without internal mass transfer limitations can be treated as the sum of two processes in series (pyrolysis and char gasification), and (2) the reactivity of the char generated during pyrolysis not only depends on the pressure and temperature but is also affected by the heating rates. Thus low heating rates (10-50 °C/min) typical of PTGA fail to produce char that would typically be formed at high heating rates (~104 °C/sec), encountered in entrained flow gasifiers. The char morphology, also a function of the heating rate, would influence the transport rates during the char gasification phase. Thus, heating rate plays a critical role through which both, pyrolysis and char gasification, are interconnected. We utilized two complementary gasification experiments: PEFR (pressurized entrained flow gasifier) and PTGA (pressurized thermo-gravimetric analyzer). The PEFR allowed us to study gasification at pressures, temperatures, and heating rates relevant for coal-biomass gasifiers. The PTGA work was useful in understanding the basic chemistry of the evolution of various gaseous species during pyrolysis. These results helped improved our understanding of the chemistry and chemical changes during pyrolysis. The role alkali metals and other inorganics in char gasification using steam and/or CO2 was investigated. Finally, the mathematical models for char gasification without the transport effects were developed at commercial operating conditions.

A research project was undertaken that had the overall objective of developing the models needed to accurately predict conversion rates of coal/biomass mixtures to synthesis gas under conditions relevant to a commercially-available coal gasification system configured to co- produce electric power as well as chemicals and liquid fuels. In our efforts to accomplish this goal, experiments were performed in an entrained flow reactor in order to produce coal and biomass chars at high heating rates and temperatures, typical of the heating rates and temperatures fuel particles experience in real systems. Mixed chars derived from coal/biomass mixtures containing up to 50% biomass and the chars of the pure coal and biomass components were subjected to a matrix of reactivity tests in a pressurized thermogravimetric analyzer (TGA) in order to obtain data on mass loss rates as functions of gas temperature, pressure and composition as well as to obtain information on the variations in mass specific surface area during char conversion under kinetically-limited conditions. The experimental data were used as targets when determining the unknown parameters in the chemical reactivity and specific surface area models developed. These parameters included rate coefficients for the reactions in the reaction mechanism, enthalpies of formation and absolute entropies of adsorbed species formed on the carbonaceous surfaces, and pore structure coefficients in the model used to describe how the mass specific surface area of the char varies with conversion. So that the reactivity models can be used at high temperatures when mass transport processes impact char conversion rates, Thiele modulus - effectiveness factor relations were also derived for the reaction mechanisms developed. In addition, the reactivity model and a mode of conversion model were combined in a char-particle gasification model that includes the effects of chemical reaction and diffusion of reactive gases through particle pores and energy exchange between the particle and its environment. This char-particle gasification model is capable of predicting the average mass loss rates, sizes, apparent densities, specific surface areas, and temperatures of the char particles produced when co-firing coal and biomass to the type environments established in entrained flow gasifiers operating at high temperatures and elevated pressures. A key result of this work is the finding that the reactivities of the mixed chars were not always in between the reactivities of the pure component chars at comparable gasification conditions. Mixed char reactivity to CO2 was lower than the reactivities of both the pure Wyodak coal and pure corn stover chars to CO_2. In contrast, mixed char reactivity to H_2O was higher than the reactivities of both the pure Wyodak coal and pure corn stover chars to H_2O. This was found to be in part, a consequence of the reduced mass specific surface areas of the coal char particles formed during devolatilization when the coal and biomass particles are co-fired. The biomass particles devolatilize prior to the coal particles, impacting the temperature and the composition of the environment in which the coal particles devolatilize. This situation results in coal char particles within the mixed char that differ in specific surface area and reactivity from the coal char particles produced in the absence of the devolatilizing biomass particles. Due to presence of this "affected" coal char, it was not possible to develop a mixed char reactivity model that uses linear mixing rules to determine the reactivity of a mixed char from only the reactivities of the pure mixture components. However, it was possible to predict both mixed char specific surface area and reactivity for a wide range of fuel mixture rat os provided the specific surface area and reactivity of the affected coal char particles are known. Using the kinetic parameters determined for the Wyodak coal and corn stover chars, the ...

The 1st World Conference and Technology Exhibition on Biomass for Energy and Industry, held in Sevilla in June 2000, brought together for the first time the traditional European Conference on Biomass for Energy and Industry and the Biomass Conference of the Americas, thus creating the largest and most outstanding event in the worldwide biomass sector. The conference elaborated innovative global strategies, projects and efficient practice rules for energy and the environment at a key stage in the industry's development. New concepts and projects were highlighted to increase the social and political awareness for a change in worldwide resource consumption and to promote economically, socially and environmentally sustainable development for the next millennium. In 2 volumes, the Proceedings include some 470 papers essential to an understanding of current thinking, practice, research and global developments in the biomass sector - a vital reference source for researchers, manufacturers, and policy makers involved or interested in the use of biomass for energy and industry.

With the steady stream of new web based information technologies being introduced to organizations, the need for network and communication technologies to provide an easy integration of knowledge and information sharing is essential. Network and Communication Technology Innovations for Web and IT Advancement presents studies on trends, developments, and methods on information technology advancements through network and communication technology. This collection brings together integrated approaches for communication technology and usage for web and IT advancements.

Biomass, as a renewable energy resource, can be utilized to generate chemicals, heat, and electricity. Compared with biomass combustion, biomass gasification is more eco-friendly because it generates less amount of green gas (CO_2) and other polluting gases (NO_x and SO_2). This research is focused on biomass gasification using a circulating fluidized bed. In the gasifier, fully fluidized biomass particles react with water vapor and air to generate syngas (CO and H_2). A comprehensive model, consisting of three modules, hydrodynamics, mass transfer and energy transfer modules, is built to simulate this process using ANSYS Fluent software and C programming language. In the hydrodynamics module, the k-epsilon turbulence equations are coupled with the fluctuating energy equation to simulate gas-particle interaction in the turbulent flows occurring in the riser. In the mass transfer and energy transfer modules, heat transfer and mass transfer in turbulent flows are simulated to solve for the profiles of temperature and species concentration in the gasifier. The impacts of thermal radiation, water gas shift reaction (WGS), equivalence ratio (ER), and char combustion product distribution coefficient are also investigated to gain deeper understanding of biomass gasification process.

As an increasing number of professionals and graduate students enter the field of solid-based power generation, they all require an command of process and equipment, as well as the theory behind it all. However, their informational needs and understanding differ based on their experience and the task at hand. Solid Fuels Combustion and Gasification: Modeling, Simulation, and Equipment Operations, Second Edition explores evolving solid fuel combustion and gasification techniques that are leading to much lower sulfur and nitrogen oxide emissions. It also shows how to increase the efficiency of processes dealing with materials such as coal, biomass, solid residues, etc. Many of the successes of these methods are the result of process optimization resulting from mathematical modeling and simulation. This book introduces and explores these techniques, taking a moderate approach that is neither too narrow nor too basic, making it useful to graduate students, engineers, and professionals. It illustrates the modeling and constructive and operational aspects of equipment used in combustion and gasification of solid fuels. It was written based on the idea that developing models and computer simulators is the optimal method to acquire real and testable understanding of a subject in the area of processing. Model complexity is extended only as far as needed to achieve a reasonable representation of the equipment described in the book, and the author provides specific and carefully selected case studies that: Cover many industrial processes involving combustion or gasification of solid fuels Provide easy-to-follow examples on how to set simplifying assumptions regarding the operation of real industrial equipment Enable relatively quick introduction of fundamental equations without the need for unnecessarily complex treatments The main strategy of the book is to teach by example, and the basic methods illustrated here can be used for modeling a wide range of processes and equipment commonly found in industry. It is a carefully constructed volume which presents essential concepts that minimize the need for other texts, and it can also be used as an introduction to more complex models.

"This book introduces Higher Order Neural Networks (HONNs) to computer scientists and computer engineers as an open box neural networks tool when compared to traditional artificial neural networks"--Provided by publisher.

This book offers comprehensive coverage of the design, analysis, and operational aspects of biomass gasification, the key technology enabling the production of biofuels from all viable sources--some examples being sugar cane and switchgrass. This versatile resource not only explains the basic principles of energy conversion systems, but also provides valuable insight into the design of biomass gasifiers. The author provides many worked out design problems, step-by-step design procedures and real data on commercially operating systems. After fossil fuels, biomass is the most widely used fuel in the world. Biomass resources show a considerable potential in the long term if residues are properly handled and dedicated energy crops are grown. Includes step-by-step design procedures and case studies for Biomass

Gasification Provides worked process flow diagrams for gasifier design. Covers integration with other technologies (e.g. gas turbine, engine, fuel cells)

Biomass Gasification: Fundamentals, Experiments, and Simulation

Biomass gasification has received tremendous research attention all over the world because (a) biomass is abundant, diverse, renewable, and environmentally friendly, (b) the produced biogas/syngas is clean, versatile, efficient, and easily controllable, and (c) the system used is generally simple. This book aims to present up-to-date research on biomass gasification. The content of this book is divided to three parts or sections: the fundamentals of biomass gasification as presented in chapters 1 to 4, experimenting of biomass gasification as presented in chapters 5 and 6, and simulation of biomass gasification as presented in chapters 7 to 8. In chapter 1 (An introduction to biomass), biomass is introduced, and these mainly include biomass resources, biomass and energy, biomass and environment, benefits of biomass, etc. In chapter 2 (Biomass properties), the properties of biomass are introduced, and these include structural compositions (cellulose, hemicellulose, lignin, starch, extractives, proteins, etc.), physical properties (moisture content, particle size, bulk density, porosity, etc.), chemical properties (elemental compositions, chemical compositions, heating value, etc.) and the other properties (thermal conductivity, ignition temperature, specific heat, etc.). In chapter 3 (Biomass gasification technologies), biomass gasification technologies are classified and introduced according to the gasification agents used (air, oxygen, steam, hydrogen, supercritical water, carbon dioxide and the combination of the above gases), and some factors that have significant impacts on gasification technologies (or performances) are also discussed. Then the emerging gasification technologies (microwave gasification, solar gasification and plasma gasification) using new heat sources are also detailed, and the effects of heat source on biomass gasification are also discussed. In chapter 4 (Biomass gasifiers), the main gasifier structures are introduced, and these include fixed bed gasifiers (updraft and downdraft), fluidized bed gasifiers (bubbling fluidized bed, circulating fluidized bed and dual fluidized bed), entrained flow gasifiers (Koppers-Totzek (K-T) gasifier, shell gasifier and Gas Schwarze Pumpe (GSP) gasifier and Colin gasifier). The other gasifier structures are also presented, and these include solar gasifier, microwave gasifier and plasma gasifier, etc. In chapter 5 (High-temperature gasification of biomass), the effects of physical and chemical properties of biomass on high-temperature gasification are analyzed, and these mainly include high-temperature pyrolysis of biomass, thermal cracking of biomass tar, and high-temperature gasification of biomass char. In chapter 6 (Supercritical water gasification of biomass), the properties of SCW (supercritical water) are detailed and the effects of different operating parameters on CE (carbon conversion efficiency) and GE (gasification efficiency) are summarized. The operating parameters include feedstock characteristics, biomass concentration, gasification temperature, reactor pressure, residence time and catalyst types and concentration. In chapter 7 (Simulation of biomass gasification using thermodynamic equilibrium model), the two thermodynamic equilibrium models of stoichiometric thermodynamic equilibrium models and non-stoichiometric equilibrium models (using Gibbs free energy minimization approach) are initially introduced, and the simulation results obtained from biomass gasification using thermodynamic equilibrium models based on Aspen Plus are then presented. In chapter 8 (Simulation of biomass gasification using intrinsic reaction rate submodel), the numerical simulation of biomass gasification using the intrinsic reaction rate submodel was introduced. The kinetic model for char-gas reaction as well as the intrinsic kinetic data for various biomass materials are detailed. A CFD (computational fluid dynamic) model based on the intrinsic kinetics is developed for biomass entrained flow gasification, and the effects of operating conditions including gasification temperature, equivalence ratio, CO_2/biomass mass ratio and average particle size on the gasification performances in a lab-scale entrained flow reactor are investigated. Multi-objective optimization of biomass gasification based on response surface method is then studied to improve the gasification performances. Hopefully, the content of this book can supply a helpful guide to the up-to-date research on the fundamentals, experimental, and simulation of biomass gasification.

This book gathers the proceedings of the 8th International Symposium on Coal Combustion. The contributions reflect the latest research on coal quality and combustion, techniques for pulverized coal combustion and fluidized bed combustion, special issues regarding CO_2 capture (CCS), industrial applications, etc. – aspects that are of great importance in promoting academic communications between related areas and the technical development of coal-related fields. The International Symposium on Coal Combustion (ISCC), sponsored and organized by Tsinghua University since 1987, has established itself as an important platform allowing scientists and engineers to exchange information and ideas on the science and technology of coal combustion and related issues, and to forge new partnerships in the growing Chinese market. Researchers in the fields of clean coal combustion, carbon dioxide capture and storage, coal chemical engineering, energy engineering, etc. will greatly benefit from this book. Guangxi Yue, professor of the Department of Thermal Engineering in Tsinghua University, Beijing, China, and a member of Chinese Academy of Engineering(CAE). Shuiqing Li, professor of the Department of Thermal Engineering in Tsinghua University, Beijing, China.

A new, simpler form of downdraft gasifier, the "stratified downdraft gasifier" is being developed. In its simplest form it is a cylindrical tube with a grate at the bottom. Air or oxygen and biomass are fed together at the top and move down into a "flaming pyrolysis" zone where the oxidant burns the emerging pyrolysis gases and tars to provide the heat for pyrolysis. The gas then enters an "adiabatic char reaction" zone where the char further reduces the gas to the final composition and a temperature between 700 and 800 degrees C.

This PhD thesis presents the work carried out by kinetic modeling incorporated with particle simulation on selected plant based biomass during pyrolysis and gasification followed by an experimental investigation of those processes under entrained flow to satisfy the engineering requirement.Renewable energy sources are becoming a significant part of the primary energy share for mitigating the CO_2 emission along with addressing the issue of fossil fuel depletion. According to the lifecycle of biomass, it is CO_2 neutral and can be a potential replacement for fossil fuels. Being a solid fuel, it can be consumed using the existing technology for solid fossil fuels, however, with modification. To modify any available technology, significant research effort is needed in both fundamental and engineering level to find out optimum reaction conditions. One appropriate technology for solid fuel conversion is entrained flow gasification which uses a high heating rate and low residence time to produce high energy gas. Non-conventional biomass (e.g. algae) along with woody biomass might be consumed by this technology. At the same time, fossil fuel (coal) can be potentially replaced by blending biomass with it.To model the inherent kinetics involved in the pyrolysis process, a new algorithm was proposed for higher order distributed activation energy model. The new algorithm was found to be versatile in estimating the intrinsic pyrolysis kinetics for different types of biomass (algae, sawdust, and coconut shell) along with predicting the pyrolysis behavior of the blends of one those biomass samples and coal. To link this fundamental development to the engineering application, entrained flow pyrolysis experiments on biomass were performed on biomass by varying different operating conditions. After that, a particle model was developed for this process to predict the conversion profile of the solid biomass particle using apparent kinetics which showed good agreement with the experimental data. A guideline was also generated on the basis of parametric study (particle size, temperature, gas velocity, residence time etc.) to design a laminar entrained flow reactor for pyrolysis. Further development of the particle model was achieved by incorporating the intrinsic kinetic parameters obtained by the newly developed algorithm. It was proposed that inclusion of pyrolysis heat of reaction would improve the prediction of the model if intrinsic kinetic parameters were to be used.At the same time, effect of operating parameters (temperature, particle size) and species variation on entrained flow pyrolysis was evaluated. The study was limited to the particle size ranges under 600 ?m (suitable particle size for entrained flow gasification) and up to a temperature of 1000 °C. Among all the parameters, particle size was found to be the most critical because of its influence on both residence time and heating rate. Also, temperature was found be very important for achieving full conversion in case of larger particle size. At 1000 °C, pyrolysis of all types of biomass under consideration reached completion. In case of a lower temperature (800 °C), some unconverted particles were observed for larger size (500-600 ?m). Tar production was minimized at 1000 °C for the smaller particle size (150-250 ?m). At a higher temperature, the gas yield was also increased considerably due to the increase in conversion efficiency. Morphological study on the char particles showed that sawdust experienced a molten phase during its pyrolysis and due to the gas release from inside, the smaller particles were converted into cenospheres where no morphology of the parent particle was visible. This resulted in highly reactive char with an extremely porous structure. However, this observation could not be generalized as algae and coconut shell char showed different morphological development.As the char obtained from the entrained flow pyrolysis process were different from fixed bed chars, they were studied for their reactivity and kinetics under CO2. Generally, gasification kinetics of most of the chars was predicted well by random pore model. Only the algal char obtained from rapid pyrolysis was different because of its low amount of gasifiable mass attached to the surface which did not show any porous structure, therefore, followed the volumetric reaction model. Along with the fixed bed chars, only coconut shell char from entrained flow reactor showed very low reactivity. This difference in the reactivity was attributed to the lack of mesopores along with the variation of indigenous alkali in the ash among the biomass species to a lesser extent.This low reactivity of coconut shell char resulted in the entrained flow gasification experiments which were performed by varying the temperature, particle size and also concentration of gasifying agent (CO2). The char from coconut shell did not show any significant increase in conversion due to the decrease in particle size whereas a steady linear increase was observed for temperature. In contrast, the sawdust char was highly reactive and reached its highest conversion (50%) at 1000 °C under 20% CO2 for a reactor length of 1.885 m. Remarkable increase in the conversion was observed with decrease in the particle size and increase of temperature. The increase in reactor length also showed positive effect on char conversion and gas production. These findings have important implications on the gasifier design and sample preparation meaning there will be no benefit of reduced particle size on conversion if the sample itself is less reactive in the first place. Also it was revealed that if raw biomass was gasified, these effects would have been indistinguishable because of the dominance of pyrolysis. No tar was observed during char gasification process at 1000 °C as most of it removed during the pyrolysis process.Along with the above studies, a new analytical technique (Synchrotron based Infrared spectrum) was used to study the pyrolysis process of biomass. The study delineated the evolution of functional groups from the surface of biomass along with the effect of heating rate during the process. This was a preliminary study which opened up new possibilities in energy research considering in situ gasification of biomass.

"The importance of climate change and subsequently the necessity for sustainable energy production have been evident to researchers and experts in this field for the past decades. However, moving forward with increasing the industrialization of biofuels and replacing them with conventional fuels require persuading businesses with robust and vast research results on the benefits of biofuels. Implementing numerical modeling as preliminary tests for different biomass as well as analyzing the behavior of the system by changing the effective properties, provides a resourceful tool for experimentation and is financially beneficial. Gasification has become one of the most desirable thermochemical conversion processes in the clean energy production, specifically for the hydrogen gas, with the biomass being compatible with this conversion system as a feedstock. However, the complexity of this process and the high range of temperature limit the possible number of the experimental tests, leading to the lack of extensive experimental results in the literature for biomass gasification compared to the combustion process. As a result, computational modeling is an ¬attractive alternative to fill the gap of knowledge on this matter. This work consists of one extensive literature review on the numerical modeling of the gasification process and two numerical modeling that have the potential for better understanding of the gasification process in biomass feedstock. The first model provides effective thermal conductivity (ETC) of the wood-plastic composites (WPCs) by using a homogenization method implemented by a finite element method (FEM). The solid volume fraction and porosity is considered as parameters, and high-density polyethylene (HDPE) plastic and wood-char were the materials. The results showed improved ETC as the solid volume fraction increased and the polymer is added to the wood-char. The ETC is one of the most important properties that affect the thermal processes of gasification. Using the homogenization technique, we potentially can design the microstructure of feedstocks to optimize their performance when used in the gasification process. The second model is a 1D gasification model for a single particle in a downdraft gasifier. The 1D model considers reduction and oxidation reactions for char and provides temperature distribution along the radius and time. Temperature rapidly increases before reaching a steady state after 3000s. The temperature on the radiuses closer to the surface has a higher temperature compared to the core. The results were consistent with the analytical data and can be used to better understand the effect of porosity and thermal conductivity on temperature changes in feedstock during gasification"--

Sustainable Biomass and Waste Conversion: Modeling Tools for Planning and Optimization provides practical knowledge on the

technical, economic and environmental aspects of bioenergy, biorefining, and waste-to-energy systems through modeling. The book covers key-technologies and cutting-edge advances for biomass assessment using statistics and GIS systems, logistics optimization using Vehicle Routing Problem solvers, Neural Networks and Optimization models based on MILP and NLP, and energy demand assessment. In addition, sections cover feasibility plans for biorefineries and combined heat and power systems, and the fundamentals and challenges of modeling biomass and waste conversion processes, such as anaerobic digestion, pyrolysis, gasification, combustion, transesterification, fermentation and hydroprocessing. The authors also examine economic and market factors influencing feedstock availability and price and provide tools for environmental and social impact analysis. Finally, the book illustrates the application of the methodologies covered through a number of case studies from around the globe, quizzes and exercises. Presents practical tools to design supply plans for waste-to-energy and bioenergy plants, as well as biorefineries, optimizing collection, and logistics within the context of the bioeconomy Explores methodologies for the realistic development of bioenergy business plans, environmental impact analysis, plant control and management Includes a broad selection of global case studies and practical exercises that illustrate the application of discussed methodologies in biomass and waste conversion chains
The present science book "Application of Solar Energy" is edited by Professor R. D. Rugescu in the series on Solar Power and consists of 7 chapters that begin with the proof of the high thermal efficiency of the gravitational draught through concentrated solar heating. It continues with novel technologies of producing organic fuels through solar heating, new types of photovoltaic cells, long term use of thermal solar power plants, the efficiency of thermal storage and applications in Niger of the Solar power. The reader will be pleasantly impressed by the accompanying drawings and pictures that ease the text assimilation and makes it an attractive practice.

This dissertation combines the practical and theoretical aspects of atmospheric bubbling fluidized bed (BFB) biomass gasifiers through the integration of - operational experience from the gasification of thirty-nine biomass fuels (mono-fuels and mixed-fuels) using a laboratory-scale BFB gasifier, - a step-by-step design methodology of a BFB gasifier, and - a kinetic model incorporating both fluid dynamics and chemical reaction kinetics, which is validated with experimental data from BFB biomass gasifiers of different scales (laboratory-, pilot- and demonstration-scale). It provides a platform for an enhanced understanding of a sustainable production of hydrogen- and carbon-monoxide-rich fuel gases from gasification of woody and non-woody biomass in atmospheric bubbling fluidized bed gasifiers.

This book is for chemical engineers, fuel technologists, agricultural engineers and chemists in the world-wide energy industry and in academic, research and government institutions. It provides a thorough review of, and entry to, the primary and review literature surrounding the subject. The authors are internationally recognised experts in their field and combine to provide both commercial relevance and academic rigour. Contributions are based on papers delivered to the Fifth International Conference sponsored by the IEA Bioenergy Agreement.

Focusing on the conversion of biomass into gas or liquid fuels the book covers physical pre-treatment technologies, thermal, chemical and biochemical conversion technologies • Details the latest biomass characterization techniques • Explains the biochemical and thermochemical conversion processes • Discusses the development of integrated biorefineries, which are similar to petroleum refineries in concept, covering such topics as reactor configurations and downstream processing • Describes how to mitigate the environmental risks when using biomass as fuel • Includes many problems, small projects, sample calculations and industrial application examples

Biomass is the most widely used non-fossil fuel in the world. Biomass resources show a considerable potential in the long-term given the increasing proliferation of dedicated energy crops for biofuels. The second edition of Biomass Gasification and Pyrolysis is enhanced with new topics, such as torrefaction and cofiring, making it a versatile resource that not only explains the basic principles of energy conversion systems, but also provides valuable insight into the design of biomass conversion systems. This book will allow professionals, such as engineers, scientists, and operating personnel of biomass gasification, pyrolysis or torrefaction plants, to gain a better comprehension of the basics of biomass conversion. The author provides many worked out design problems, step-by-step design procedures and real data on commercially operating systems. With a dedicated focus on the design, analysis, and operational aspects of biomass gasification, pyrolysis, and torrefaction, Biomass Gasification, Pyrolysis and Torrefaction, Second Edition offers comprehensive coverage of biomass in its gas, liquid, and solid states in a single easy-to-access source. Contains new and updated step-by-step process flow diagrams, design data and conversion charts, and numerical examples with solutions Includes chapters dedicated to evolving torrefaction technologies, practicing option of biomass cofiring, and biomass conversion economics Expanded coverage of syngas and other Fischer-Tropsch alternatives Spotlights advanced processes such as supercritical water gasification and torrefaction of biomass. Provides available research results in an easy-to-use design methodology

This book includes selected peer-reviewed papers presented at the International Conference on Modeling, Simulation and Optimization, organized by National Institute of Technology, Silchar, Assam, India, during 3–5 August 2020. The book covers topics of modeling, simulation and optimization, including computational modeling and simulation, system modeling and simulation, device/VLSI modeling and simulation, control theory and applications, modeling and simulation of energy system and optimization. The book disseminates various models of diverse systems and includes solutions of emerging challenges of diverse scientific fields.

Owing to increasing concerns that climate change poses an urgent threat to the existence of human society, there is a need to develop cost-effective and scalable technologies to produce renewable, drop-in transportation fuels. Fluidized bed biomass gasification (FBBG) is one of the most promising options for the thermochemical conversion of lignocellulosic biomass to synthetic liquid fuels. When biomass is introduced into the high temperature bed (700-900 °C), it rapidly devolatilizes and subsequently reacts with steam, carbon dioxide, and oxygen to form syngas (hydrogen, carbon monoxide) as well as a complex assortment of light gases and condensable compounds known as tar. The main technical challenges facing FBBG technologies are incomplete char conversion and generation of polycyclic aromatic hydrocarbons (PAH's), which require expensive cleanup steps to avoid downstream operational issues. Existing approaches to optimize the performance of FBBG have examined the manipulation of operational parameters such as temperature, pressure, in-bed additives, steam to carbon ratio (SCR), and air fuel equivalence ratio (ER). However, the optimization of FBBG through experimental studies has proven difficult because the extremely complex, coupled, physical and chemical phenomena obscure the actual causal mechanisms. Prior modeling efforts are deficient in several key areas including gas-phase chemistry and char conversion processes, rendering them unable to conclusively determine operating conditions which achieve high cold gas efficiency and complete char/tar conversion. The first part of this work describes the development of a flexible, modular, robust, coupled reactor network model (CRNM) enabling the steady-state simulation of a variety of feedstocks over a wide-range of conditions. The CRNM consists of three independently validated and parameterized sub-models that consider i) particle devolatilization, ii) char conversion, and iii) hydrodynamics and homogeneous reaction kinetics. For each sub-module, the dominant physico-chemical processes and modeling assumptions are identified using characteristic time-scale analyses. The proposed char conversion model describes simultaneous and competing particle-scale processes including gasification, combustion, inhibition, intra/extra particle mass transfer, attrition, and elutriation both under transient and steady-state conditions. Bed hydrodynamics is described using the two-phase theory of fluidization resulting in a network of idealized reactors. This enables the efficient solution of comprehensive gas-phase kinetics mechanisms (327 species and 10933 reactions). The second part of this study validates the CRNM by comparing its results with data from lab-scale steam/air blown gasification experiments performed in collaboration with the National Renewable Energy Laboratory (NREL) and the MIT Chemical Engineering Practice School. The experimental results show that the composition of tar is highly sensitive to the addition of air/oxygen, which appears to accelerate the conversion of lighter PAH's into soot precursors at a fixed operating temperature. Experimental data and modeling results agree that the char reacts with very significant fraction of air/oxygen, improving its overall conversion drastically and reducing the steady state bed inventory of char. The validated model is used to carry out a constrained parametric analysis and optimization of the key operating variables, feed location, and fluidizing agent options. Standalone biomass gasification with steam and air tends to result in a syngas with low H2:CO ratio (/=1). The addition of steam improves the hydrogen content and reduces tars slightly; however, complete conversion of the methane and tar compounds (99%) is ultimately only possible if sufficient secondary air is injected into the freeboard to raise its temperature above 1300 °C. The modeling results demonstrate that methane and biomass act synergistically in the gasifier: the addition of methane acts to significantly improve the carbon yield and energy content of the syngas while the catalytic impact of minerals contained in the biomass act to promote the water-gas shift reaction in the bed region.

Given the environmental concerns and declining availability of fossil fuels, as well as the growing population worldwide, it is essential to move toward a sustainable bioenergy-based economy. However, it is also imperative to address sustainability in the bioenergy industry in order to avoid depleting necessary biomass resources. Sustainable Bioenergy Production provides comprehensive knowledge and skills for the analysis and design of sustainable biomass production, bioenergy processing, and biorefinery systems for professionals in the bioenergy field. Focusing on topics vital to the sustainability of the bioenergy industry, this book is divided into four sections: Fundamentals of Engineering Analysis and Design of Bioenergy Production Systems, Sustainable Biomass Production and Supply Logistics, Sustainable Bioenergy Processing, and Sustainable Biorefinery Systems. Section I covers the fundamentals of genetic engineering, novel breeding, and cropping technologies applied in the development of energy crops. It discusses modern computational tools used in the design and analysis of bioenergy production systems and the life-cycle assessment for evaluating the environmental sustainability of biomass production and bioenergy processing technologies. Section II focuses on the technical and economic feasibility and environmental sustainability of various biomass feedstocks and emerging technologies to improve feedstock sustainability. Section III addresses the technical and economic feasibility and environmental sustainability of different bioenergy processing technologies and emerging technologies to improve the sustainability of each bioenergy process. Section IV discusses the design and analysis of biorefineries and different biorefinery systems, including lignocellulosic feedstock, whole-crop, and green biorefinery.

It is widely believed that a large proportion of greenhouse gas emissions originated anthropogenically from the use of fossil fuels with additional contributions coming from manufactured materials, deforestation, soil erosion, and agriculture (including livestock). The global society actively supports measures to create a flexible and low-carbon energy economy to attenuate climate change and its devastating environmental consequences. In this Special Issue, the recent advancements in the next-generation thermochemical conversion processes for solid fuels and renewable energies (e.g., the operational flexibility of co-combustion of biomass and lignite, integrated solar combined cycle power plants, and advanced gasification systems such as the sorption-enhanced gasification and the chemical looping gasification) were shown.

Provides a comprehensive review on the brand-new development of several multiphase reactor techniques applied in energy-related processes Explains the fundamentals of multiphase reactors as well as the sophisticated applications Helps the reader to understand the key problems and solutions of clean coal conversion techniques Details the emerging processes for novel refining technology, clean coal conversion techniques, low-cost hydrogen productions and CO2 capture and storage Introduces current energy-related processes and links the basic principles of emerging processes to the features of multiphase reactors providing an overview of energy conversion in combination with multiphase reactor engineering Includes case studies of novel reactors to illustrate the special features of these reactors

This book addresses the science and technology of the gasification process and the production of electricity, synthetic fuels and other useful chemicals. Pursuing a holistic approach, it covers the fundamentals of gasification and its various applications. In addition to discussing recent advances and outlining future directions, it covers advanced topics such as underground coal gasification and chemical looping combustion, and describes the state-of-the-art experimental techniques, modeling and numerical simulations, environmentally friendly approaches, and technological challenges involved. Written in an easy-to-understand format with a comprehensive glossary and bibliography, the book offers an ideal reference guide to coal and biomass gasification for beginners, engineers and researchers involved in designing or operating gasification plants.

Biomass can be converted to energy, biofuels, and bioproducts via thermochemical conversion processes, such as combustion, pyrolysis, and gasification. Combustion technology is most widely applied on an industrial scale. However, biomass gasification and pyrolysis processes are still in the research and development stage. The major products from these processes are syngas, bio-oil, and char (called also biochar for agronomic application). Among these products, biomass chars have received increasing attention for different applications, such as gasification, co-combustion, catalysts or adsorbents precursors, soil amendment, carbon fuel cells, and supercapacitors. This Special Issue provides an overview of biomass char production methods (pyrolysis, hydrothermal carbonization, etc.), characterization techniques (e.g., scanning electronic microscopy, X-ray fluorescence, nitrogen adsorption, Raman spectroscopy, nuclear magnetic resonance spectroscopy, X-ray photoelectron spectroscopy, and temperature programmed desorption and mass spectrometry), their properties, and their suitable recovery processes.

The proceedings of the 20th International Conference on Fluidized Bed Combustion (FBC) collect 9 plenary lectures and 175 peer-

reviewed technical papers presented in the conference held in Xi'an China in May 18-21,2009. The conference was the 20th conference in a series, covering the latest fundamental research results, as well as the application experience from pilot plants, demonstrations and industrial units regarding to the FBC science and technology. It was co-hosted by Tsinghua University, Southeast University, Zhejiang University, China Electricity Council and Chinese Machinery Industry Federation. A particular feature of the proceedings is the balance between the papers submitted by experts from industry and the papers submitted by academic researchers, aiming to bring academic knowledge to application as well as to define new areas for research. The authors of the proceedings are the most active researchers, technology developers, experienced and representative facility operators and manufacturers. They presented the latest research results, state-of-the-art development and projects, and the useful experience. The proceedings are divided into following sections: • CFB Boiler Technology, Operation and Design • Fundamental Research on Fluidization and Fluidized Combustion • C02 Capture and Chemical Looping • Gasification • Modeling and Simulation on FBC Technology • Environments and Pollutant Control • Sustainable Fuels The proceedings can be served as idea references for researchers, engineers, academia and graduate students, plant operators, boiler manufacturers, component suppliers, and technical managers who work on FBC fundamental research, technology development and industrial application.
Biomass obtained from agricultural residues or forest can be used to produce different materials and bioenergy required in a modern society. As compared to other resources available, biomass is one of the most common and widespread resources in the world. Thus, biomass has the potential to provide a renewable energy source, both locally and across large areas of the world. It is estimated that the total investment in the biomass sector between 2008 and 2021 will reach the large sum of $104 billion. Presently bioenergy is the most important renewable energy option and will remain so the near and medium-term future. Previously several countries try to explore the utilization of biomass in bioenergy and composite sector. Biomass has the potential to become the world’s largest and most sustainable energy source and will be very much in demand. Bioenergy is based on resources that can be utilized on a sustainable basis all around the world and can thus serve as an effective option for the provision of energy services. In addition, the benefits accrued go beyond energy provision, creating unique opportunities for regional development. The present book will provide an up-to-date account of non-wood, forest residues, agricultural biomass (natural fibers), and energy crops together with processing, properties and its applications to ensure biomass utilization and reuse. All aspects of biomass and bioenergy and their properties and applications will be critically re-examined. The book consists of three sections, presenting Non wood and forest products from forestry, arboriculture activities or from wood processing, agricultural biomass (natural fibers) from agricultural harvesting or processing and finally energy crops: high yield crops and grasses grown especially for energy production.
Technologies for the conversion of biomass to liquid fuels are important to develop because the demand for liquid fuels remains unchanged even with the necessity of limiting dependence on fossil fuels. Fluidized Bed Biomass Gasification (FBBG) is one such technology that can perform the initial step of converting raw biomass into syngas as an intermediate to liquid fuels. The char that is left in the reactor after devolatilization can be oxidized in order to maximize the amount of biomass carbon that is converted to gaseous carbon and generate heat to drive endothermic gasification reactions. This paper examines the rate of each of the three processes that occur during char conversion (external diffusion, chemical reactions, and intraparticle diffusion) to determine which process limits the rate of the reaction under a range of conditions. It was determined that at most FBBG operating points, the rate of char conversion will be limited by the rate of diffusion of oxygen through the particle's boundary layer and through its pores. Only at low reactor temperatures and small particle diameters will the reaction rate be purely kinetically limited. An overall rate expression accounting for all three processes has been formulated which can be implemented in more detailed reactor models.
The Handbook of Clean Energy Systems brings together an international team of experts to present a comprehensive overview of the latest research, developments and practical applications throughout all areas of clean energy systems. Consolidating information which is currently scattered across a wide variety of literature sources, the handbook covers a broad range of topics in this interdisciplinary research field including both fossil and renewable energy systems. The development of intelligent energy systems for efficient energy processes and mitigation technologies for the reduction of environmental pollutants is explored in depth, and environmental, social and economic impacts are also addressed. Topics covered include: Volume 1 - Renewable Energy: Biomass resources and biofuel production; Bioenergy Utilization; Solar Energy; Wind Energy; Geothermal Energy; Tidal Energy. Volume 2 - Clean Energy Conversion Technologies: Steam/Vapor Power Generation; Gas Turbines Power Generation; Reciprocating Engines; Fuel Cells; Cogeneration and Polygeneration. Volume 3 - Mitigation Technologies: Carbon Capture; Negative Emissions System; Carbon Transportation; Carbon Storage; Emission Mitigation Technologies; Efficiency Improvements and Waste Management; Waste to Energy. Volume 4 - Intelligent Energy Systems: Future Electricity Markets; Diagnostic and Control of Energy Systems; New Electric Transmission Systems; Smart Grid and Modern Electrical Systems; Energy Efficiency of Municipal Energy Systems; Energy Efficiency of Industrial Energy Systems; Consumer Behaviors; Load Control and Management; Electric Car and Hybrid Car; Energy Efficiency Improvement. Volume 5 - Energy Storage: Thermal Energy Storage; Chemical Storage; Mechanical Storage; Electrochemical Storage; Integrated Storage Systems. Volume 6 - Sustainability of Energy Systems: Sustainability Indicators, Evaluation Criteria, and Reporting; Regulation and Policy; Finance and Investment; Emission Trading; Modeling and Analysis of Energy Systems; Energy vs. Development; Low Carbon Economy; Energy Efficiencies and Emission Reduction. Key features: Comprising over 3,500 pages in 6 volumes, HCES presents a comprehensive overview of the latest research, developments and practical applications throughout all areas of clean energy systems, consolidating a wealth of information which is currently scattered across a wide variety of literature sources. In addition to renewable energy systems, HCES also covers processes for the efficient and clean conversion of traditional fuels such as coal, oil and gas, energy storage systems, mitigation technologies for the reduction of environmental pollutants, and the development of intelligent energy systems. Environmental, social and economic impacts of energy systems are also addressed in depth. Published in full colour throughout. Fully indexed with cross referencing within and between all six volumes. Edited by leading researchers from academia and industry who are internationally renowned and active in their respective fields. Published in print and online. The online version is a single publication (i.e. no updates), available for one-time purchase or through annual subscription.