Flue Gas Desulfurization Acid Gas Removal Systems

This book provides extensive information on high-temperature H2S removal for integrated gasification combined cycle (IGCC) coarse gas, together with briefly introductions to the concept of clean coal technology, and to the mechanism and kinetics of hot coal gas desulfurizers. Readers will gain a comprehensive understanding of available control methods for high-temperature H2S removal in IGCC coarse gas and how the technology has been adopted by industry. As such, the book offers a unique resource for researchers and engineers in the fields of energy science and technology, environmental science and technology, and chemical engineering.

Dry sulfurization processes offer the significant advantages of low capital and low operating costs when compared to wet desulfurization. They hold great potential for the economical reduction of sulfur emissions from power utilities that use high-sulfur coal. Dry Scrubbing Technologies for Flue Gas Desulfurization represents a body of research that was sponsored by the State of Ohio's Coal Development Office for the development of technologies that use coal in an economic, environmentally-sound manner. One of the project's major goals was the development of dry, calcium-based sorption processes for removing sulfur dioxide from the combustion gases produced by high-sulfur coal. Dry Scrubbing Technologies for Flue Gas Desulfurization highlights a number of fundamental research findings that have had a significant and lasting impact in terms of scientific understanding. For example, the experimental investigation of the upper-furnace sulfur capture obtained time-resolved kinetic data in less than 100 millisecond time-scales for the first time ever, thereby revealing the true nature of the ultra-fast and overlapping phenomena. This was accomplished through the development of a unique entrained flow reactor system. The authors also identify a number of important areas for future research, including reaction mechanisms, sorbent material, transport effects, modeling, and process development. Dry Scrubbing Technologies for Flue Gas Desulfurization will appeal to both chemical and environmental engineers who examine different ways touse coal in a more environmentally benign manner. It will make an essential reference for air pollution control researchers from coal, lime, cement, and utility industries; for government policy-makers and environmental regulatory agencies; and for those who teach graduate courses in environmental issues, pollution control technologies, and environmental policy.

Process Synthesis and Innovation in Flue Gas Desulfurization

Air Pollution Abstracts

Characteristics, Utilization and Beneficiation

Dry Scrubbing Technologies for Flue Gas Desulfurization

Symposium on Flue Gas Desulfurization, Hollywood, Fla., November 1977

Proceedings

Since the passage of the Clean Air Act of 1970, flue gas desulfurization (FGD) or scrubber systems have come into common use in fossil fuel power generation plants. Linings used in such systems must be able to withstand harsh service conditions that include wide fluctuations in temperature; acidic gases; a wide range of contaminants, both organic and inorganic; abrasion from fly ash and limestone slurry; and vibration. The properties of fluorelastomers, a relatively new material for such systems, are explored in detail and compared with four other types of materials used in FGD service: specialized alloys, inorganic monolithic cements, acid-resistant masonry, and other organic coatings.

Combustion Ash and Residue Management assists owners and operators of Coal-fired and Resource Recovery Power Plants. By applying the principles and reviewing the case studies examples described within this book, accidents and upsets can be avoided and regulatory permitting can be achieved – reducing costs. This unique book is an essential reference for anybody responsible for disposal or utilization of combustion residues. It reflects over 30 years of engineering practice, applying the principles of concrete chemistry and civil engineering/soil mechanics as confirmed by field data. Dr. Richard Goodwin assesses the composition and environmental impact of combustion residues, and provides not only best practices for safe disposal, but also a blueprint for effective reuse, including applications like structural fill, grout, and capping material. Case studies and cost information for ash disposal options are included, in addition to the lessons learned by high-profile failures, such as the TVA Kingston fossil plant coal fly ash slurry spill in 2008. It also applies engineering principles to discuss how to avoid future upsets, including better operator training and monitoring methods. A comprehensive update to reflect changes in legislation and practice, including new material on the safe disposal or beneficial use of coal ash A straightforward engineering approach, providing practical guidance and field data Written by an established expert in the field

Flue Gas Desulfurization by the Modified Citrate Process

Encyclopedia of Renewable Energy

High-Temperature H2S Removal from IGCC Coarse Gas

Air Quality and Stationary Source Emission Control

Economic Evaluation of SO2 Control Options for Acid Rain Legislation

Coal Combustion Products (CCPs)

Scholarly Research Paper from the year 2013 in the subject Engineering - Chemical Engineering, grade: Master, course: Engineering, language: English, abstract: In 1927, the limestone desulfurization process was first applied in the Barthes and Bansside Power Plants (total 120MW) beside the Thames River in UK to protect high-rise building in London. Up to now, over 10 desulfurization processes have been launched and applied. Based on the desulfurizing agent being used, there include calcium process (limestone/lime), ammonia process, magnesium process, sodium process, alkali alumina process, copper oxide/zinc process, active carbon process, ammonium dihydrogen phosphate process, etc. The calcium process is commercially available and widely used in the world, i.e. more than 90%. Flue gas desulfurization processes, survey made by the coal research institute under the International Energy Agency shows that the wet-process desulfurization accounts for 85% of total installed capacity of flue gas desulfurization units across the world. The wet-process desulfurization is mainly applied in countries, like Japan (98%), USA (92%), Germany (90%), etc. The limestone-

gypsum wet desulfurization process, the most mature technology, the most applications, the most reliable operation in the world, may have rate of desulfurization of more than 90%. Currently, the flue gas desulfurization technology used at thermal power plants at home and abroad tends to be higher rate of desulfurization, bigger installed capacity, more advanced technology, lower investment, less land acquisition, lower operation cost, higher level of automation, more excellent reliability, etc. This paper briefs current situations and trends of flue gas desulfurization technology also append short descript of different type of FDG and their category.

A basic technical book on the design and application of gas cleaning technologies that use liquids, first published in the 1980's and used by plant and environmental engineers, regulatory personnel, and others concerned with air pollution. The second edition enlarges the discussion on the theory of

Performance of Flue-gas Desulfurization (FGD) Capping and Stream Diversion in Treating Acid Mine Drainage

Energy Resources and Systems

Industrial Combustion Pollution and Control

Symposium on Flue Gas Desulfurization, New Orleans, March 1976

Opportunities in a New Asset Class

Spray-Applied Fluoroelastomers for Protection of Carbon Steel Structures in Flue Gas Desulfurization Service

Environmental asset classes are not a hope for tomorrow but a reality today. This new asset category promises to grow dramatically in the 21st Century as financial analysts, investors, and corporations around the world try to find ways to profit or reduce costs while promoting environmental social benefits. Sustainable Investing and Environmental Markets: Opportunities in a New Asset Class presents a groundbreaking new way to “do well and to do good”. With a combination of over 50 years of practical experience in the field of environmental finance, Richard Sandor, Nathan Clark, Murali Kanakasabai and Rafael Marques provide a solid preliminary understanding of the promising and transformational new investment category of environmental assets. Three broad asset classes – air and water; catastrophic and weather risk; and sustainability – are covered across 12 chapters which analyze how these environmental asset classes are currently being incorporated into commodities, fixed income, and equity instruments and what the future holds for the field. Contents:A Brief Survey of Environmental Asset ClassesMarket Failures and Policy ResponsesAcid Rain Pollutants as an Asset ClassGreenhouse Gas Pollutants as an Asset ClassEmerging Geographies for Greenhouse Gas Emissions MarketsForest Carbon as an Asset ClassClean Energy Markets and Associated Asset ClassesWater Markets and Associated Asset ClassesWater Quality Trading and Its Associated Asset ClassesSustainable Fisheries Management and Its Associated Asset ClassesWeather Risks and Associated Asset ClassesSustainability and Associated Asset ClassesConclusion: You Can Put a Price on Nature Readership: Readers interested in the environment as an asset class; investors, financial analysts, policymakers, undergraduates and postgraduates of finance and economics. Key Features:There is no equivalent book in the market right now that covers environment-financial issues from a practitioner's standpointThis book combines economic theory and practical experience – making it a valuable tool for anyone who is interested in the environment as an asset class (investors, analysts, policymakers, students of finance and economics)Keywords:Environment;Emissions;Trading;Finance;Derivatives;Water;Energy;Carbon;Catastrophe;Weather;Sustainability;Fisheries;Greenhouse Gases;Sulfur Dioxide;Acid Rain;Clean Energy MarketsReviews: “A “how-to” manual for using eco-markets to save the planet … laced with deep, important history and the foresight of the truest financial and environmental market pioneer, this book tells the tale of how, with leadership, we can change the world.” Commissioner Bart Chilton US Commodity Futures Trading Commission “With this book, Dr Richard Sandor and his colleagues help bridge a critical gap between academic theory and business practice. A must-read for students, investors, policymakers, and anyone interested on the worldwide opportunities for markets to tackle pressing issues such as climate and water. An important reference piece, written by someone who has helped shape the field of environmental finance as both an academic and practitioner.” Joseph P Kenendy II Founder, Chairman, and President of Citizens Energy Corporation and Member of the US House of Representatives for Massachusetts 8th District (1987–1999) “This is a great book. Every student should read it as a freshman. It is the handbook of how different innovative approaches accelerate the creation of a sustainable future for all of us. Nature has a monetary price, and Richard Sandor and his co-authors tell you in this book how price discovery leads to environmental protection.” Alexander J B Zehnder Nayang Technological University, Singapore Former President of ETH Zurich, and a father of the concept of the “2000 Watt Society”

ENCYCLOPEDIA OF RENEWABLE ENERGY Written by a highly respected engineer and prolific author in the energy sector, this is the single most comprehensive, thorough, and up-to-date reference work on renewable energy. The world’s energy industry is and has always

been volatile, sometimes controversial, with wild swings upward and downward. This has, historically, been mostly because most of our energy has come from fossil fuels, which is a finite source of energy. Every so often, a technology comes along, like hydrofracturing, that is a game-changer. But is it, really? Aren’t we just delaying the inevitable with these temporary price fixes The only REAL game-changer is renewable energy. For decades, renewable energy sources have been sought, developed, and studied. Sometimes wind is at the forefront, sometimes solar, and, for the last decade or so, there has been a surge in interest for biofeedstocks and biofuels. There are also the “old standbys” of nuclear and geothermal energy, which have both been around for a very long time. This groundbreaking new volume presents these topics and trends in an encyclopedic format, as a go-to reference for the engineer, scientist, student, or even layperson who works in the industry or is simply interested in the topic. Compiled by one of the world’s best-known and respected energy engineers, this is the most comprehensive and up-to-date encyclopedia of renewable energy ever written, a must-have for any library. Encyclopedia of Renewable Energy: Is written in an encyclopedic style, covering every aspect of renewable energy, including wind, solar, and many other topics Offers a comprehensive coverage of the industry, from the chemical processes of biofeedstocks and biofuels to the machinery and equipment used in the production of fuel and power generation Is filled with workable examples and designs that are helpful for practical applications Covers the state of the art, an invaluable resource for any engineer Audience Engineers across a variety of industries, including wind, solar, process engineering, waste utilization for fuels, and many others, such as process engineers, chemical engineers, electrical engineers, petroleum engineers, civil engineers, and the technicians and other scientists who work in this field

Flue Gas Desulfurization and Industrial Minerals

Pessel-AEL Flue-gas Desulfurization Process. Final Report

Ninth Symposium on Flue Gas Desulfurization, Cincinnati, Ohio, June 4-7, 1985

Environmental Assessment

Capsule Report

Acid Precipitation

As regulations push the fossil fuel industry toward increasing standards of eco-friendliness and environmental sustainability, desulfurization (the removal of SO2 from industrial waste byproducts) presents a new and unique challenge that current technology is not equipped to address. Advances in nanotechnology offer exciting new opportunities poised to revolutionize desulfurization processes. Applying Nanotechnology to the Desulfurization Process in Petroleum Engineering explores recent developments in the field, including the use of nanomaterials for biodesulfurization and hydrodesulfurization. The timely research presented in this volume targets an audience of engineers, researchers, educators as well as students at the undergraduate and post-graduate levels.

Coal Combustion Products (CCPs): Their Nature, Utilization and Beneficiation is a valuable resource for engineers and scientists from the coal, cement, concrete, and construction industries seeking an in-depth guide to the characteristics, utilization, beneficiation, and environmental impacts of coal combustion by-products. Researchers in universities working in this area will also find much to expand their knowledge. The book provides a detailed overview of the different waste materials produced during power generation from coal, exploring their nature, beneficiation techniques, applications, and environmental impacts. Strong focus is placed on coal fly ash, bottom ash, and flue gas desulfurization materials, and their employment in cement, concrete, gypsum products, aggregates, road construction, geotechnics, and agriculture, among other products and industries. Part 1 focuses on the nature of coal ashes, with chapters on their origin, generation, and storage, both in ponds and landfill. The coal combustion by-products produced as a result of clean coal technologies are the focus of the final chapter in the section. The next group of chapters in Part 2 considers the utilization of different waste materials, including the key products coal fly ash, bottom ash, and flue gas desulfurization materials. This is followed by a contribution reviewing the latest research into innovative and advanced uses for coal ash. After an introduction to ash quality problems and quality monitoring, Part 3 concentrates on the essential area of by-product beneficiation techniques, in other words how to maximize the quality of materials for the end user. Topics covered include separation methods, thermal processing, and chemical passivation. The final section of the book addresses environmental issues, including the use of coal combustion by-products in green construction materials and the essential health and safety considerations associated with their use. An essential reference on the nature, reactivity, beneficiation, potential and environmental risks of coal-combustion by-products Contains an in-depth review of the origin and geochemistry of coal ash Explores the utilization of coal combustion by-products as supplementary cementitious materials to reduce the anthropomorphic greenhouse gas emissions associated with the use of ordinary Portland cement concrete Describes the essential area of the toxicology of coal combustion by-products

Calcium Reclamation and Synthesis of PCC for Acid Gas Control in Flue Gas

Flue Gas Desulfurization and Sulfuric Acid Production Via Magnesia Scrubbing

Beneficial Reuse of Lime Softening Residuals for Flue Gas Desulfurization

Sustainable Investing and Environmental Markets

Volume 1: Fundamentals and Non-Renewable Resources

Flue Gas Desulfurization

This reference overflows with an abundance of experimental techniques, simulation strategies, and practical applications useful in the control of pollutants generated by combustion processes in the metals, minerals, chemical, petrochemical, waste, incineration, paper, glass, and foods industries. The book assists engineers as they attempt to meet e

In the lifetimes of the authors, the world and especially the United States have received three significant “wake-up calls” on energy production and consumption. The first of these occurred on October 15, 1973 when the Yom Kippur War began with an attack by Syria and Egypt on Israel. The United States and many western countries supported Israel. Because of the western support of Israel, several Arab oil

exporting nations imposed an oil embargo on the west. These nations withheld five million barrels of oil per day. Other countries made up about one million barrels of oil per day but the net loss of four million barrels of oil production per day extended through March of 1974. This represented 7% of the free world’s (i. e. , excluding the USSR) oil production. In 1972 the price of crude oil was about $3. 00 per barrel and by the end of 1974 the price of oil had risen by a factor of 4 to over $12. 00. This resulted in one of the worst recessions in the post World War II era. As a result, there was a movement in the United States to become energy independent. At that time the United States imported about one third of its oil (about five million barrels per day). After the embargo was lifted, the world chose to ignore the “wake-up call” and went on with business as usual.

Controlling SO2 emissionsa review of technologies

A Basic Handbook

A Review

Acid Mine Drainage Abatement Using Flue Gas Desulfurization By-product

The Status of Flue Gas Desulfurization Applications in the United States

Natural Gas

"This Environmental Assessment (EA) has been prepared to obtain approval under the Environment Assessment Act for one critical component of Ontario Hydro's Acid Gas Control Program. The undertaking ... is a program of activities to retrofit flue gas desulphurization (FGD) facilities at selected Ontario Hydro coal-fired generating stations, as necessary to satisfy the requirements of Ontario Regulation 281/87 under the Environmental Protection Act."--Foreword.

Abstract: Fossil fuels currently play an invaluable role; accounting for over 80 % of the world's energy needs. The combustion of these fuels, however, generates the majority of anthropogenic acid gases, such as SO2 and CO2. Thus, reducing emissions from fossil fuel conversion systems and stabilizing current levels of major pollutants in the atmosphere are essential to ensure the continued use of inexpensive fossil fuels while maintaining the delicate equilibrium in the environment. The increased number of natural disasters and the passage of major political programs, like the Clear Skies Act of 2003 and the Clean Air Act of 1990, highlight this need. Post-combustion removal of SO2 in flue gas can be achieved by contacting acidic SO2 with alkaline sorbents such as limestone (CaCO3), lime (CaO), and hydrated lime (Ca(OH)2). The conventional flue gas desulfurization (FGD) processes are broadly classified as wet and dry processes and their overall conversions are about 90 % and 60 %, respectively. Considering the large quantity of Ca-bearing sorbents needed for FGD processes, the reclamation of unused Ca in these wastes is an attractive solution for improving the overall process economics. In this project, various calcium sources are used to synthesize precipitated calcium carbonate (PCC) that has optimal morphological properties for both SO2 and CO2 capture from flue gas. First, different industrial wastes, Ca(OH)2, and CaCO3 are procured and characterized for their Ca content. Various chelating agents are then used to promote the dissolution of solid samples. Based on the results of the calcium leaching tests, a common chelating agent, IDA, is selected for the subsequent investigation of PCC synthesis. It is found that IDA promotes the dissolution of Ca-bearing solids, while it does not interfere with the subsequent precipitation of PCC process. Finally, the effectiveness of PCC, produced with IDA, on SO2 capture and CO2 separation is investigated using a multi-gas thermal gravimetric analyzer.

An Engineering Perspective

The Rock Run Refuse Pile

Evaluation of Flue Gas Desulfurization (FGD) Processes at TVA Plants

A Bibliography

New Developments in Flue Gas Desulfurization Technology

Fossil Energy Update

Natural Gas: A Basic Handbook, Second Edition provides the reader with a quick and accessible introduction to a fuel source/industry that is transforming the energy sector. Written at an introductory level, but still appropriate for engineers and other technical readers, this book provides an overview of natural gas as a fuel source, including its origins, properties and composition. Discussions include the production of natural gas from traditional and unconventional sources, the downstream aspects of the natural gas industry. including processing, storage, and transportation, and environmental issues and emission controls strategies. This book presents an ideal resource on the topic for engineers new to natural gas, for advisors and consultants in the natural gas industry, and for technical readers interested in learning more about this clean burning fuel source and how it is shaping the energy industry. Updated to include newer sources like shale gas Includes new discussions on natural gas hydrates and flow assurance Covers environmental issues Contain expanded coverage of liquefied natural gas (LNG)

This process was conceived as a fully regenerative method of Flue Gas Desulfurization, (FGD), by combining two basic reactions which, by themselves, had been known for a long time, but never utilized for FGD. In Reaction No. 1, the sulfur dioxide in the Flue Gas reacts with an aqueous solution of ferric ions, preferably made available by ferric sulfate. The SO/sub 2/ is oxidized to SO/sub 3/, which is absorbed as sulfuric acid in the solution. An equivalent amount of ferric sulfate is reduced to ferrous sulfate. While this reaction, in a flue gas environment comprising only about 0.5 volume percent of SO/sub 2/, proceeds slowly at room temperature, it can be greatly accelerated by heat. The investigations have revealed that the sulfuric acid formed in the scrubbing fluid exerts an inhibitive effect on the rate of the SO/sub 2/ .-->. Fe/sup + + +/ reaction. The inhibition increases with growing H/sub 2/SO/sub 4/ content. This fact was not known before. It is proposed to remove the sulfuric acid from the scrubbing fluid to a separate reservoir, preferably by electrodialysis. The feasibility of such transfer was shown. It is anticipated that the diluted acid thus transferred will be concentrated by evaporation, utilizing the stack gas heat, to produce a commercially useful and shippable acid. In Reaction No. 2, the ferrous sulfate is re-oxidized (regenerated) to ferric sulfate by oxygen, preferably supplied from air. Thus regenerated, the solution can undertake additional oxidation of sulfur dioxide in accordance with Reaction No. 1. By repeated cycling between Reactions No. 1 and No. 2, the process was conceived to be theoretically and practically fully regenerative.

A Report

Cost and Functional Analysis of Large-scale and Proven Plants

A Technological Assessment : Highlights :

Flue Gas Desulphurization Program

Combustion Ash Residue Management

Applying Nanotechnology to the Desulfurization Process in Petroleum Engineering

As the need to control process emissions has increased, so have the number of FGD treatment and control strategies. The effectiveness of these treatments vary greatly, depending the types and levels of the materials, as well as the size of the facility.

Profiles in Flue Gas Desulfurization will help engineers and managers identify the technologies that best fit their plant and/or processes. It's a quick and easy reference to all "tail-end" SO2 control processes currently in commercial use or "on the brink," providing an effective "snapshot" of where this technology stands in industry today. The technologies are divided into waste producing processes, where the end product is a "clean waste," and byproduct processes, where the end product has market value. Each technology profile includes a schematic depicting its major equipment components and arrangement, laid out side-by-side with descriptive text on how the process works, where and how it is currently being utilized, its operational requirements, advantages and limitations for typical applications, and a brief list of principal suppliers.
Contains 4,101 references on FGD [Flue Gas Desulfurization] ... primarily from 1982 through June 1993. Complements the "Flue Gas Desulfurization and Denitrification" bibliography published by the U.S. Dept. of Energy in Jan. 1985. References were located on the Energy, Science and Technology, Pollution Abstracts, and Environmental Bibliography databases. Primarily covers FGD and the use of industrial minerals in the desulfurization process or in by-product utilization and disposal. Emphasizes post-combustion removal of sulfur dioxide through processes such as in-duct injection and wet and dry scrubbing.
Application and Development Trend of Flue Gas Desulfurization (FGD) Process
The Adipic Acid Enhanced Flue Gas Desulfurization Process for Industrial Boilers
Profiles in Flue Gas Desulfurization
Wet Scrubbers