Heat Transfer Fluids For Concentrating Solar Power Systems

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Introduction to Thermal and Fluid Engineering Springer
This book focuses on CFD (Computational Fluid Dynamics) techniques and the recent developments and research works in thermo-mechanics applications. It is devoted to the publication of basic and applied studies broadly related to this area. The chapters present the development of numerical methods, computational techniques, and case studies in the thermo-mechanics applications. They offer the fundamental knowledge for using CFD in real thermo-mechanics applications and complex flow problems through new technical approaches. Also, they discuss the steps in the CFD process and provide benefits and issues when using the CFD analysis in understanding of complicated flow phenomena and its use in the design process. The best practices for reducing errors and uncertainties in CFD analysis are also discussed. The presented case studies and development approaches aim to provide the readers, such as engineers and PhD students, the fundamentals of CFD prior to embarking on any real simulation project. Additionally, engineers supporting or being supported by CFD analysts can benefit from this book. ?

The Potential of Nanoparticle Enhanced Ionic Liquids (Neils) as Advanced Heat Transfer Fluids BoD – Books on Demand
The corrosion behavior of aluminum, copper, and iron in inhibited ethylene glycol-ASTM corrosive water solutions was evaluated in a laboratory loop under isothermal and heat-flux conditions for 1000 h at temperatures between 378 and 413/sup 0/K, in static autoclave tests at 450/sup 0/K for 500 h, and by potentiodynamic polarization measurements at temperatures between 298 and 348/sup 0/K. The effect of time, temperature, and ethylene glycol concentration of the heat-transfer fluid on the extent of inhibitor depletion was determined from analyses of the reserve alkalinity, pH, and inhibitor content of the solutions. The performance of an electrochemical sensor as a monitor of fluid quality was also evaluated. A heat flux of 0.4 to 1.0 kW/m/sup 2/ did not have a significant effect on the corrosion behavior of the various materials at temperatures between 378 and 413/sup 0/K. The corrosion rates of aluminum, copper, and iron in the 50 volume percent inhibited ethylene glycol-corrosive water solution decreased as a function of time during the 1000-h test. At 413/sup 0/K, the corrosion rate of copper was considerably higher than that of iron or aluminum at low flow velocity. Significant degradation of the fluid quality, as indicated by the measurement of the pH, reserve alkalinity, and inhibitor concentrations, occurred after several hundred hours at temperatures of approx. 450/sup 0/K.

Concentrating Solar Thermal Technologies CRC Press
This broad-based book covers the three major areas of Chemical Engineering. Most of the books in the market involve one of the individual areas, namely, Fluid Mechanics, Heat Transfer or Mass Transfer, rather than all the three. This book presents this material in a single source. This avoids the user having to refer to a number of books to obtain information. Most published books covering all the three areas in a single source emphasize theory rather than practical issues. This book is written with emphasis on practice with brief theoretical concepts in the form of questions and answers, not adopting stereo-typed question-answer approach practiced in certain books in the market, bridging the two areas of theory and practice with respect to the core areas of chemical engineering. Most parts of the book are easily understandable by those who are not experts in the field. Fluid Mechanics chapters include basics on non-Newtonian systems which, for instance find importance in polymer and food processing, flow through piping, flow measurement, pumps, mixing technology and fluidization and two phase flow. For example it covers types of pumps and valves, membranes and areas of their use, different equipment commonly used in chemical industry and their merits and drawbacks. Heat Transfer chapters cover the basics involved in conduction, convection and radiation, with emphasis on insulation, heat exchangers, evaporators, condensers, reboilers and fired heaters. Design methods, performance, operational issues and maintenance problems

are highlighted. Topics such as heat pipes, heat pumps, heat tracing, steam traps, refrigeration, cooling of electronic devices, NOx control find place in the book. Mass transfer chapters cover basics such as diffusion, theories, analogies, mass transfer coefficients and mass transfer with chemical reaction, equipment such as tray and packed columns, column internals including structural packings, design, operational and installation issues, drums and separators are discussed in good detail. Absorption, distillation, extraction and leaching with applications and design methods, including emerging practices involving Divided Wall and Petluk column arrangements, multicomponent separations, supercritical solvent extraction find place in the book.

Chemical Engineering Practice KIT Scientific Publishing

Parabolic trough power systems that utilize concentrated solar energy to generate electricity are a proven technology. Industry and laboratory research efforts are now focusing on integration of thermal energy storage as a viable means to enhance dispatchability of concentrated solar energy. One option to significantly reduce costs is to use thermocline storage systems, low-cost filler materials as the primary thermal storage medium, and molten nitrate salts as the direct heat transfer fluid. Prior thermocline evaluations and thermal cycling tests at the Sandia National Laboratories' National Solar Thermal Test Facility identified quartzite rock and silica sand as potential filler materials. An expanded series of isothermal and thermal cycling experiments were planned and implemented to extend those studies in order to demonstrate the durability of these filler materials in molten nitrate salts over a range of operating temperatures for extended timeframes. Upon test completion, careful analyses of filler material samples, as well as the molten salt, were conducted to assess long-term durability and degradation mechanisms in these test conditions. Analysis results demonstrate that the quartzite rock and silica sand appear able to withstand the molten salt environment quite well. No significant deterioration that would impact the performance or operability of a thermocline thermal energy storage system was evident. Therefore, additional studies of the thermocline concept can continue armed with confidence that appropriate filler materials have been identified for the intended application.

Desalination CRC Press

Phenylnaphthalene Derivatives as Heat Transfer Fluids for Concentrating Solar PowerLoop Experiments and Final Report

Processes, Systems and Technologies ScholarlyEditions

This book presents select proceedings of the international conference on Innovations in Clean Energy Technologies (ICET 2020) and examines a range of durable, energy efficient and next-generation smart green technologies for sustainable future by reflecting on the trends, advances and development taking place all across the globe. The topics covered include smart technologies based product, energy efficient systems, solar and wind energy, carbon sequestration, green transportation, green buildings, energy material, biomass energy, smart cites, hydro power, bio-energy and fuel cell. The book also discusses various performance attributes of these clean energy technologies and their workability and carbon footprint. The book will be a valuable reference for beginners, researchers and professionals interested in clean energy technologies.

Thermophysical Properties of Mixed Alkali and Earth Alkaline Nitrate Salts Used as Heat Transfer Fluids for Concentrated Solar Power

Scholar's Choice

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Select Proceedings of ICET 2020 John Wiley & Sons

This document summarizes a workshop on thermal energy storage for concentrating solar power (CSP) that was held in Golden, Colorado, on May 20, 2011. The event was hosted by the U.S. Department of Energy (DOE), the National Renewable Energy Laboratory, and Sandia National Laboratories. The objective was to engage the university and laboratory research communities to identify and define research directions for developing new high-temperature materials and systems that advance thermal energy storage for CSP technologies. This workshop was motivated, in part, by the DOE SunShot Initiative, which sets a very aggressive cost goal for CSP technologies -- a levelized cost of energy of 6 cents per kilowatt-hour by 2020 with no incentives or credits.

New Concepts and Materials for Thermal Energy Storage and Heat-transfer Fluids, May 20, 2011 CRC Press

Alkenes—Advances in Research and Application: 2013 Edition is a ScholarlyBrief™ that delivers timely, authoritative, comprehensive, and specialized information about ZZZAdditional Research in a concise format. The editors have built Alkenes—Advances in Research and Application: 2013 Edition on the vast information databases of ScholarlyNews.™ You can expect the information about ZZZAdditional Research in this book to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Alkenes—Advances in Research and Application: 2013 Edition has been produced by the world ' s leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at http://www.ScholarlyEditions.com/.

A Device for Measuring Thermal Conductivity of Molten Salt Nitrates at Elevated Temperatures for Use in Solar Thermal Power Applications

LAP Lambert Academic Publishing

Binary and Ternary mixtures of Molten Salt Nitrates are ideal candidates for future concentrating solar power (CSP) plant heat transfer fluids (HTFs) because of their high operating temperature limits resulting in greater Rankine efficiency. The inclusion of these HTFs into CSP plants is expected to revolutionize the industry by allowing for energy and cost savings that are attractive to potential plant developers and investors. It is vital for plant designers to have access to fully characterized thermo-physical properties of the intended HTFs, with thermal conductivity, viscosity, and specific heat capacity being the most crucial. Existing literature has not fully elucidated the thermo-physical properties of binary and ternary molten salt nitrates through their operating temperature range. This work presents the viscosity of eutectic ternary and binary compositions of molten alkali salt nitrates (Li-NO3, K-NO3, and Na-NO3) up to 550 ° C. A device to measure the thermal conductivity of these salts with accuracy at elevated temperatures was designed and built as no commercial offerings are able to withstand the corrosive nature of molten salt at high temperatures. The device is shown to accurately measure the thermal conductivity of water at room temperature. The present work is a step towards fully characterizing the thermo-physical properties of the aforementioned molten salts.

Effects of Particle Concentration and Surfactant Use in Convective Heat Transfer of CuO Nanofluids in Microchannel Flow Woodhead Publishing

Solar Hydrogen Production: Processes, Systems and Technologies presents the most recent developments in solar-driven hydrogen generation methods. The book covers different hydrogen production routes, from renewable sources, to solar harvesting technologies. Sections focus on solar energy, presenting the main thermal and electrical technologies suitable for possible integration into solar-based hydrogen production systems and present a thorough examination of solar hydrogen technologies, ranging from solar-driven water electrolysis and solar thermal methods, to photo-catalytic and biological processes. All hydrogen-based technologies are covered, including data regarding the state-of-the art of each process in terms of costs, efficiency, measured parameters, experimental analyses, and demonstration projects. In the last part of the book, the role of hydrogen in the integration of renewable sources in electric grids, transportation sector, and end-user applications is assessed, considering their current status and future perspectives. The book includes performance data, tables, models and references to available standards. It is thus a key-resource for engineering researchers and scientists, in both academic and industrial contexts, involved in designing, planning and developing solar hydrogen systems. Offers a comprehensive overview of conventional and advanced solar hydrogen technologies, including simulation models, cost figures, R&D projects, demonstration projects, test standards, and safety and handling issues Encompasses, in a single volume, information on solar energy and hydrogen systems Includes detailed economic data on each technology for feasibility assessment of different systems

Using Encapsulated Phase Change Material in Thermal Energy Storage for Baseload Concentrating Solar Power (EPCM-TES). Woodhead Publishing

After decades of research and development, concentrating solar thermal (CST) power plants (also known as concentrating solar power (CSP) and as Solar Thermal Electricity or STE systems) are now starting to be widely commercialized. Indeed, the IEA predicts that by 2050, with sufficient support over ten percent of global electricity could be produced by concentrating solar thermal power plants. However, CSP plants are just but one of the many possible applications of CST systems. Advances in Concentrating Solar Thermal Research and Technology provides detailed information on the latest advances in CST systems research and technology. It promotes a deep understanding of the challenges the different CST technologies are confronted with, of the research that is taking place worldwide to address those challenges, and of the impact that the innovation that this research is fostering could have on the emergence of new CST components and concepts. It is anticipated that these developments will substantially increase the cost-competeveness of commercial CST solutions and reshape the technological landscape of both CST technologies and the CST industry. After an introductory chapter, the next three parts of the book focus on key CST plant components, from mirrors and receivers to thermal storage. The final two parts of the book address operation and control and innovative CST system concepts. Contains authoritative reviews of CST research taking place around the world Discusses the impact this research is fostering on the emergence of new CST components and concepts that will substantially increase the cost-competitiveness of CST power Covers both major CST plant components and system-wide issues

Advances in Clean Energy Technologies Phenylnaphthalene Derivatives as Heat Transfer Fluids for Concentrating Solar PowerLoop Experiments and Final ReportORNL and subcontractor Cool Energy completed an investigation of higher-temperature, organic thermal fluids for solar thermal applications. Although static thermal tests showed promising results for 1-phenylnaphthalene, loop testing at temperatures to 450 C showed that the material isomerized at a slow rate. In a loop with a temperature high enough to drive the isomerization, the higher melting point byproducts tended to condense onto cooler surfaces. So, as experienced in loop operation, eventually the internal channels of cooler components such as the waste heat rejection exchanger may become coated or clogged and loop performance will decrease. Thus, pure 1-phenylnaphthalene does not appear to be a fluid that would have a sufficiently long lifetime (years to decades) to be used in a loop at the increased temperatures of interest. Hence a decision was made not to test the ORNL fluid in the loop at Cool Energy Inc. Instead, Cool Energy tested and modeled power conversion from a moderate-temperature solar loop using coupled Stirling engines. Cool Energy analyzed data collected on third and fourth generation SolarHeart Stirling engines operating on a rooftop solar field with a lower temperature (Marlotherm) heat transfer fluid. The operating efficiencies of the Stirling engines were determined at multiple, typical solar conditions, based on data from actual cycle operation. Results highlighted the advantages of inherent thermal energy storage in the power conversion system.Concentrating Solar Thermal TechnologiesAnalysis and Optimisation by CFD Modelling

This book addresses the evaluation and optimization of key elements in concentrating solar thermal (CST) technologies, such as solar receivers and working fluids, using computational fluid dynamics (CFD) modeling. It discusses both general and specific aspects, explaining the methodology used to analyze and evaluate the influence of different parameters on the facility performance. This information provides the basis for optimizing design and operating conditions in CST systems.

Measurement of Thermal Conductivity of Liquids at Elevated Temperatures Academic Press

Nanofluids are solid-liquid composite material consisting of solid nanoparticles suspended in liquid with enhanced thermal properties. This book introduces basic fluid mechanics, conduction and convection in fluids, along with nanomaterials for nanofluids, property characterization, and outline applications of nanofluids in solar technology, machining and other special applications. Recent experiments on nanofluids have indicated significant increase in thermal conductivity compared with liquids without nanoparticles or larger particles, strong temperature dependence of thermal conductivity, and significant increase in critical heat flux in boiling heat transfer, all of which are covered in the book. Key Features Exclusive title focusing on niche engineering applications of nanofluids Contains high technical content especially in the areas of magnetic nanofluids and dilute oxide based nanofluids Feature examples from research applications such as solar technology and heat pipes Addresses heat transfer and thermodynamic features such as efficiency and work with mathematical rigor Focused in content with precise technical definitions and treatment

CFD Techniques and Thermo-Mechanics Applications Academic Press

Heat transfer enhancement has seen rapid development and widespread use in both conventional and emerging technologies. Improvement of heat transfer fluids requires a balance between experimental and numerical work in nanofluids and new refrigerants. Recognizing the uncertainties in development of new heat transfer fluids, Advances in New Heat Transfer Fluids: From Numerical to Experimental Techniques contains both theoretical and practical coverage.

SolarPACES CRC Press

Binary and ternary mixtures of molten salt nitrates (LiNO3 -NaNO3 and KNO3) are ideal candidates as large scale phase change thermal energy storage materials and as heat transfer fluids for concentrating solar power systems. They have higher specific heat capacities and wider operating temperature ranges (150-600 C) compared to the silicon based oils which are currently used in parabolic trough type plants. For design considerations related to power plant and equipment, it is critically important to know the thermo-physical properties of molten salt nitrates; as thermal conductivity being one of the most important. In this regard, the measurements of thermal conductivity of molten salt nitrates are of interest in the present study."

Policy, Materials and Devices Springer

Thermal Energy Storage Analyses and Designs considers the significance of thermal energy storage systems over other systems designed to handle large quantities of energy, comparing storage technologies and emphasizing the importance, advantages, practicalities, and operation of thermal energy storage for large quantities of energy production. Including chapters on thermal storage system configuration, operation, and delivery processes, in particular the flow distribution, flow arrangement, and control for the thermal charge and discharge processes for single or multiple thermal storage containers, the book is a useful reference for engineers who design, install, or maintain storage systems. Includes computer code for thermal storage analysis, including code flow charts Contains a database of material properties relevant to storage Provides example cases of input and output data for the code

From Numerical to Experimental Techniques CRC Press

Terrafore successfully demonstrated and optimized the manufacturing of capsules containing phase-changing inorganic salts. The phase change was used to store thermal energy collected from a concentrating solar-power plant as latent heat. This latent heat, in addition to sensible heat increased the energy density (energy stored per unit weight of salt) by over 50%, thus requiring 40% less salt and over 60% less capsule container. Therefore, the cost to store high-temperature thermal energy collected in a concentrating solar power plant will be reduced by almost 40% or more, as compared to conventional two-tank, sensible-only storage systems. The cost for thermal energy storage (TES) system is expected to achieve the Sun Shot goal of $15 per kWh(t). Costs associated with poor heat-transfer in phase change materials (PCM) were also eliminated. Although thermal energy storage that relies on the latent heat of fusion of PCM improves energy density by as much as 50%, upon energy discharge the salt freezes and builds on the heat transfer surfaces. Since these salts have low thermal conductivity, large heat-transfer areas, or larger conventional heat-exchangers are needed, which increases costs. By encapsulating PCM in small capsules we have increased the heat transfer area per unit volume of salt and brought the heat transfer fluid in direct contact with the capsules. These two improvements have increased the heat transfer coefficient and boosted heat transfer. The program was successful in overcoming the phenomenon of melt expansion in the capsules, which requires the creation of open volume in the capsules or shell to allow for expansion of the molten salt on melting and is heated above its melting point to 550 ° C. Under contract with the Department of Energy, Terrafore Inc. and Southwest Research Institute, developed innovative method(s) to economically create the open volume or void in the capsule. One method consists of using a sacrificial polymer coating as the middle layer between the salt prill and the shell material. The selected polymer decomposes at temperatures below the melting point of the salt and forms gases which escape through the pores in the capsule shell thus leaving a void in the capsule. We have demonstrated the process with a commonly used inorganic nitrate salt in a low-cost shell material that can withstand over 10,000 high-temperature thermal cycles, or a thirty-year or greater life in a solar plant. The shell used to encapsulate the salt was demonstrated to be compatible with molten salt heat transfer fluid typically used in CSP plants to temperatures up to 600 ° C. The above findings have led to the concept of a cascaded arrangement. Salts with different melting points can be encapsulated using the same recipe and contained in a packed bed by cascading the salt melting at higher melting point at the top over the salt melting at lower melting point towards the bottom of the tank. This cascaded energy storage is required to effectively transfer the sensible heat collected in heat transfer fluids between the operating temperatures and utilize the latent heat of fusion in the salts inside the capsule. Mathematical models indicate that over 90% of the salts will undergo phase change by using three salts in equal proportion. The salts are selected such that the salt at the top of the tank melts at about 15 ° C below the high operating-temperature, and the salt at the bottom of the tank melts 15 ° C above the low operating-temperature. The salt in the middle of tank melts in-between the operating temperature of the heat transfer fluid. A cascaded arrangement leads to the capture of 90% of the latent-heat of fusion of salts and their sensible heats. Thus the energy density is increased by over 50% from a sensible-only, two-tank thermal energy storage. Furthermore, the Terrafore cascaded storage method requires only one tank as opposed to the two-tanks used in sensible heat storage. Since heat is transferred from the ...

Advances in New Heat Transfer Fluids Academic Press

Heat transfer enhancement has seen rapid development and widespread use in both conventional and emerging technologies. Improvement of heat transfer fluids requires a balance between experimental and numerical work in nanofluids and new refrigerants. Recognizing the uncertainties in development of new heat transfer fluids, Advances in New Heat Transfer Fluids: From Numerical to Experimental Techniques contains both theoretical and practical coverage.

Thermal Systems Process and Components Laboratory (Fact Sheet). Springer Nature

ORNL and subcontractor Cool Energy completed an investigation of higher-temperature, organic thermal fluids for solar thermal applications. Although static thermal tests showed promising results for 1-phenylnaphthalene, loop testing at temperatures to 450 C showed that the material isomerized at a slow rate. In a loop with a temperature high enough to drive the isomerization, the higher melting point byproducts tended to condense onto cooler surfaces. So, as experienced in loop operation, eventually the internal channels of cooler components such as the waste heat rejection exchanger may become coated or clogged and loop performance will decrease. Thus, pure 1-phenylnaphthalene does not appear to be a fluid that would have a sufficiently long lifetime (years to decades) to be used in a loop at the increased temperatures of interest. Hence a decision was made not to test the ORNL fluid in the loop at Cool Energy Inc. Instead, Cool Energy tested and modeled power conversion from a moderate-temperature solar loop using coupled Stirling engines. Cool Energy analyzed data collected on third and fourth generation SolarHeart Stirling engines operating on a rooftop solar field with a lower temperature (Marlotherm) heat transfer fluid. The operating efficiencies of the Stirling engines were determined at multiple, typical solar conditions, based on data from actual cycle operation. Results highlighted the advantages of inherent thermal energy storage in the power conversion system.