

Review

Review of Developments in Plate Heat Exchanger Heat Transfer Enhancement for Single-Phase Applications in Process Industries

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Abstract: A plate heat exchanger (PHE) is a modern, effective type of heat transfer equipment capable of increasing heat recuperation and energy efficiency. For PHEs, enhanced methods of heat transfer intensification can be further applied using the analysis and knowledge already available in the literature. A review of the main developments in the construction and exploration of PHEs and in the methods of heat transfer intensification is presented in this paper with an analysis of the main construction modifications, such as plate-and-frame, brazed and welded PHEs. The differences between these construction modifications and their influences on the thermal and hydraulic performance of PHEs are discussed. Most modern PHEs have plates with inclined corrugations on their surface that create a strong, rigid construction with multiple contact points between the plates. The methods of PHE exploration are mostly experimental studies and/or CFD modelling. The main corrugation parameters influencing PHE performance are the corrugation inclination angle in relation to the main flow direction and the corrugation aspect ratio. Optimisation of these parameters is one way to enhance PHE performance. Other methods of heat transfer enhancement, including improving the form of the plate corrugations, use of nanofluids and active methods, are considered. Future research directions are proposed, such as improving fundamental understanding, developing new corrugation shapes and optimisation methods and area and cost estimations.

Keywords: plate heat exchanger; heat transfer; pressure drop; energy efficiency; heat recuperation



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1. Introduction

To satisfy the needs of the increasing population on our planet in terms of energy and rising standards of individual comfort, a steady increase in energy demand is inevitable. Even with the contemporary trend for the use of renewable energy sources, the main proportion of energy is generated from the combustion of fossil fuels. With this, significant volumes of greenhouse gases (GHGs) are generated. About 6 Gt CO₂ equivalent was generated during the year 2020 in the United States based on data from the US Environmental Protection Agency [1]. Of that amount, 89.0% was due to fossil fuel combustion in various sectors. The European Environmental Agency [2] reported a similar picture, with 77% of GHG generation in the energy sector and 9% added by the contribution of the industry. To mitigate GHG generation, the plans in the EU include a requirement to enhance the efficiency of energy usage by 32.5% by the year 2030 [2]. One of the measures enabling the fulfilment of these plans is improved recuperation of heat energy, which is possible with the wider use of efficient, compact heat exchangers in which modern methods of heat transfer intensification are implemented [3].

Modern Developments In Heat Transfer

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Modern Developments in Heat Transfer Warren E. Ibele, 1963 **Modern Developments in Heat Transfer** Warren Ibele, 2012-12-02 Modern Developments in Heat Transfer provides information pertinent to heat transfer investigation including convective heat transfer radiation heat transfer as well as heat and mass transfer This book examines the aspects and properties of high temperature heat transfer Organized into 14 chapters this book starts with an overview of noncircular duct heat transfer in a wide range of engineering applications from automobile radiators to nuclear power plants This text then examines the differences between circular and noncircular duct flows Other chapters describe energy transport by radiation wherein photons as energy carriers are released from molecules of the radiating body and travel on straight lines until they are scattered or absorbed by other atoms or molecules This book discusses as well the process of evaporation which results in the conversion of a liquid into a vapor The final chapter deals with plasma dynamics and its features Physicists chemists mathematicians and engineers will find this book extremely useful **Modern Developments in Heat Transfer** Massachusetts Institute of Technology, 1960* **Advances in Heat Transfer** , 1968 Advances in Heat Transfer

Combustion Technology: Some Modern Developments Howard Palmer, 2012-12-02 Combustion Technology Some Modern Developments reviews modern developments in combustion technology with emphasis on furnace flames Topics covered range from equilibria and chemical kinetics in flames to corrosion and deposits in combustion systems along with combustion aerodynamics and noise Heat transfer from non luminous flames in furnaces is also investigated Comprised of 15 chapters this book begins with an overview of some aspects of the chemistry of flames followed by a discussion on the problem of corrosion and deposits Subsequent chapters focus on aerodynamics and heat transfer in combustors together with combustion noise and the application of aerodynamic principles to flame stabilization in high speed flow radiative heat transfer in combustion chambers electrical properties of flames flame field interactions and their practical applications generation of electricity by magnetohydrodynamic methods and practical aspects of magnetohydrodynamic power generation The book also assesses the influence of stirred reactor theory on design principles for high performance combustion chambers and concludes with a summary of developments in the design and utilization of oil burners This monograph should be of interest to engineers and combustion technologists MODERN DEVELOPMENTS IN HEAT TRANSFER. WE Ibele (Ed), 1963 Recent Developments in Aerodynamics Arash Shams Taleghani, Farschad Torabi , Mohammad Mehdi Rashidi, 2025-01-24 Aerodynamics is a branch of fluid mechanics that deals with the motion of air and other gaseous fluids and the forces acting on bodies in motion relative to such fluids Aerodynamics are classified according to Mach number into incompressible subsonic compressible subsonic transonic supersonic and hypersonic aerodynamics Aerodynamics can be divided into different forms of internal or external aerodynamics For example the study of flow properties inside a gas turbine or rocket engine is an example of internal aerodynamics that is important in accurately estimating thrust force

Examples of external aerodynamics include the flow around the body of airplanes helicopters space capsules cars rockets and missiles trains ships wind turbines and even such structures as bridges and tall buildings which often have to withstand strong winds Since the first human flights until today aerodynamics has been growing and developing rapidly Aerodynamics is one of the applied sciences in engineering that pursues several goals such as estimating forces moments on objects moving in the air or estimating heat transfer from these objects Aerodynamics investigates how gases interact with moving bodies The main purpose of aerodynamics in most cases is to reduce drag forces and increase lift force which can lead to less fuel consumption in vehicles and achieving the greatest speed Of course in some special cases such as hypersonic aerodynamics there is a greater interest in increasing drag to reduce the adverse effects of aerodynamic heating Another goal of studying aerodynamics is to obtain the details of the flow around flying objects For example the correct operation of a control rudder or flap in a supersonic aircraft or the recognition of the phenomenon of blackout during spacecraft reentry which occurs under the influence of aerothermodynamic heating and plasma formed around the antenna is of great importance

Modern Developments in Energy, Combustion and Spectroscopy F.A. Williams,A.K. Oppenheim,D.B. Olfe,M.

Lapp,2013-10-22 This compendium of technical articles is dedicated to Professor Stanford Solomon Penner on the occasion of his 70th birthday As one of the most prominent scientists of our times he has been particularly instrumental in advancing the field of combustion science while simultaneously he has developed quantitative spectroscopy into an important engineering discipline and is also a leading international expert on energy issues Written primarily by researchers who were Professor Penner s doctorate students during the last four decades the articles consist of original contributions as well as previously published papers that provide important insights into combustion spectroscopy and energy problems Among the topics included are turbulent combustion flame structure detonations spectroscopic diagnostics spectroscopy of atmospheric gases and physical problems associated with nuclear reactors as well as electric power distribution and energy conversion The book includes a short biography of Professor Penner and a complete bibliography of his publications

Modern Developments in Fluid Dynamics Sydney Goldstein,1965 **Notes for Special Summer Program in Modern**

Developments in Heat Transfer Massachusetts Institute of Technology. Special Summer Program in Modern

Developments in Heat Transfer, 1962,1962 *Advances in New Heat Transfer Fluids* Alina Adriana Minea,2017-03-16 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 **New Developments in**

Computational Fluid Dynamics Kozo Fujii,Kazuhiro Nakahashi,Shigeru Obayashi,Satoko Komurasaki,2006-01-05 Contains 20 papers presented at the Sixth International Nobeyama Workshop on the New Century of Computational Fluid Dynamics

Nobeyama Japan April 21 24 2003 These papers cover computational electromagnetics astrophysical topics CFD research and applications in general large eddy simulation mesh generation topics visualization and more

Recent developments in ocean thermal energy. ,1980 **Recent Developments in Automotive Safety Technology** Daniel J Holt,2004-09-23 Automotive engineers have been working to improve vehicle safety ever since the first car rolled down some pathway well over 100 years ago Today there are many new technologies being developed that will improve the safety of future vehicles Featuring the 69 best safety related SAE technical papers of 2003 this book provides the most comprehensive information available on current and emerging developments in automotive safety It gives readers a feel for the direction engineers are taking to reduce deaths and injuries of vehicle occupants as well as pedestrians All of the papers selected for this book meet the criteria for inclusion in SAE Transactions the definitive collection of the year's best technical research in automotive engineering technology

Recent Developments in Ocean Thermal Energy United States. Congress. Office of Technology Assessment,1980 **A Review of Some Recent Developments in Hypersonic Flow** Antonio Ferri,1958 *Recent Developments in Turbulence Management* K.-S. Choi,2012-12-06 The European Drag Reduction Meeting has been held on 15th and 16th November 1990 in London This was the fifth of the annual European meetings on drag reduction in engineering flows The main objective of this meeting was to discuss up to date results of drag reduction research carried out in Europe The organiser has adopted the philosophy of discussing the yesterday's results rather than the last year's results No written material has therefore been requested for the meeting It was only after the meeting the submission of papers was requested to the participants from which 16 papers were selected for this proceedings volume The meeting has attracted a record number of participants with a total of 52 researchers from seven European countries U K France Germany the Netherlands Italy Switzerland and U S S R as well as from Japan Canada and Australia The subjects covered in this proceedings volume include riblets LEBUs Large Eddy Break Up device surface roughness compliant surfaces and polymer additives Riblets seem to be one of the most extensively studied devices in the past years Reflecting this situation in the European community there are six papers on riblets covering their practical applications to aircraft and to a model ship near wall coherent structure of the boundary layer and effects of flow three dimensionality Possibility of heat transfer enhancement with riblets and potential use in the laminar flow are also investigated An analytical model is developed for the boundary layer with a LEBU device

Transport Phenomena In Thermal Control Guang-Jyh Hwang,1989-08-01 A collection of research papers into transport phenomena in thermal control closely related to several important aspects of cooling technology Articles provide overviews of current advances and details of individual technologies including electronic and turbine cooling and Marangoni convection

Cryogenic Heat Transfer Randall F. Barron,Gregory F. Nellis,2017-12-19 Cryogenic Heat Transfer Second Edition continues to address specific heat transfer problems that occur in the cryogenic temperature range where there are distinct differences from conventional heat transfer problems This updated

version examines the use of computer aided design in cryogenic engineering and emphasizes commonly used computer programs to address modern cryogenic heat transfer problems It introduces additional topics in cryogenic heat transfer that include latent heat expressions lumped capacity transient heat transfer thermal stresses Laplace transform solutions oscillating flow heat transfer and computer aided heat exchanger design It also includes new examples and homework problems throughout the book and provides ample references for further study New in the Second Edition Expands on thermal properties at cryogenic temperatures to include latent heats and superfluid helium Develops the material on conduction heat transfer and divides it into four separate chapters to facilitate understanding of the separate features and computational techniques in conduction heat transfer Introduces EES Engineering Equation Solver a computer aided design tool and other computer applications such as Maple Describes special features of heat transfer at cryogenic temperatures such as analysis with variable thermal properties heat transfer in the near critical region Kapitza conductance and network analysis for free molecular heat transfer Includes design procedures for cryogenic heat exchangers Cryogenic Heat Transfer Second Edition discusses the unique problems surrounding conduction heat transfer at cryogenic temperatures This second edition incorporates various computational software methods and provides expanded and updated topics concepts and applications throughout The book is designed as a textbook for students interested in thermal problems occurring at cryogenic temperatures and also serves as reference on heat transfer material for practicing cryogenic engineers

Thermal Radiation Heat Transfer, Fourth Edition Robert Siegel, 2001-12-07 This extensively revised 4th edition provides an up to date comprehensive single source of information on the important subjects in engineering radiative heat transfer It presents the subject in a progressive manner that is excellent for classroom use or self study and also provides an annotated reference to literature and research in the field The foundations and methods for treating radiative heat transfer are developed in detail and the methods are demonstrated and clarified by solving example problems The examples are especially helpful for self study The treatment of spectral band properties of gases has been made current and the methods are described in detail and illustrated with examples The combination of radiation with conduction and or convection has been given more emphasis nad has been merged with results for radiation alone that serve as a limiting case this increases practicality for energy transfer in translucent solids and fluids A comprehensive catalog of configuration factors on the CD that is included with each book provides over 290 factors in algebraic or graphical form Homework problems with answers are given in each chapter and a detailed and carefully worked solution manual is available for instructors

Reviewing **Modern Developments In Heat Transfer**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is really astonishing. Within the pages of "**Modern Developments In Heat Transfer**," an enthralling opus penned by a very acclaimed wordsmith, readers attempt an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve into the book's central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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