ADVANCES IN NEW HEAT TRANSFER FLUIDS

From Numerical to Experimental Techniques

Edited by

Alina Adriana Minea

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ADVANCES IN NEW HEAT TRANSFER FLUIDS

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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.

FEATURES

- Explores new heat transfer fluids for high temperatures (salts)
- Examines the thermophysical characteristics of new heat transfer fluids
- Outlines the numerical and experimental approaches for new fluids
- Includes contributed chapters from leading researchers in the field

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Advances in New Heat Transfer Fluids

From Numerical to Experimental Techniques

Preface

This book is intended primarily as a bridge between academics in universities, scientists from research institutes, and practitioners from industry and aims at helping researchers to deal with the basic principles of industrial heat transfer enhancement. It also introduces enhancement techniques based on new heat transfer fluid development and how they work. This work is intended to present information to you in an interesting way and includes many different types of information such as texts, pictures, graphs, and definitions.

The chapters are written by the world's renowned and recognized experts in their fields and serve as a reference and guide for future research.

The topics covered in the book can be divided into five themes:

1. Experimental and numerical techniques for heat transfer enhancement with nanofluid implementation
2. Hybrid nanofluid studies
3. Liquid metals as heat transfer fluids
4. Molten salt–based nanofluids
5. Refrigerants

Ultrahigh-performance cooling is one of the most vital needs of many industrial technologies. However, inherently low thermal conductivity is a primary limitation in developing energy-efficient heat transfer fluids that are required for ultrahigh-performance cooling.

Modern nanotechnology can produce different particles (metallic or nonmetallic, carbon-based, silicon-based particles) of nanometer dimensions. Nanomaterials have unique mechanical, optical, electrical, magnetic, and thermal properties. Nanofluids are engineered by suspending nanoparticles with average sizes below 100 nm in traditional heat transfer fluids such as water, oil, and ethylene glycol. A very small amount of guest nanoparticles, when dispersed uniformly and suspended stably in host fluids, can provide dramatic improvements in the thermal properties of host fluids. "Nanofluids" (nanoparticle fluid suspensions) is the term coined by Choi (1995) to describe this new class of nanotechnology-based heat transfer fluids that exhibit thermal properties superior to those of their host fluids or conventional particle fluid suspensions.

Nanofluid technology has to be seen as a new interdisciplinary field of great importance where nanoscience, nanotechnology, and thermal engineering meet. This new technology, even if its roots are about 20 years old, is still at its infancy since the nanofluid technology readiness level is lower than 3. Anyway, a large debate exists in the literature based on thermophysical properties of nanofluids, method of approach, and validity of applications in terms of pumping power.

Since Choi conceived the novel concept of nanofluids in the spring of 1993, the research topic of nanofluids has been receiving increased attention worldwide. The recent growth of work in this rapidly emerging area of nanofluids is most evident from the exponentially increasing number of publications.

As for refrigerants, the number of substances suitable for use as refrigerants by virtue of their thermodynamic properties is relatively limited. When those synthetic substances that are toxic and flammable or have the potential to damage the ozone layer are removed, very few remain. Industry's response to lack of pure substances that can serve as nontoxic, nonflammable, zero-ozone-depleting refrigerants has been to blend the few available substances, sometimes with the addition of hydrocarbons. The dominant requirement for nontoxic hydrofluorocarbon refrigerants is that they should be efficient in operation. It is also important, but not essential, that they should be nonflammable.

The decision to write a book on new heat transfer fluids was bold but also had its problems. First, with the variety of aspects of these new fluid researches driving in every day, it was difficult to find a unified approach. Also, there was difficulty in determining the prerequisites for each chapter, due to the highly interdisciplinary nature of all new fluids (i.e., nanofluids, refrigerants, liquid metals). After considerable deliberation among authors located around the globe, it was decided that the book should be written for researchers in all areas of science and technology, without prerequisites.

With the continuously increasing archive of research articles on new heat transfer fluids, it is difficult to present a book that includes all the important research works. Although every effort has been made to include the available literature, we had to limit ourselves to journal publications as authentic research works, and basically latest publications have been included.

Anyway, the best judge of any book is the reader. If the present text can draw a few new ideas toward a better technology with new heat transfer fluids, the authors will consider their efforts to be well rewarded.

This book is written by researches from academic areas and research institutes together with industry applicants, and its specific features are the following:

- The chapters serve as a reference and guide for future research.
- The book is easy to understand, due to the editor and authors' experience in writing textbooks.
- The book contains some industrial application, that goes to a better phenomenon understanding.
- The book represents a more complete approach—from nanofluid use to hybrid nanofluids, molten salts, and liquid metals to refrigerants.
- The wide range of numerical, analytical, and experimental methods described to solve practical problems makes this volume a valuable asset to practicing engineers.

The editor thanks all the contributors for their patience, help, and availability during the long period for manuscript production and processing. This work has been developed with the help and dedication of participants of the COST Action CA15119 Overcoming Barriers to Nanofluids Market Uptake (NANOUPTAKE). Also, it is a pleasure to acknowledge the assistance of the staff at Taylor & Francis Group in the production of the text and to express my gratitude to CRC Press for publishing this book.

Alina Adriana Minea

REFERENCE

Stephen U. S. Choi, 1995. The Energy Technology Division, Argonne National Laboratory, USA.

Editor

Alina Adriana Minea's major field of research is heat and mass transfer. She published more than 120 articles (45 are in international peer-reviewed journals) and authored or coauthored 21 books, most of them in heat transfer area. Her current interests are in heat transfer in industrial equipment, based on modifying heat chamber geometry and improving energy consumption. Dr. Minea is a member in EuMat international organization, as well as in AGIR national society, and ASME. She received many awards for one of her patents: "Procedure for Heat transfer efficiency in classical electrical furnaces used for medium temperature heat treatment."

Now she is a full professor at Technical University "Gheorghe Asachi" Iaşi, one of the greatest universities in Romania, and owns habilitation in the area of materials engineering. Her professional activity is based on teaching and research. As a reviewer, she participated in peer review for many international journals and conferences, as well as for national grants and study programs. As a researcher, she has 4 national grants awarded as principal investigator and more than 15 as team member and is a member of the Management Committee for COST action Overcoming Barriers to Nanofluids Market Uptake (NANOUPTAKE). She is currently a member of many editorial advisory boards and performs evaluation on Horizon 2020 projects.

She received the Dr. habil. title in 2013 with a thesis on "Heat transfer enhancement for reducing energy consumptions." Her current research interests are in heat transfer for industrial equipments and nanofluids for heat transfer enhancement techniques. She is currently a member of the regional board of editors of the *Journal of Thermal Science* and a member of the editorial board at MEHTA Press for the *Journal of Engineering*.

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