Preface

A number of technological processes and natural phenomena are accompanied by heat transfer concerned with media thermal radiation. Generally, thermal radiation is thought to be relevant only at high temperatures. This widespread error is easily overcome if we recall, for example, that the weather and climate on our planet are mainly determined by thermal radiation of cloudy atmosphere and the Earth surface. Few people are aware that the quality of an ordinary sleeping-bag is connected with changing of radiation transfer conditions in a fibrous material.

In the examples mentioned, as well as in many other cases, thermal radiation emission, absorption, and scattering take place in a medium containing numerous particles of size comparable with the radiation wavelength. Such media are customary called the disperse systems. One has to solve radiation heat transfer problems for disperse systems in highly different applications such as heat transfer in solid propellant rocket engines and solar chemical reactors, characterization of advanced composite coatings and highly porous thermal insulations, microwave remote sensing of the ocean surface with breaking waves, and spacecraft thermal control by use of a liquid droplet radiator. The geometrical scales of particles, bubbles, and pores in the above mentioned thermal radiation problems and in many other problems may vary in a very wide range — from nanometers in some advanced materials to several millimeters or even greater in the microwave applications. As a result, both the experimental technique and theoretical modeling should be based on a general physical analysis of electromagnetic waves interaction with single particles and adequate description of the radiation propagation in complex disperse systems. It goes without saying that direct simulation of the radiation emission, absorption, and scattering based on the first principles is impractical at the moment and one should find alternative engineering approaches by using the known solutions to some simplified problems. Of course, a correct choice or elaboration of an approximate model which is appropriate to the problem to be solved depends on personal skill and experience of a researcher in this field. In our book, we were trying to do our best to help our young colleagues in improving their knowledge and qualification in thermal radiation problems specific for various disperse systems.

One should remember the usual error of some people who are starting to work in heat transfer modeling. They think that all the problems can be solved by more and more computational skill in combination with great possibilities of the present-day supercomputers. We have several arguments which show that this ambitious point of view is not correct:

- In many problems, radiative heat transfer is not a sole transfer mode and it should be considered simultaneously with the conduction and convective heat transfer. The complex hydrodynamic processes and phase change in the medium components makes a rigorous mathematical statement of such transient combined problems too complicated for the direct numerical simulation.
The spectral radiative properties of substances are not well-known especially at very low or high temperatures as well as in the regions of extreme values of other physical parameters. The uncertainties in these properties limit the resulting accuracy of the radiation field calculations and make the use of detailed numerical simulation to be not so important.

To our mind, the understanding of physics and the use of relatively simple theoretical models are very important components of the engineering approach to experimental and computational study of thermal radiation in disperse systems.

The known textbooks on thermal radiation are not focused on detailed analysis of radiative properties of various disperse systems and do not give practical examples of solving the radiative and combined heat transfer problems. In this book, we were trying to bridge a gap between the ordinary university education and the research and engineering work. The contents of the book is determined by research and teaching experience by the authors in this field. To make reading easier, we avoid detailed derivations and give the minimal mathematical transformations. All these details can be found in the referenced archive papers.

Of course, the analysis of some problems considered in the book is not so detailed. A reader could find these sections as a kind of starting points which still await his or her further research contributions. But we hope that our efforts were sufficient to pave the way for engineers and researchers in the field of thermal radiation and combined heat transfer in disperse systems. By including a large number of references for further reading, the book may also be used as a reference book by the practicing engineer.

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