S. G. Il'yasov and V. V. Krasnikov

METHODS OF DETERMINING THE OPTICAL AND THE HEAT-RADIATION CHARACTERISTICS OF FOOD PRODUCTS*

Reviewed by L. S. Slobodkin and Yu. M. Sotnikov-Yuzhik

The monograph by S. G. Il'yasov and V. V. Krasnikov deals with the urgent problem of determining the optical and heat-radiation characteristics of materials which are involved in radiative heat transfer. Although food products were the main object of the study, it can be said that the methods and the test procedures proposed by the authors for determining the optical and the heat-radiation characteristics are applicable to any engineering materials with a heterogeneous structure – so far as the propagation of electromagnetic waves in the conventional near and intermediate infrared ranges through such materials is concerned.

The heat-radiation and the optical spectral characteristics of diverse engineering and structural materials are needed for more accurate calculations of radiative heat transfer. Such studies have become especially significant lately in view of the developments in space and rocket technology, where the thermal state of a craft under vacuum conditions, for example, is wholly determined by processes of radiative heat transfer. However, in the technical literature there is little available on methods of determining the spectral radiation characteristics of various materials in the thermal range. For this reason, the publication of the monograph reviewed here fills a long felt need.

The book consists of four chapters. In Chap. 1 are described the physical models of the study object, namely of food products, from the standpoint of radiative heat transfer in them. It also contains a few very useful tables where all types of optical and heat-radiation characteristics are classified and interrelated through analytical expressions.

In Chap. 2 are discussed the theoretical aspects of the method of determining the optical and the heat-radiation characteristics of food products which selectively absorb and disperse radiant energy. The two-flux approximation in the theory of radiative transfer is further developed here. The authors propose original experimental–analytical methods for determining the spectral coefficients of effective attenuation. With the aid of the analytical expressions derived here, it is possible to calculate these coefficients for a selectively absorbing and dispersing layer of material, if test data on the hemispherical reflectivity and transmittivity are given. In this chapter the authors also describe their graphical methods of determining the basic characteristics of a radiation field inside a layer.

In Chap. 3 are shown experimental methods of determining the heat-radiation characteristics of materials which selectively absorb and disperse radiant heat. The methods of reflectivity and transmittivity measurements are properly classified here. It is noted, quite correctly, that data obtained by different authors on the reflectivity and the transmittivity of the same dispersive materials are often not comparable. In order to avoid such a situation in describing the reflection and the transmission, it is necessary to define precisely the conditions of incidence and reflection (transmission) of energy fluxes. There follows a critical review of existing methods of measuring the spectral reflectivity and transmittivity of dispersing and absorbing materials within the near and intermediate infrared range. Original optical systems developed by the authors for two-beam techniques of measuring the heat-radiation characteristics are also shown here. The merits and drawbacks of each experimental technique are discussed in detail, each is also evaluated in terms of accuracy.

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Chapter 4 contains results obtained by measuring the optical and the heat-radiation characteristics of food products. Data are given pertaining to the hemispherical transmittivity and reflectivity of food products (dough, vegetables, fruits, starches, etc.) of various specimen thicknesses, also data pertaining to R_λ and T_λ as functions of the layer thickness, density, and moisture content. It is demonstrated that the reflectivity of most materials considered here increases with increasing layer thickness. This is caused by multiple dispersion of the radiant flux inside a layer.

There are a few items in the text which the reviewers find inaccurate. It is stated in Chap. 2 that "the fundamental Bouguer, Bouguer—Lambert, and Bouguer—Lambert—Beer laws of radiation" do not apply to several materials when the latter are exposed to integral radiation fluxes. But these laws are, strictly speaking, valid only for monochromatic radiation and, therefore, a priori cannot apply to integral fluxes. Further on, in Chap. 3 the authors cite as one reason why a two-beam measurement of R_λ and T_λ is more sensitive than a single-beam measurement that the effect of radiation absorption by atmospheric H_2O vapor and CO_2 on the instrument readings has been eliminated in the two-beam method. But radiation is absorbed by the atmosphere in either method and, therefore, the instrument sensitivity drops at those frequencies of the spectrum at which absorption is appreciable. All this does not detract from the very valuable work of these authors.

The monograph by S. G. Il'yasov and V. V. Krasnikov is today the only one available in the Soviet technical literature which covers all problems involved in determining the optical and the heat-radiation characteristics of various dispersing and absorbing materials within the thermal range of the spectrum. The publication of this book meets an urgent need of practical engineering and its appearance should speed up the introduction of infrared heating as well as radiative heat treatment into various sectors of the national economy. The methods of analysis proposed by S. G. Il'yasov and V. V. Krasnikov can, as they become further developed, contribute to a significant progress in one of the important areas of radiative heat transfer.

The book contains valuable scientific data, many of them published for the first time, the text is rather well illustrated with graphs and tables. There is no doubt that the scientific–technical community will welcome this monograph with great interest.

B. M. Smol'skii, Z. P. Shul'man, and V. M. Gorislavets

RHEODYNAMICS AND HEAT TRANSFER IN NONLINEARLY VISCOPLASTIC MATERIALS*

Reviewed by A. Kh. Kim

The problem of heat and mass transfer in rheologically complex media has during the last decade become extraordinarily urgent. Along with widely used industrial polymer materials, very important in engineering and in consumer applications are such disperse materials as confectioneries, pharmaceuticals, foods, varnish-dye composites, enriched fuels and fuel mixtures, structural mortars, petroleum extractants, water-coal and water-sand pulps, ceramic and peat pastes, nuclear fuels in suspensions, and also biological media like blood, etc. Many disperse fluids acquire a complex mechanical behavior when subjected to external electric and magnetic fields. Until recently, the Shvedov–Bingham model of linearly viscoplastic medium has been widely and successfully used for the rheological description of such disperse media. With the latest developments and improvements in instrumental rheology, however, the inadequacy and the limitation of this equation of rheological state has become apparent, especially in the case of low and moderate shearing rates. On the basis of many theoretical–experimental studies and data analyses made in the USSR as well as abroad, at the Institute of Heat and Mass Transfer (Academy of Sciences of the Belorussian SSR) there has been derived a new phenomenological equation of nonlinearly viscoplastic media, an equation which generalizes over 10 classical rheological models with the Shvedov–Bingham model included. This served as the basis for an extensive cycle of theoretical–experimental studies concerning the rheodynamics and the convective heat transfer in nonlinearly viscoplastic disperse fluids flowing laminarly under pressure through pipes and channels.

The book by B. M. Smol'skii, Z. P. Shul'man, and V. M. Gorislavets contains essentially the most important results of these studies. It is made up of nine chapters, some dealing with mechanical, physicochemical, and rheological properties of various varnish-dye composites very successfully selected by the authors as model media with a nonlinear flow curve. Most prominently are covered the rheodynamics and the convective heat transfer in the case of nonlinearly viscoplastic materials flowing through circular pipes, orifices, and coaxial cylinders under various boundary conditions, with viscous dissipation as well as slippage at the wall and shear anisotropy of heat conduction taken into account. The calculations here are quite original and should be very useful for engineering practice. An excellent feature of the book is that it contains a great deal of reference material in the form of many tables, nomograms, and graphs. This material will prove to be valuable to engineers, designers, and technicians. The bibliography contains 202 entries. All this makes the monograph very useful for solving many application problems. It is to be noted that neither in the foreign nor the Soviet scientific literature has the problem of rheodynamics and convective heat transfer in rheologically complex media been treated monographically prior to the appearance of this book. I expect the book by B. M. Smol'skii, Z. P. Shul'man, and V. M. Gorislavets to be widely read.

*Nauka i Tekhnika, Minsk, 1970, 446 pp.

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