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Book Review

Solar Engineering of Thermal Processes, 2nd ed., by J. A. Duffie and William A. Beckman. John Wiley and Sons, New York, 1991. 919 pages. Price: $69.95.

REVIEWED BY W. M. WOREK[1]

This book is the second edition of probably the most well-known text dealing with the engineering aspects of solar energy and the thermal processes related to the design and operation of solar systems. The second edition represents an improvement over the previous edition allowing the book to appeal to a more diverse audience of readers. In the second edition, the book has been divided into three parts: Part I—Fundamentals; Part II—Applications; and Part III—Thermal Design Methods. Structuring the contents into this manner enables the book to be used in either a senior or graduate level class covering the fundamental and design aspects of solar energy, or a class or seminar illustrating the application of solar energy in alternate energy system design.

By comparing the chapters in both the first and second editions, it is obvious that the authors have diligently expanded and updated the material to include important developments that have occurred in the solar energy field over the last 11 years (i.e., since the publication of the first edition). The topics covered in each part of the text are reviewed in the following sections.

Part I—Fundamentals. In Chapter 1, the characteristics of solar radiation are discussed. This includes the general characteristics of the sun, the solar constant, and the variation of extraterrestrial solar radiation with time. Also, the directional characteristics of beam radiation including methods to calculate the zenith angle, the surface azimuth angle, and the angle of incidence with respect to a tilted plane are covered. Using these relations, an equation used to determine the ratio of the beam radiation on a tilted plane to that on a horizontal plane is given. New sections in this chapter include relations giving the angles for tracking surfaces and techniques to determine shading. Chapter 2 presents methods to determine the amount of available solar radiation. This chapter covers topics on methods and instrumentation to measure solar radiation, techniques to estimate the average and clear sky solar radiation, the hours of sunshine, including the distribution of clear and cloudy hours and days, and methods to determine beam and diffuse components of hourly, daily, and monthly radiation. Also, the radiation on sloped surfaces for isotropic and anisotropic skies are given and techniques to augment radiation on tilted surfaces by reflection are discussed. New sections in Chapter 2 present methods to determine average radiation on sloped surfaces, effect of receiving surface orientation, and utilizability.

Chapter 3 reviews selected topics in heat transfer. This chapter is basically unchanged from the first edition. However, the authors have added a section covering the effectiveness-NTU method for heat exchangers. In Chapter 4, the general radiation characteristics of opaque materials are given. These concepts include absorptance and emittance, Kirchoff's law, and the relationship between absorptance, emittance, and reflectance. Also, methods to measure surface properties are discussed, the characteristics of selective surfaces are given and the dependence of absorptance on the angle of incidence is addressed. New sections in the chapter include the calculation of broadband emittance and absorptance, the mechanisms to create a selective surface and optimum properties of a selective surface. A section on the absorptance of cavity receivers also has been added.

Chapter 5 presents radiation transmission and absorption by glazing materials. Here radiation reflection and absorption by glazings is given and the transmittance of collector cover systems is discussed. This includes the angular dependence of the transmittance absorptance product, the spectral dependence and the effect of surface layers on the transmittance, absorbed solar radiation, and monthly absorbed radiation. A new section that appears in the second edition discusses the absorptance of rooms.

Flat-plate collectors are covered in Chapter 6. Topics in this chapter include methods to determine the temperature distributions in flat-plate collectors, the overall loss coefficient, the temperature distribution between tubes and in the flow direction, the collector efficiency factor, the heat removal factor, and the flow factor. In addition, the effective transmittance absorptance product, the effect of dust and shading and the heat capacity effects are given. New material in this chapter includes sections on the critical radiation level, the measurement of collector performance, and flow corrections for collector performance parameters. Also, practical considerations in the design, manufacture, shipment, installation and long-term use of flat-plate collectors are discussed.

In Chapter 7, concentrating collectors are discussed. This chapter has been extensively revised. Here both the geometrical and thermal aspects of concentrating collectors are discussed. This includes optical characteristics of both imaging and non-imaging concentrators. Chapter 8 deals with energy storage including sections on water, packed-bed, phase change, and chemical storage systems. New topics in this chapter include sections on the effect of stratification in water storage tanks, the performance of thermal storage walls, and a description of seasonal storage systems.

Chapter 9, which covers solar process loads, is a new chapter that appears in the second edition. Material covered in this chapter includes hot water loads, space heating loads and the degree-day method, cooling loads, and swimming pool heating loads. Also included is a brief discussion of how to calculate building loss coefficients and building energy storage capacity.

In Chapter 10, system thermal calculations are discussed.

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Here component models, development of the collector heat exchanger factor, which allows incorporation of a heat exchanger to isolate the collector system from the thermal storage system, is discussed and duct and pipe loss factors and solar system controls are presented. New material includes methods to calculate the performance of collector arrays, collector arrays having sections at different orientations, and collectors that are partially shaded. The usage of the models developed in the chapter are illustrated in example problems.

The economics of solar systems is given in Chapter 11. The material given in this chapter includes how to determine the solar savings, design variables to minimize the cost of a solar system, and economic figures of merit. Also, economic factors relevant to energy systems including discounting, inflation, and the present work factor are given. These concepts are then used in a life-cycle savings method.

Part II—Applications. This part of the text is largely qualitative and descriptive illustrating applications that have been done and practical problems stemming from these applications.

Chapter 12 covers active and passive solar water heating systems. Here water heating systems, including forced-circulation, low-flow pumped, and natural-circulation systems are given. Also included in this chapter are integral collector storage systems, the practical aspects of retrofit water heaters, and the economics of solar water heating systems. New sections include the section on low-flow pumped systems and a section on the methods of testing solar water heaters. In Chapter 13, active building heating systems are addressed. Here various type of systems are described and the economics and the architectural considerations that arise when designing these systems are reviewed. Chapter 14 covers building heating using passive and hybrid methods. In this chapter, the concepts of passive heating, comfort criteria, and heating loads are discussed. Techniques and concepts used in passive system design also are included. These concepts include movable insulation, passive shading devices, direct-gain systems, and collector-storage walls and roofs. Additional material in the chapter include the description of other hybrid systems, various passive applications, and the costs and economics of passive heating systems. New material in the chapter includes sections on sunspaces, active collection-passive storage hybrid systems, and methods to distribute the heat in passive buildings.

The next chapter, Chapter 15, deals with cooling. Here cooling technologies that have been activated by solar energy are described. These include absorption, desiccant, solar-mechanical cooling systems, and other indirect methods for space cooling. New sections in this chapter include sections on the applications of solar absorption air conditioning, ventilation and recirculation desiccant cycles, and passive cooling techniques. Chapter 16 describes solar energy used in process heat applications.

The material that appears Chapter 17, covering solar thermal power systems, has been extensively expanded. Here more examples of the successful design of solar thermal power systems are cited. In the first edition, only one section was devoted to solar ponds. Now a complete chapter is devoted to solar ponds (Chapter 18). This chapter includes a description of solar ponds, the physics that allows a solar pond to operate, and typical applications that utilize a solar pond are given.

Part III—Thermal Design Methods. In the final part of the book, methods to simulate and design solar systems are given. This part assembles all of the thermal design methods into one part of the text and the material also has been extensively revised. In the previous edition, sections on the f-chart method and utilizability method was given. This material has been retained and updated in the second edition (i.e., Chapters 20 and 21) and chapters describing other design methods are given. In Chapter 19, simulations of solar process design are given. This chapter reviews different design programs and discusses the information gained from system simulations. Also, the thermal simulation program, TRNSYS, is described and a comparison of simulated results using TRNSYS and experimental data are given. Chapter 19 also includes a description and sources of meteorological data. Design methods for passive and hybrid systems, which is a new addition in the second edition, are given in Chapter 22. Finally the last chapter of the text, Chapter 23, describes the design of photovoltaic systems.

In my opinion, this is the best book available dealing with solar energy and the engineering aspects of solar energy. I highly recommend this as a textbook for anyone teaching courses in the solar energy area. Also, given the depth of coverage and the extensive amount of references cited in the book makes this book a required reference for any individual working in the area of solar energy or alternate energy system design.

Start by marking â€œSolar Engineering of Thermal Processesâ€ as Want to Read: Want to Read savingâ€¦ Want to Read.Â This Third Edition of the acknowledged leading book on solar engineering features: Complete coverage of basic theory, systems design, and applications Updated material on such cutting-edge topics as photovoltaics and wind power systems New homework problems and exercises ...more. Get A Copy. Amazon.