Preface

Sunlight and Its Utilization

One of the greatest problems facing humankind in the 21st century is the lack of available potable water. The reason behind the origins of this precarious problem is the limited natural water–resources available on the planet earth. The rate of potable-water use is growing drastically with time and has almost quadrupled over the past century. Therefore, it is now necessary to find alternatives to challenge water-related problems to protect the limited natural water–resources remaining on the earth.

In this universe, only the sun is available as one of the most ample and unlimited energy resources. There would be no life on the earth without sunlight. Electromagnetic radiation in the form of sunlight reaches the earth through the atmosphere. Sunlight consists of ultraviolet, visible, and infrared light. Statistically, every year 6×10^9 J/m^2 of solar radiation is incident on the earth (based on an average of 6 hours of sunlight a day), which is a very large amount. For a 10-m^2 roof, the amount of energy received is approximately three times more than the energy used in a typical house per day. These are the reasons that solar energy has gained much–attention worldwide. For efficient utilization of solar energy, is essential to understand the basic science of solar energy, including solar radiation and heat transfer.

Objective

The availability of clean potable water is expected to be the biggest problem that humanity will encounter in the next few decades. Therefore, to reduce the gap between the demand and supply of clean potable water using renewable sources of energy, the main focus of our book is on solar-distillation systems. With our teaching and research experience of many years on the subject, we choose to write a book on solar distillation by incorporating many concepts such as fundamentals of solar radiation, i.e., heat and mass transfer as well as various solar-distillation systems including solar still integrated with photovoltaic thermal (PVT) flat-plate collector (PVT-FPC) evacuated tubular collector (ETC), and PVT–compound parabolic concentrator (PVT-CPC). The feasibility of any system depends on its return in terms of revenue, cost, and energy produced by the system over its entire life. Therefore, to analyze the feasibility of solar-distillation systems, energy and exergy analysis, parametric study of solar-distillation systems, energy matrices, and economic and exergoeconomics analysis of solar-distillation systems must also be extensively elaborated.

The main purpose of writing this book is to provide a suitable text for teaching the subject to engineering and science students as well as a reference book for scientists and professionals. For better understanding of the subject, some solved examples, problems, and objective questions are given at the end of each chapter.

The first chapter (General Introduction) comprises the increasing demand, resources, and availability of potable water. It also describes various types of water pollution and their effects on human health. The historical background of solar distillation and various desalination technologies are vital to understand. Therefore, this chapter emphasizes some simple and some advanced techniques for potable-water production from contaminated or saline water.

Chapter 2 (Solar Radiation and Heat Transfer) summarizes the basics of solar radiation including solar angles and solar radiation on horizontal and inclined surfaces. The section on heat and mass transfer deals with different types of heat- and mass-transfer mechanisms involved in the solar-distillation process. Different kind of thermal efficiencies are also discussed in this chapter.

Chapter 3 (History of Solar-Distillation Systems) presents the history of various types of passive solar-distillation systems. It describes modifications in the design of the solar still in recent times. Different cases of the wick-type solar still and modified designs of the single-slope solar still are discussed. In some advanced solar stills using recent technologies, various effects with the use of phase-changing materials (PCM), vacuum, and nano-fluids is also explained.

Chapter 4 (Solar Collectors) includes different varieties of solar collectors that can be integrated with a solar still to optimize and enhance the performance of passive/conventional solar stills. This is a prerequisite to understand the basics of solar collectors before proceeding further, which is explained in this chapter. Different cases of solar collectors—such as partially covered, fully covered as well as natural and forced mode of operation—are discussed. A glimpse of conventional solar thermal collectors integrated with photovoltaic modules (PV), i.e., photovoltaic thermal (PVT) solar collectors, has been provided in order to understand active solar stills. The effect of reflectors on the performance of the solar still is also briefly described in this chapter.

Chapter 5 (Thermal Modeling of Active Solar-Distillation Systems) summarizes the mathematical modeling of active solar-distillation systems, which basically describes a solar still integrated with photovoltaic thermal (PVT) flat-plate collector (PVT-FPC), evacuated tubular collector (ETC), and PVT–compound parabolic concentrator (PVT-CPC). To compare the performance of different solar stills, characteristic equations are essential tools; hence, the last section of this chapter is devoted to the characteristic equations of different passive and active solar stills.

Chapter 6 (Parametric Study of Solar Distillation and Its Application) summarizes the effect of different climatic and design parameters (such as water depth, absorptivity of basin, wind velocity, effect of dye, transmissivity of glass cover, insulation thickness, etc.) on the performance of various passive and active solar stills. An insight for optimizing the performance of solar stills by choosing the appropriate values of different parameters is provided in this chapter.

Chapter 7 (Energy and Exergy Analysis of Solar Distillation) is dedicated to the analysis of the energy and exergy of active and passive solar stills. In addition to the energy and exergy analysis of the conventional solar still, it also describes energy and exergy analysis of photovoltaic thermal (PVT) flat-plate collector (PVT-FPC), evacuated tube collector (ETC) and PVT–compound parabolic concentrator (PVT-CPC). The results are discussed in detail.

Chapter 8 (Energy Matrices of Solar-Distillation Systems) presents embodied energies of different types of passive and active solar stills. The corresponding energy matrices, i.e., energy-payback time (EPBT), energy-production factor (EPF), life-cycle conversion efficiency (LCCE) are discussed. This chapter also includes the positive impact on environment from solar stills (a renewable source of energy).

Chapter 9 (Exeroeconomics of Solar-Distillation Systems) introduces fundamental equations that include the general balance equation, thermodynamic-balance equations, and economic-balance equations. Essential terms—such as "waste energy," "exergy-loss rates," "capital cost of equipment," and "ratio of thermodynamic loss rate–to–capital cost—are explained. Eergoeconomic analysis of the partially covered photovoltaic thermal flat-plate collector (PVT-FPC) solar-distillation system is discussed as an example, which includes the experimental set-up and thermal modeling of this hybrid system. The results and conclusion has been given in the last section.

The last chapter (Economic Analysis of Solar-Distillation Systems) deals with important terminology regarding the economic viability of solar-distillation systems, essential formulae that include capital-recovery factor (CRF), uniform annual cost (UNACOST), sinking-fund factor (SFF) and benefit–cost ratio. It also contains a discussion of cash-flow diagram and cost comparison. Four crucial methods (single present-value method, Annual Cost Method, capitalized-cost method, and fourth method) of cost comparison for unequal duration are explained in detail.

SI units have been used throughout the book. Appendixes are given at the end of the book.

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