Design of
Solar Thermal Systems

Moustafa M. Elsayed
Mechanical Engineering Department,
King Abdulaziz University, Jeddah, Saudi Arabia

Ibrahim S. Taha
Mechanical Engineering Department,
Assuit University, Assiut, Egypt

Jaffar A. Sabbagh
Mechanical Engineering Department,
King Abdulaziz University
Jeddah, Saudi Arabia

Scientific Publishing Centre
King Abdulaziz University
P.O. Box 1540, Jeddah 21441
Saudi Arabia.
Preface

This book presents the design of solar thermal systems using mathematical modeling. The importance of mathematical modeling is continuously increasing because of the rapid spread in the use of computers as design tools. The book is thus prepared for those who are involved in the design, optimization, or evaluation of the performance of solar thermal systems.

The book is based on teaching notes for undergraduate and first year graduate courses for thermal engineering students. It is recommended as a text for senior undergraduate students or first year graduate students, and also as a reference book for engineers working in various solar thermal applications.

The book consists of 10 chapters. The first chapter reviews the world resources of energy and their classification and relation to solar energy. The second chapter reviews important topics in thermal radiation which are relevant to the subject of the book. The third chapter is concerned with the estimation of solar angles and the hourly, daily, and monthly average daily solar radiation. Mathematical equations are given to enable the designer of a solar thermal system to estimate the beam, diffuse, or total radiation on horizontal or tilted surfaces.

The transmission of solar radiation through transparent sheets of different material is treated in Chapter 4. This chapter gives mathematical equations to predict the radiation properties of multi-layer partially transparent sheets with or without an absorber plate. A computer program is included to enable the designer to estimate the radiation properties for several geometries of a stack of similar or nonsimilar transparent sheets with or without an absorber plate at any incidence angle. The program is useful in the design and optimization of flat plate collectors and solar concentrators, and can also be utilized by air conditioning engineers to estimate solar heat gain through transparent windows and doors.

Chapter 5 gives the design of flat plate collectors, and presents various types. Complete simulation of the collectors is given, and the various factors affecting their performance are discussed. A computer program is given to design and optimize the design parameters of the flat plate collectors. This program can also be used to evaluate the performance of flat plate collectors in off-design conditions.
Chapter 6 deals with solar desalination. The chapter will be helpful to those designing either roof-type or diffusion-type solar desalination systems, since it includes a more detailed description of these systems than most other solar energy textbooks. Analysis are given to predict the transient performance of the roof-type still. A computer program is given to assist the designer in predicting the effect of various design and operating conditions on the performance of the still. Various novel designs of roof-types stills are presented with the advantages and disadvantages of each. The chapter also gives the analysis of both the single effect and the multiple-effect diffusion-type still together with a brief presentation of the mass diffusion theory. Other methods of solar desalination are also discussed in the chapter.

The collection of solar energy at medium and high temperatures by solar concentrators is discussed in Chapter 7. Various types of concentrators are presented. Thermal analyses are given to show the important factors affecting the performance of solar concentrators. Different tracking modes are given. The material in this chapter will help the reader to select the type of solar concentrator most suitable for a particular application together with the adequate tracking mode. Details of the designing of intermittent tracking are given in the chapter. Readers interested in continuous tracking will find ample material in section 10.8 of Chapter 10.

In Chapter 8, the design of solar energy storage is considered. The first part of the chapter deals with storage methods, characteristics, location, and the evaluation of the storage process. Mathematical simulations of various types of sensible heat storage are carried out for low, intermediate, and high temperature applications. In particular, mathematical simulations are presented for the transient performance of the mixed liquid storage, underground liquid storage, and stratified liquid storage. With these simulations the reader of the chapter should be able to size the liquid storage tank required for a certain application. Designers of solid storage tanks will also find that the mathematical simulation of rock bed storage and its sizing are covered in the chapter. In addition, other techniques of solar energy storage such as low, intermediate, and high temperature phase change and chemical and mechanical storages are considered. The user of the simulation models given in this chapter should have a reasonable background in the finite difference numerical technique.

The solar-operated absorption cooling system is treated in Chapter 9. Both H₂O-LiBr and NH₃-H₂O absorption systems are considered. Different arrangements of solar-operated absorption cooling systems are given, together with the criteria to evaluate and compare these systems. Alternative combinations of absorption cooling systems, such as the dual series connected system and the two stage absorption cooling system, are presented. Mathematical simulations of both the H₂O-LiBr and NH₃-H₂O absorption machines are considered. A computer program is included to predict the performance of the absorption cooling machine in various design and operating conditions. An optimization procedure is given for the determination of the design parameters of the absorption cooling machine. The chapter also contains a brief description of the intermittent absorption cooling system.

Chapter 10 deals with solar power generation. The chapter includes the charac-
teristics required for the working fluids of the solar-operated Rankine cycle. Mathematical simulation is given for the Rankine cycle and selection of the various design parameters of the system is presented. The chapter also includes the performance of the solar-operated Rankine cycle (SORC) in various operating conditions. In addition, the engineering considerations for the selection of the various components of SORC are given. Analyses are also presented to select the optimum collector temperature for solar-operated power cycles. A sizeable section of the chapter is devoted to power tower technology, including material for the determination of the heliostat field layout, the determination of the tilt and orientation angle of each heliostat, and the sizing of the receiver.

The book adds considerably to engineering expertise in the design of solar thermal systems. Chapters 5 and 8 are relevant to the design of solar water heaters, swimming pool heating systems, and space heating. Chapter 6 will also assist in the design of solar desalination systems. Those involved in the design of solar operated absorption cooling systems should read Chapter 9 in addition to Chapter 8 and Chapters 5 or 7. Information on solar power generation is given in Chapter 10 and also in Chapters 7 and 8.

Authors

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The components that a solar thermal energy system needs in order to work. The main ones are solar collectors, a heat exchanger and an accumulator. The solar collector is a type of solar panel designed to take advantage of solar thermal energy. These elements capture solar radiation and convert it into thermal energy, into heat. They are often covered by glass. The glass that covers the collector not only protects the installation but also conserves heat. Solar thermal systems have become part of modern heating technology and reduce the consumption of fossil fuels. This protects the environment and lowers energy cost. This technical guide is designed to educate the homeowner, the installer, the engineer, and the architect on solar product offered by Bosch. It features descriptions of components, system sizing, and piping diagrams. The installations in this manual have been tried and tested by Bosch and were selected for their simplicity, energy savings, cost effectiveness, and comfort.

1.2 Free solar energy. The energy that is provided by the solar Thermal water heating systems capture the sun's energy in the form of heat which is transferred to hot water cylinders. Replacing the need to burn fuels such as gas, coal or wood. Depending on how much hot water you need, the hot water system you already have, your budget and where you are located there are a few ways you can put a system together.

Slimline Evacuated Tubes for Solar Thermal Hot Water: Have the dual benefit of high performance and flexible mounting. They are designed to operate at the low light levels found in the UK maximising solar gain even at freezing temperatures. For a system that performs well throughout the year in challenging conditions or off perfect mounting these slimline evacuated tube systems are hard to beat.

Top of page. Articles. Why use TRANSOL in design of solar thermal systems? For practical purposes, most of the solar thermal installations are sized according to the known F-Chart method, for practical reasons, economic and historical. We would like to highlight some inconsistencies of this habit. We will not explain in detail the F-Chart method, but basically it consists on 300 TRNSYS simulations of a solar thermal system model that responds to the following hydraulic system: F-CHART scheme. SCH_SC (Semi-Centralized Solar Thermal System). If we use this method of calculation, we observe the same behavior on the three schemes above. Clearly, this is not true, and also easily demonstrable. Plate heat exchangers are used for solar thermal systems with solar collector areas of 15 m² and more. They are made of parallel plates. In between the plates there is a counter flow of the heat transfer fluids.

3.3 Design of the solar membrane expansion vessel. In general it must be said that it is better to choose the expansion vessel rather too big than too small! The results of simulations of expansion vessels are often too optimistic. Certain processes in the solar thermal system, like the stagnation, have not (or not adequately) been taken into account. Please see in the following calculation method (that considers the influence of the stagnation) to the state of the art. statische Anlagenhöhe [bar].