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Parabolic Trough Collector Prototypes for Low-Temperature Process Heat



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Preface

This book is a short but concise summary of prototypes of parabolic trough solar collectors (PTCs) presented in the technical literature and used for low-enthalpy (low-temperature) demands. The idea of writing this book started from a paper that two of the Authors wrote last year, which dealt with the design and manufacture of a low-temperature and low-cost PTC prototype developed in the Department of Industrial Engineering and Mathematical Sciences of Marche Polytechnic University (UNIVPM). Since that work brought us to deepen the field of PTCs adopted for thermal industrial processes, in particular low-temperature prototypes usually developed in the academic world, we thought that it could be useful and interesting to provide a book concerning these fascinating solar collectors.

We believe that this work is particularly addressed to researchers who have fundamentals of solar thermal energy, theoretical and/or practical, and intend to enhance their knowledge of the field of PTCs starting from low-temperature prototypes. Students of Engineering faculties could also be interested in the topic of this book, if their purpose is to study more advanced applications of renewable energy and applied physics.

The book is divided into five chapters. The introduction is presented in Chap. 1, which presents some fundamentals of solar thermal energy, including the characteristics of the sun. In addition, a classification of solar collectors available in the market is given, and concentrating collectors, among which PTCs, are described. Solar thermal applications typically used nowadays are also discussed.

Chapter 2 is the longest chapter of the book, providing a detailed description of the physical/mathematical modeling of PTCs. We decided to organize this chapter into three sections. The first section is a discussion of the angles which we refer to in order to calculate the position of the sun. As concerns PTCs, these angles are important to determine the correct slope necessary to the tracking system of the collector and to calculate the angle of incidence, a quantity which has a central role in solar collectors, and even more in PTCs. The second section presents the optical analysis of a PTC, i.e., all the aspects regarding the geometry of a PTC and the selected materials that influence its optical efficiency. Finally, the third section deals

with the thermal analysis of a PTC, in other words the energy balance of the receiver and, hence, the thermal efficiency of a PTC.

The standards used to assess the performance of solar thermal collectors such as PTCs are discussed in Chap. 3. The procedures required for testing PTCs will be discussed in detail, focusing the attention on the most relevant parameters that should be measured in a solar collector. Moreover, uncertainty in thermal efficiency testing will be described in detail, along with some details on quality test methods.

Chapter 4 presents an overview of the manufacture of several concentrators of PTC prototypes available in literature. PTC concentrators are used to reflect the solar radiation to the other element of a PTC which will be treated in the last chapter, the receiver. Having the shape of a cylindric parabola, PTC concentrators are able to reflect each normal incident solar beam to a line belonging to the parabola itself and called focal line, where the receiver is located. These systems require an accurate design and manufacture in order to correctly concentrate the solar radiation, and they should be built adopting materials with good mechanical and optical properties. All these aspects will be discussed in the chapter in object.

Receivers, the elements of a PTC where the solar radiation is concentrated and collected, are described in Chap. 5. In particular, this chapter presents an overview of the receivers used in PTC prototypes, providing also some characteristics about the adopted materials. PTC receivers have a tubular form and are placed in the focal line of the concentrator. A fraction of solar energy absorbed by the receiver is transferred to the heat transfer fluid which circulates inside the tube, obtaining a useful heat gain. Thus, a correct design of such components is crucial. Along with a description of available receivers, this chapter discusses the performance of the presented prototypes. Finally, nanofluids, novel heat transfer fluids which seem to have very interesting thermophysical properties, are introduced.

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As concerns students, we would like to express our special gratitude to everyone who contributed to realize some sections of the present book. We decided not to report the entire list of the people involved in the project, as it would be extremely long; we hope that our decision will be shared by everyone.

However, we cannot forget to be grateful to Eng. Marco Sotte, Ph.D., who originally undertook at DIISM an experimental program called PTC project which marked the beginning of our work on parabolic trough collectors.

We hope that this book will be appreciated by all of them.

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