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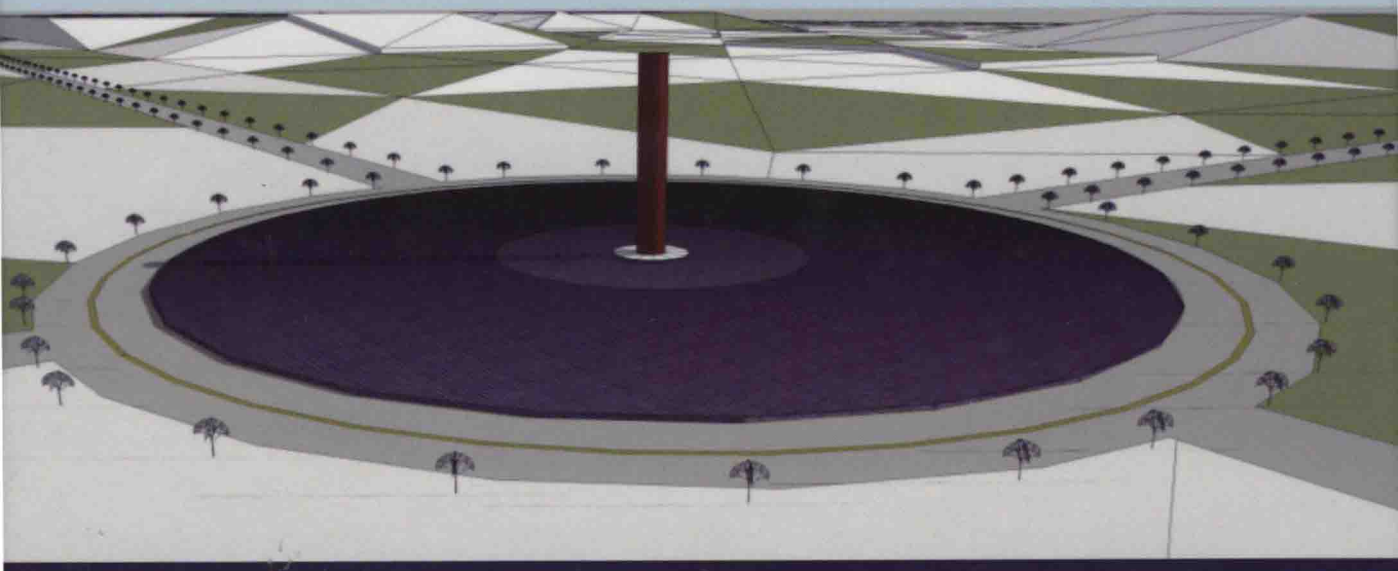
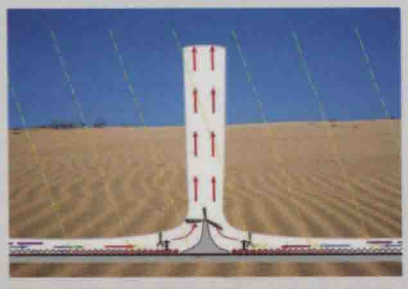
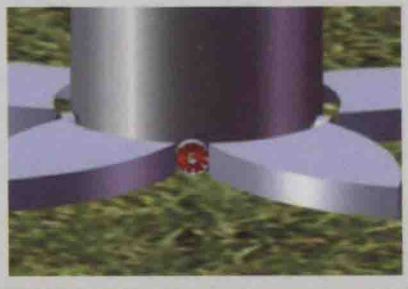
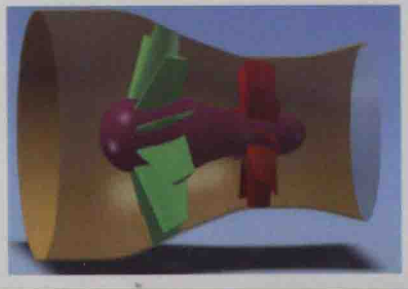
Tingzhen Ming

Solar Chimney Power Plant Generating Technology









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Solar Chimney Power Plant Generating Technology

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This book is dedicated to the memory of my beloved mother who died on March 30, 2012 before her 70th birthday.

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Preface

The field of renewable and sustainable energy is changing rapidly worldwide, and various technologies concerning energy saving and renewable energy utilization are constantly being reported. Further, the widespread use of solar energy, as an alternate and nondepletable resource for agriculture and industry as well as other applications, is dependent on the development of solar systems which possess the reliability, performance, and economic characteristics that compare favorably with the conventional systems.

The solar chimney power plant system (SCPPS) or solar updraft power plant system (SUPPS), which is composed of the solar collector, the chimney, and the turbine, has been investigated all over the world since the German researcher Professor Jörg Schlaich made the brainchild in the 1970s. The SCPPS, due to its attractive advantages of being easier to design, more convenient to draw materials, higher operational reliability, fewer running components, more convenient maintenance and overhaul, lower maintenance expense, no environmental contamination, continuous stable running, and longer operational life span, has excited many researchers all over the world, especially in countries with plenty of deserts and arid and "useless" areas. However, the book on SCPPS written by Professor Jörg Schlaich was published 20 years ago, and now it is necessary to update the progress made in the state-of-the-art technologies of SCPPS over recent years worldwide.

In this book we are going to reveal the basic mechanisms of fluid flow, heat transfer, power output, energy storage, and operation procedure of the turbine of SCPPS. We hope this book can provide good guidance for developers who are interested in SCPPS.

The remaining chapters are arranged in the following way. In chapter "Introduction," we will present a brief introduction of the background of various solar energy power plant systems and SCPPS, and we will also introduce the recent research developments of SCPPS during the past 20 years. In chapter "Thermodynamic Fundamentals," basic theory related to thermodynamics and the efficiency of the SCPPS will be introduced. This covers the basic thermodynamic process, Brayton cycle, and exergy analysis of various SCPPSs. Chapter "Helio-Aero-Gravity (HAG) Effect of SC" unveils the Helio-Aero-Gravity (HAG) effect of the SCPPS. In this chapter, how the SCPPS operates will be analyzed in detail dealing with the various parameters including the dimensions and ambient. In chapter "Fluid Flow and Heat Transfer of Solar Chimney Power Plant," a mathematical model describing the fluid flow, heat transfer, and power output of the SCPPS will be presented, validation of the model by comparing the experimental results of the Spanish prototype will also be presented. Later, optimization of the dimensions of SCPPS based upon the results of power output will be performed.

In chapter "Design and Simulation Method for SC Turbines," a detailed design of the turbine used for SCPPS will be presented, accompanied by a mathematical model and simulation method of the SCPPS coupling the moving part pressure-based wind turbine. In chapter "Energy Storage of Solar Chimney," a detailed discussion on the energy storage characteristic of SCPPS will be presented. In this chapter, analysis of different materials and layout of energy storage will be shown. In chapter "The Influence of Ambient Crosswind on the Performance of Solar Updraft Power Plant System," we will introduce the effect of ambient crosswind on the performance of SCPPS. In chapter "Experimental investigation of a solar chimney prototype," an experimental investigation of an SCPPS setup will be briefly introduced. In chapter "Research Prospects," the future research development will be discussed.

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A large part of the work of this book was performed when I worked in Huazhong University of Science and Technology and the rest was accomplished in Wuhan University of Technology. The contributors of this book include my two supervisors, Professor Wei Liu from School of Energy and Power Engineering, Huazhong University of Science and Technology (HUST) and Professor Yuan Pan from School of Electrical and Electronic Engineering, HUST. In addition, the contributors also include Professors Shuhong Huang, Suyi Huang, Guoliang Xu, and Tianhua Wu, Drs Renaud K. de Richter, Xuemin Li, Xiaoming Huang, Aiwu Fan, and Kun Yang, my students Dr Jun Liu, Mr Xiaoyang Shi, Yong Zheng, Xinjiang Wang, Fanlong Meng, Yongjia Wu, Wenqing Shen, Lixian Wang, Tao Fang, Zhou Zhou, Jinle Gui, Chao Liu, Tao Pan, and Keyuan Peng, Ms Xiangfei Yu, Cheng Zhou, Yue Qiu, and so on. Drs Xiaohu Liu, Hui Liu, Dongyuan Shi, Xinchun Lin, and Xinping Zhou are greatly appreciated for their kind suggestions on the work of this book.

January 20, 2016

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