

CLEAN AND EFFICIENT COAL-FIRED POWER PLANTS

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**Development Toward
Advanced Technologies**

BY

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New York

ASME Press

2003

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Three Park Avenue, New York, NY 10016

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Library of Congress Cataloging-in-Publication Data

Termuehlen, Heinz, 1936–

Clean and efficient coal-fired power plants : development toward advanced technologies / by Heinz Termuehlen, Werner Emsperger.
p. cm.

Includes bibliographical references and index.

ISBN 0-7918-0194-2

1. Coal-fired power plants. I. Emsperger, Werner. II. Title.

TK1051.T47 2003

621.31'2132—dc21

2003043719

Cover photos: Lignite-Fueled RWE, Niederaussem Power Station with 1000 MW Unit K, Tandem-Compound Turbine-Generator, 3830 psig/ 1070°F/1112°F (265 bar/ 576°C/600°C) Photo courtesy of RWE Power

PREFACE

I have been involved in the power plant development process in Europe since 1958 and in the United States since 1969. After working in the power-generation industry for more than 40 years, I retired in August 1999. Not long after that, I received a phone call from the editor of ASME Press inviting me to write a book based on my experience and the approximately 100 technical articles I have written. These articles covered a wide variety of subjects related to power generation. That book, *100 Years of Power Plant Development*, focusing on steam and gas turbines as prime movers, was published in 2001 by ASME Press.

Since then, I wrote an article on the needed growth of electric power with a reduction of CO₂ discharge and without losing fuel diversity. I realized that clean and efficient coal-fired power plants were needed. I discussed this matter with ASME Press, and we agreed that a book on this subject would be very timely. Since I was mostly involved with the prime movers but not with steam generators of power plants, I looked for a coauthor. Werner Emsperger, who has been working in the fields of boiler concepts, flue gas cleanup, fuel gasification, etc. for 33 years was the right expert, and he accepted the challenge of becoming the coauthor of this book.

Werner Emsperger lives with his family in Erlangen, Germany. He is planning to retire from Siemens next year. I live with my family in the summertime in Wisconsin and have 4 grandchildren with whom I often need to share my office. But writing this book worked out well with modern communication systems and the fact that a 7-hour time difference allowed us to work almost around the clock. Werner worked when I slept and vice versa.

I would like to give a special “thank you” to Werner Emsperger, who did a great portion of our work, and also to my wife Heidi for her patience with me spending most of my time in the last months in front of the computer.

Heinz Termuehlen

ACKNOWLEDGMENTS AND COPYRIGHTS

Reference to illustrations and/or information in this book are given in the text in the form of numbered references []. The following Societies and Companies have granted permission to publish information and illustrations from books and articles covering various subjects of power generation:

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- Institution of Mechanical Engineers (I Mech E)
- International Electric Power for China
- Modern Power Systems
- Power-Gen Conference - granted by Penn Well Publishing Company
- Process Engineering Associates
- RWE Power A.G.
- Siemens Power Generation Group
- Springer Verlag
- Tsinghua University Press
- Turbomachinery International
- VGB-Kraftwerkstechnik GmbH
- Verlag TUEV Rheinland
- we energies

The authors are thankful for the copyright permissions provided by the above organizations, which made it possible to give a historic overview of the evolutionary coal-fired power plant development with many illustrations to help the reader follow this progress. As engineers like to say, “A good drawing is better than a thousand words.”

The authors appreciate the support given by experts to cover the wide range of specific issues. The following experts provided input on the listed

subjects:

- Steam generators Joachim Franke and Rudolf Kral
- Steam turbines Andreas Feldmueller and
Andreas Wichtmann
- Thermodynamic plant design Bert Rukes and
Georg Haberberger
- Desulfurization systems Heimo Friede
- Selective catalytic converters Ralf Sigling
- Power plant emissions Guenther Haupt

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INTRODUCTION

For more than 100 years, coal-fired power plants have generated the major portion of the worldwide electric power. The evolutionary development of the coal-fired power plant technology started by the generation of electric power with a specific coal consumption of more than 7.7 lb/kWh (3.5 kg/kWh). Today, an advanced pulverized-coal-fired power plant consumes only one tenth the fuel to generate a kWh electricity. This performance improvement is a result of applying highly efficient power plant concepts based on advanced steam generator and steam turbine technologies using supercritical steam conditions.

In the year 2000, more than 50% of the electric power in the United States was generated in coal-fired power plants, most of them being of a 1950 to 1970 vintage design. These more than 30-year-old power plants operate mostly at low steam conditions with an average power plant net efficiency of roughly 30% to 35%. Applying emission-reduction measures, including scrubbers and selective catalytic reduction (SCR) systems, reduces this power plant efficiency level by about 2 to 3 percentage points. All the efficiency data in this book is based on the low heat value (LHV) of coal.

Coal is the most abundant fossil fuel and plays a key part in terms of fuel-supply security. It is and will remain the most important fuel for power generation for a long time.

Besides the efficiency improvement of coal-fired power plants, major advancements have been made to reduce any kind of emissions from coal-fired power plants. Highly effective electrostatic precipitators to remove dust from the flue gas are in use. Scrubbers to mitigate sulfur dioxide (SO₂) and SCRs to reduce the nitrogen oxide (NO_x) emission are being used. The development of these systems for pulverized-coal-fired power plants and their potential for the future will be addressed, and information on the specific emission trends of the past, present, and future will be presented in this book.

The design of a highly efficient pulverized coal-fired power plant with highly effective emission-reduction systems will be described, and detailed information on the operational flexibility of such plants will be presented.

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As alternative technologies, the development of other coal-fired power plant concepts, namely fluidized bed combustion (FBC) plants and integrated coal gasification combined cycle (IGCC) power plants, will be discussed and their performance compared with pulverized-coal-fired units.

The importance of coal-fired power generation for the future will be discussed, including the importance of having a domestic fuel supply and reducing carbon dioxide (CO₂) discharge when increasing power generation by building new coal-fired plants and upgrading or replacing existing ones.