

**Energy Efficient
Industrial Technology
in Europe and Japan**

ENERGY TECHNOLOGY REVIEW No. 85

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ENERGY EFFICIENT INDUSTRIAL TECHNOLOGY IN EUROPE AND JAPAN

by

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for

Gas Research Institute

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**ENERGY EFFICIENT INDUSTRIAL TECHNOLOGY
IN EUROPE AND JAPAN**

Foreword

This book describes energy efficient industrial technology currently in use in Europe and Japan.

Energy prices in Europe and Japan, particularly natural gas prices, have exceeded those in the U.S. for many years. These higher energy costs create a demand for energy efficient industrial equipment. Information on this equipment has previously been available only in bits and pieces. This book is an effort to collect information on these technologies in one reference.

The technologies described constitute most of the advanced, gas-related technologies available to European and Japanese industry. Some of the technologies are unique and some are currently available in the U.S.

The book contains three parts. Part I, European Technology, concentrates on equipment in use in West Germany, France, and the United Kingdom. Part II, Japanese Technology, stresses equipment used in the Japanese aluminum, steel, and cement industries. Part III, Selected Technologies—In-Depth Studies, describes those technologies considered to have potential for widespread use.

A short overview of each general technological category, as well as a brief statement of the U.S. position in the field, precedes detailed descriptions of specific technologies. Information provided for each technology includes, where available, the developer or manufacturer, application or use, features, principles of operation, energy-saving performance, operating data, cost data, schematic diagrams, and patenting and licensing status.

The information in the book is from the following documents:

Energy Efficient Industrial Technology in Europe: A Compendium, prepared by A.G. Fassbender and M.J.

McGee of Battelle, Pacific Northwest Laboratories for Gas Research Institute, August 1982.

Energy Efficient Industrial Technology in Japan: A Compendium, prepared by A.G. Fassbender, Y. Yanase, and M.J. McGee of Battelle, Pacific Northwest Laboratories for Gas Research Institute, August 1982.

Selected Energy Efficient Industrial Technology in Europe and Japan, prepared by A.G. Fassbender of Battelle, Pacific Northwest Laboratories for Gas Research Institute, January 1983.

The table of contents is organized in such a way as to serve as a subject index and provides easy access to the information contained in the book.

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COGENERATION TECHNOLOGY AND ECONOMICS FOR THE PROCESS INDUSTRIES

Edited by D.J. De Renzo

Energy Technology Review No. 81

This book assesses the potential for industrial cogeneration development in the immediate future, for the process industries. Available technology and economics are discussed, and the details of case studies in five major energy-intensive industries—textiles, chemicals, pulp and paper, petroleum refining, and food—are presented. The case studies involve plants actually using cogeneration, as well as projected sites for this energy-saving technology. The book is based on research by *Resource Planning Associates, Inc.*; *Jack Faucett Associates*; *TRW, Inc.*; *Arthur D. Little Inc.*; *Westinghouse Electric Corp.*; and *Gibbs & Hill Inc.*

Cogeneration is the sequential production of electric or mechanical power and useful thermal energy. Much has been written and said about the energy-saving potential of co-locating facilities which generate electric power with facilities which consume large quantities of low-grade heat. Co-location of such facilities allows the by-product heat from electricity generation, which has traditionally been "thrown away," to be used productively. Properly designed and operated cogeneration facilities could, thus, save large amounts of fuel and capital.

Listed below is a condensed table of contents including **part and chapter titles**.

- I. **INDUSTRIAL COGENERATION DEVELOPMENT POTENTIAL**
 1. COGENERATION DEVELOPMENT WITHOUT ADDITIONAL GOVERNMENTAL ACTION
 2. COGENERATION DEVELOPMENT WITH ADDITIONAL GOVERNMENTAL ACTION
- II. **CELANESE FIBERS COMPANY CASE STUDY**
 1. INTRODUCTION AND BACKGROUND
 2. CELANESE CELRIVER FIBERS PLANT
 3. COGENERATION AT CELRIVER
 4. ECONOMIC AND ENERGY EFFICIENCY OF CELRIVER COGENERATION
- III. **AMERICAN CYANAMID CHEMICAL COMPANY CASE STUDY**
 1. INTRODUCTION AND BACKGROUND
 2. AMERICAN CYANAMID'S BOUND BROOK PLANT
 3. COGENERATION AT CYANAMID
 4. ECONOMIC AND ENERGY EFFICIENCY OF CYANAMID COGENERATION
- IV. **MEAD CORPORATION PAPER MILL CASE STUDY**
 1. INTRODUCTION AND BACKGROUND
 2. THE MEAD CORPORATION'S KINGSFORT MILL
 3. COGENERATION AT MEAD
 4. ECONOMIC AND ENERGY EFFICIENCY OF COGENERATION AT MEAD
- V. **AMOCO OIL REFINERY CASE STUDY**
 1. INTRODUCTION AND BACKGROUND
 2. AMOCO'S WOOD RIVER REFINERY
 3. COGENERATION AT AMOCO
 4. ECONOMIC AND ENERGY EFFICIENCY OF COGENERATION AT AMOCO
- VI. **CALIFORNIA AND HAWAIIAN SUGAR REFINERY CASE STUDY**
 1. INTRODUCTION AND BACKGROUND
 2. C AND H SUGAR—CROCKETT REFINERY
 3. COGENERATION AT C AND H
 4. ECONOMIC AND ENERGY EFFICIENCY OF COGENERATION AT C AND H SUGAR
- VII. **INDUSTRIAL COGENERATION OPTIMIZATION PROGRAM (ICOP)**
 1. INTRODUCTION
 2. OVERVIEW OF COGENERATION
 3. THE ICOP STUDIES: WHAT AND WHY
 4. ICOP FINDINGS AND CONCLUSIONS
 5. SPECIFIC ICOP RESULTS

HANDBOOK OF COAL-BASED ELECTRIC POWER GENERATION

**The Technology, Utilization, Application,
and Economics of Coal for
Generating Electric Power**

by Robert H. Shannon, P.E.

Consulting Engineer
Rockville, Maryland

The information in this book is directed toward providing a single, basic reference work which will be of assistance in future studies and evaluations by the utility industry and the nation, as they move in the direction of increased use of coal for power generation. In view of constant changes in regulatory policy, economic and energy goals, this book should be a handy and rapidly accessed source of useful and practical data on coal-based power.

The various chapters in the book detail the resource, its exploration and development; coal mining, cleaning, and transportation; utilization of coal as a fuel; environmental aspects of coal-fired power; and wastes disposal. Fundamentals included in all of the material have been keyed to provide in-depth understanding sufficient to serve as the basis for use in coal supply/utilization and electric power generation evaluations, as well as overall studies and planning leading to management decisions and action.

A condensed table of contents listing **chapter titles and selected subtitles** is given below. The book is copiously annotated with tables and figures.

1. INTRODUCTION

2. COAL AND LIGNITE RESOURCES

U.S. Coal Resources and Reserves
Summary of Coal and Lignite
Resources—Reserve Base—Recoverable
Reserves

3. COAL RESOURCE EXPLORATION AND DEVELOPMENT

Exploration and Development Drilling
Technology
Geophysical Logging of Drill Holes
Field Investigations
Estimating Reserves—Recoverable Tons
of "Clean Coal"

4. MINING

Coal/Lignite Mining
Surface Mining (Strip Mining)
Underground Mining

5. COAL PREPARATION—CLEANING

6. FUEL TRANSPORTATION

Rail/Barge Equipment and

Transportation Costs
Comparative Coal Transportation
Cost Data

7. FUEL PROPERTIES AND FACTORS

Fuel Properties
Fuel Analysis—Proximate/Ulimate
Fuel Heat Value
Fuel Properties and Factors Impacting
Boiler and Boiler Plant Design
Other Boiler Systems

8. FUEL UTILIZATION

Pulverized-Coal and Lignite-Fired
Boilers

9. FUEL PROCUREMENT

10. ENVIRONMENTAL FACTORS—COAL- FIRED POWER PLANTS

Stack Flue Gas Emissions
Ash and FGD Waste Disposal
Nitrogen Oxides
Stack Plume—Stack Gas Discharge
to the Atmosphere
"Acid Rain" and Coal-Fired Power
Plants
CO₂ "Greenhouse Effect"

11. FLUE GAS PARTICULATE CLEAN-UP

Electrostatic Precipitators
Baghouse Filter Facility
Areas of Concern
Scope of Supply and Comparative
Cost Data

12. FLUE GAS DESULFURIZATION (FGD)

Wet Lime and Limestone Systems
Double (Dual) Alkali FGD Systems
Dry SO₂ Scrubber System
FGD Systems—General
Areas of Concern
Other FGD Systems

13. ASH AND FGD WASTE DISPOSAL

Waste Disposal Options & Alternatives
FGD Waste Treatment and Disposal
System and Facilities

14. COST AND ECONOMICS—COAL-FIRED POWER PLANTS

Cost and Economic Criteria—Ground
Rules

APPENDICES

ELECTROSTATIC PRECIPITATOR MANUAL

by

Jack R. McDonald

Alan H. Dean

Southern Research Institute

Pollution Technology Review No. 91

This manual covers the fundamentals of electrostatic precipitation (ESP); mechanical and electrical components of electrostatic precipitators; factors influencing precipitator performance; measurement of important parameters; advantages and disadvantages of cold-side, hot-side, and flue gas conditioned electrostatic precipitators; safety aspects; maintenance procedures; troubleshooting procedures; the usage of a computer model for electrostatic precipitation; and features of a well-equipped electrostatic precipitator.

The manual is a summary of the results of studies performed by various individuals and organizations on the applications of electrostatic precipitators to the collection of fly ash particles produced in the combustion of pulverized coal. These studies include comprehensive performance evaluations of full-scale precipitators, in-situ and laboratory measurement of fly ash resistivity, rapping reentrainment investigations, tests to evaluate the effects of flue gas conditioning agents on precipitator performance, investigations into the fundamental operation of hot-side precipitators, basic laboratory experiments, and development of a mathematical model of electrostatic precipitation.

A condensed table of contents listing **chapter titles and selected subtitles** is given below.

1. INTRODUCTION

2. TERMINOLOGY AND GENERAL DESIGN FEATURES

3. FUNDAMENTAL PRINCIPLES OF ESP

- General Considerations
- Creation of Electric Field and Corona Current
- Particle Charging
- Particle Collection
- Removal of Collected Material

4. LIMITING FACTORS AFFECTING PRECIPITATOR PERFORMANCE

5. USE OF ELECTROSTATIC PRECIPITATORS FOR COLLECTION OF FLY ASH

- General Description
- Precipitator Shell
- Electrical Sections
- Electrical Energization

- Discharge Electrode System
- Collecting Electrode System
- Ash Removal Designs
- Rappers
- Hoppers
- Dust Removal Systems
- Gas Flow Devices
- Cold-Side Precipitators
- Hot-Side Precipitators
- Compilation of Installations

6. ANALYSIS OF FACTORS INFLUENCING ESP PERFORMANCE

- Particle Size Distribution
- Specific Collection Area
- Voltage-Current Characteristics
- Resistivity of Collected Fly Ash
- Limitations Due to Non-Ideal Effects

7. EMISSIONS FROM ELECTROSTATIC PRECIPITATORS

8. CHOOSING A PRECIPITATOR: COLD-SIDE vs HOT-SIDE vs CONDITIONING AGENTS

9. SAFETY ASPECTS

- Rules and Regulations
- Fire and Explosion Hazards
- Electric Shock Hazards
- Toxic Gas Hazard

10. MAINTENANCE PROCEDURES

11. TROUBLESHOOTING

- Diagnosis of ESP Problems
- Available Instrumentation

12. AN ESP COMPUTER MODEL

- Capabilities of the Model
- Basic Framework
- Latest Improvements
- Applications and Usefulness of the Model

13. FEATURES OF A WELL-EQUIPPED ELECTROSTATIC PRECIPITATOR

REFERENCES

APPENDICES

- Power Plant and Air Quality Data
- Cascade Impactor Stage Parameters
- Particulate Matter, SO_x, and NO_x Limits in the U.S.
- Low Temperature Corrosion and Fouling

Contents and Subject Index

PART I: EUROPEAN TECHNOLOGY

1. LOAD MANAGEMENT	2
Battelle-Geneva Burner Control System	2
Gas Turbines, Egatrol	6
Flue Gas Oxygen Probe System	7
Inter-Comp (Flame Energy Optimization System)	8
CSA Automatic Sequencing Controls for Gas Burners	9
Fuel/Air Ratio Control System	9
Combustion Control System	10
2. COGENERATION	11
Cogeneration of Electrical Energy and Process Steam	12
Total Energy System	15
CHP, Combined Heat and Power	15
Cogeneration of Steam and Electric Energy	16
Combined Cycle Power Plant	19
Diesel or Gas Engine with Exhaust Gas and Cooling Water Heat Recovery	19
Cogeneration and Peak Shaving System	20
Total Energy System	21
Totem (Total Energy Module)	22
3. HEAT RECOVERY	23
The Evertube Heat Exchanger	24
The Total ECO Flue-Gas Condenser	25
Recitherm RBG Flue Gas Washer	26
High-Temperature Glass Pipe Heat Exchanger	26

4. BURNERS AND SPECIAL GAS-USE TECHNIQUES.	28
Oxygen Enrichment.	28
Use of Oxygen	28
Linde Oxygen Burner.	29
Oxygen Fuel Burner.	30
Recuperative Burner	32
Hotwork Recuperative Burner	35
Heye-Proportional Burner for Firing of Gas and Oil	36
Radiant Plate Burners Type R.N.	38
URG Type RCS Radiant Burner System	42
Porous Radiant Burner System.	44
High-Velocity Burners	49
URG Type T High-Velocity Jet Burners.	50
Vatpak Tank or Vat Heating	54
Senator 700 Direct-Gas-Fired Water Heater	59
Thermimax Burner	62
5. METAL REHEATING AND HEAT TREATMENT FURNACES	65
Forge Furnaces.	65
Direct-Fired Large Continuous Reheating Furnaces	69
Pusher Type Furnace	70
Walking Beam Furnace.	70
6. DIRECT-FIRED BATCH FURNACES AND SOAKING PITS	72
Quenching and Tempering Furnaces for Oil Pipes	75
7. INDIRECT-FIRED HEAT TREATMENT FURNACES.	76
Metallic Radiant Tube Furnaces.	76
Ceramic Radiant Tube	77
8. CRUCIBLE FURNACES	78
Crucible Melters (UK)	79
Crucible Melter (France).	80
Immersed-Crucible Furnace.	83
The Development of Ceramic Immersion Tubes.	85
9. REVERBERATORY FURNACES	93
Dry Hearth Furnace.	93
Basin Furnace.	94
10. NON-FERROUS METALS REHEATING	97
Non-Ferrous Metals Rapid Heaters	97
Heat Treating of Non-Ferrous Metal Strip	98
11. INERT ATMOSPHERE GENERATORS	101
Endo-, Exo-, and Mono-Gas Generators	101

12. GLASS MELTING AND PRODUCTION PROCESSES	108
Heye Glass Melting Furnaces	108
"Particle Veil" Glass Melting Process.	113
Saint Gobain Emballage Glass Melting Furnaces	119
Sorg Glass Melting Furnaces	124
CNUD Lehrs for Annealing and Decorating Glass.	126
Le Four Industriel Belge Annealing Lehrs for Glass	127
Cobelcomex Lehrs for Annealing and Decorating Glass.	129
13. STRUCTURAL CLAY PRODUCTS	132
Brick Firing Kilns	134
Fast-Firing Porcelain Kilns	135
14. FOOD PROCESSING.	136
Steriflamme and Steril-Vac Food Canning Processes.	137
15. FUME INCINERATION.	142
Air Industry Generator Incinerator (AIGI).	143
REFERENCES.	146

PART II: JAPANESE TECHNOLOGY

16. LOW NO_x BURNER TECHNOLOGY.	148
Sunray XB Gas Burner	148
NFK-SRG Type Gas Burner.	150
17. WASTE HEAT RECOVERY	158
Absorption Air Conditioner Powered by Waste Heat from Industrial Furnace.	158
MERCS (Mitsubishi Energy Recovery and Conservation System) . . .	163
Daido Silent Recuperator	164
Top Pressure Recovery Turbine	172
New Absorption Air Conditioner	173
IBI-Wool Super Honeycomb	178
18. METAL PROCESSING EQUIPMENT	180
Large Walking Beam Furnace.	189
Continuous Strip Annealing Furnace.	191
19. CONTINUOUS CASTING.	195
Powder Metallurgy (Hot Isostatic Press).	196
Tower Type Jet Melter for Aluminum.	202
Daido High-Speed Melter for Aluminum	210
SE-Type Crucible Furnace for Light Alloys	211
20. ABSORPTIVE GAS ATMOSPHERE GENERATOR	217
Absorptive Gas Atmosphere Generator (O.G. Type).	217

21. CRUCIBLE FURNACE FOR COPPER ALLOYS	222
Tilting Type Crucible Furnace for Copper Alloys.	222
22. GLASS RESEARCH FURNACE	225
23. LIME AND KILN TECHNOLOGY	232
Fluid Bed Lime Calciner.	233
24. HYDRAULIC CEMENT PRODUCTION	240
Cement Kiln Technology	240
Dual Combustion and Denitration Process (DD Process)	243
Gas Generator (GG) Process	251
25. TEXTILES	259
Fabric Dyeing.	259
Hirano Heat Setting S-Tenter.	261
26. PAINT DRYING SYSTEM	267
Air Heating Furnace.	269
27. LNG COOLING TECHNOLOGY	272
Manufacture of Liquid Nitrogen and Liquid Oxygen Utilizing LNG Cooling	274
Resource Recovery of Waste by Low Temperature Grinding	278
Waste Tire Recycling Process	280
Metallic Waste Recycling Process	285
Extra Fine Crushing System Linrex Mill.	285
Osaka Gas LNG Cold-Power Generation System	288
Frozen Food Energy Recovery.	293

PART III: SELECTED TECHNOLOGIES—IN-DEPTH STUDIES

28. INTRODUCTION	299
29. BURNERS	300
Gas Lance and Insulated Burner for Glass Melting	300
Thermimax Burner	308
Radiant Burner.	316
GNC Low NO _x Burner	322
Porous Tunnel Burner	330
30. ALUMINUM MELTING FURNACES	340
The Nikkan Tower Jet Melter	340
Daido High-Speed Aluminum Melter	360
High Efficiency Reverberatory Aluminum Melting Furnace.	370
Aluminum Melting Furnace Comparison Summary	373

31. HYDRAULIC CEMENT KILNS.	375
Dual Combustion and Denitration Process (DD Process)	377
32. GLASS MELTING TECHNOLOGY	388
Particle Veil Glass Melting Process	388
33. GENERATOR INCINERATOR	409
Air Industrie Generator Incinerator.	409

Part I

EUROPEAN TECHNOLOGY

The information in Part I is from *Energy Efficient Industrial Technology in Europe: A Compendium* (GRI Report 80/0147), prepared by A.G. Fassbender and M.J. McGee of Battelle, Pacific Northwest Laboratories for Gas Research Institute, August 1982.

1. Load Management

Load management technology is usually electro-mechanical equipment that controls the inputs of a process. It ranges in complexity from simple gauges to computer systems. Load management equipment on gas-fired appliances controls the combustion of a fuel to minimize pollution, maintain product quality, conserve energy and ensure safe operating conditions. U.S. technology in load management systems is very strong. High technology load management equipment is usually made up of several components. These components include sensor or transducer equipment, electronic systems or microprocessors and servo-mechanical equipment. Technology advances in any one of these component areas improves load management technology as a whole. The recent advances in microprocessors has brought a new sophistication to load management systems. Research on in-situ combustion gas analyzers is steadily improving sensor technology. The National Bureau of Standards has an ongoing effort to develop advanced furnace sensors.

The complexity of a load management system is related to the scale and complexity of the equipment being controlled. Oil refineries have large complicated control systems that monitor far more than just combustion variables. This can be contrasted with small furnaces equipped with a thermocouple and a hand operated valve. This study will focus on the larger scale, sophisticated technologies.

BATTELLE-GENEVA BURNER CONTROL SYSTEM

The Battelle-Geneva Burner Control System (BCS) was developed as part of the Battelle Energy Program established in 1973. Patent applications are in place in France, UK, West Germany, and Japan. The BCS received U.S. Patent No. 4,118,172 on October 3, 1978.

Developer

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Application

For many precision combustion applications, control systems are required that will supply both a demand heat flux and a fixed fuel-air ratio relative to stoichiometric. This results in a need for two measurements in the control system for cases where the fuel composition is variable. In the Battelle burner control system concept, the two required signals to control the air flow rate and the fuel flow rate are generated in a control burner.

In the version discussed here, the signals are generated by simultaneous measurements in the control burner of the hot flue gas temperature near the flame and the heat release rate (using calorimeter principles).

The uniqueness associated with the Battelle burner control system relates to the temperature measuring aspect. The flame temperature sharply peaks close to stoichiometric. The air flow and fuel flow to the control burner are maintained in preset proportions relative to the respective flow rates to the main burner. The flow of air (or fuel) is supplied to the control burner with an alternating current component. The temperature output is compared with the instantaneous air flow rate. If the high temperature is associated with a low air flow rate, the main air flow rate is reduced, and vice versa. This process continues until the temperature signal is essentially constant. At this point, the control burner will be operating slightly on the rich side of stoichiometric. With the proper offset, the main burner will be operating at the desired mixture ratio. Changes in load or fuel composition are rapidly compensated for.

Fuel and air systems can be interchanged and interconnected, parameters other than temperature may be used, and the alternating current (AC) air component may be replaced by other oscillatory patterns.