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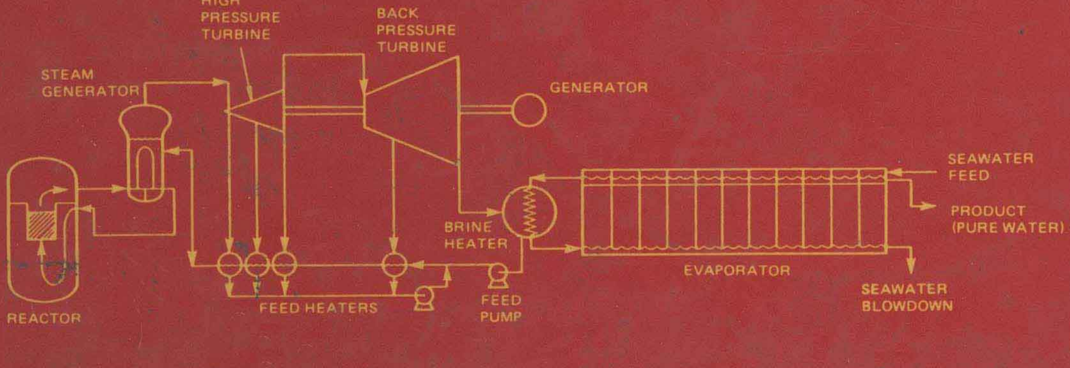
UTILIZATION OF REJECT HEAT

MITCHELL OLSZEWSKI



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To Patricia, Brandon, and Leona Olszewski
and in memory of Bernard Olszewski

Preface

Because of the growing scarcity of inexpensive energy resources, energy conservation efforts in this country have recently been accelerated. These efforts can generally be categorized as reductive or productive techniques. Reductive techniques include efforts such as reduced lighting, lower winter thermostat settings, and fewer automobile miles driven. Although these efforts are effective in conserving energy, they are associated with a decline in the standard of living, and their long-term effectiveness is uncertain.

Productive energy conservation efforts, in contrast, seek to reduce energy consumpton by increasing the efficiency with which energy resources are utilized. Since these techniques more readily allow the standard of living to remain stable or improve while reducing energy consumption, they offer a promising energy conservation approach for achieving long-term energy conservation goals. Because of these factors, productive energy conservation efforts have received a great deal of attention in the past several years.

Two major productive energy conservation options are addressed in this text. The first is utilization of reject heat, and the second is the use of dual-purpose power generation systems to minimize the quantity of reject heat produced. As used throughout this text, the term "reject" or "waste heat" refers to energy that is rejected from a process after it is no longer of economic value to that process. The term "dual-purpose power production" indicates applications where energy that does have economic value in the power cycle is used for other, more valuable processes. Since dual-purpose applications reduce the total amount of energy "wasted," they are frequently referred to as reject heat utilization systems and have, therefore, been included in this text.

Information concerning the subject of waste heat utilization has been published in various periodicals, conference proceedings, and other works. However, this information is scattered and sometimes difficult to obtain. This text was, therefore, written to provide the reader with a comprehensive background in reject heat utilization techniques without having to consult other sources. The techniques presented in this book include well-established industrial practices as well as technologies that are presently in the experimental or analytical study phase. Since the design of many of these systems depends upon site-specific conditions, an effort has been made to concentrate on system fundamentals. Engineering and economic data, however, are also presented for a number of examples to give the reader a firm background in the technical and economic aspects of these technologies.

In terms of organization, the text has been subdivided into two major sections. These sections correspond to the two major topics addressed in the book. The first section, dealing with utilization of reject heat, contains two chapters. The first deals with uses for low-grade reject heat such as that rejected in the condenser of a power generating facility. The second chapter explores uses for industrial reject heat. Since this energy is typically available at higher temperatures, the spectrum of possible uses is different from that for the low-grade utility reject heat.

The second section of the book, dealing with reject heat reduction techniques, examines dual-purpose power production applications. Chapters concerning available coupling technology, district heating, and desalting are designed to familiarize the reader with utility-scale dual-purpose plant applications. The chapter concerning industrial cogeneration is included to acquaint the reader with the scope, techniques, and energy and cost benefits of cogeneration when applied on a smaller scale.

This book has been designed to provide a comprehensive background in productive energy conservation techniques for scientists, engineers, consultants, government policy makers, and students. Hopefully, it will provide meaningful input for decisions that must be made if significant energy conservation efforts are to be implemented.

Mitchell Olszewski

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I

UTILIZATION OF REJECT HEAT

1

Use of Low-Grade Reject Heat

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I. INTRODUCTION

Low-grade [65.6°C (150°F) or lower] reject heat streams are commonly found in many industries throughout the United States. Previously, this heat was considered useless and was rejected either to the atmosphere or to a receiving body of water. With the advent of Environmental Protection Agency (EPA) discharge regulations concerning thermal effluents, disposal of this reject heat became costly. This resulted in a negative value being placed on waste or reject heat streams. Recent emphasis on energy conservation and maximum resource utilization, however, has stirred interest in the productive use of this potential resource. As a result, a number of economically viable uses for this heat have been identified and developed; and several utilities have begun to view power plant reject heat as a potentially saleable by-product.

A. Quantity and Characteristics of Reject Heat

The electrical generation and industrial sectors are the two major sources of recoverable low-grade reject heat in the United States. Together, they annually reject about 17.5×10^9 GJ (16.6×10^{15} Btu) to the environment. This is equivalent to about 22% of the total energy consumption in the United States. Thus, utilization of this heat represents a potentially significant energy resource.

As a consequence of the second law of thermodynamics, the electric utility industry annually rejects about 11.6×10^9 GJ (11×10^{15} Btu) of low-grade heat. This heat is contained in the condenser cooling water; and its characteristics will, therefore, vary with power plant design and site weather conditions. Basically, the flow rate is fixed by the plant design while the cooling water effluent temperature varies with ambient weather conditions. For example, a once-through system designed for a temperature rise of 7.8°C (14°F) will require about 0.038 m^3/s (1.34 cfs*) for each megawatt (MW) of generating capacity. During normal operation, the

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*Cubic feet per second.