Design Guide: Combustion Turbine Inlet Air Cooling Systems

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TABLE OF CONTENTS

Introduction

Combustion Turbine Inlet Air Cooling ix
Cooling Designs to Increase Turbine Capacity ix

Chapter 1 Combustion Turbines and Inlet Air Cooling

1.1 Turbines 1
1.2 Turbine Performance 2
1.3 Turbine Inlet Air Cooling 6
Capacity Enhancement 7
Heat Rate Improvement 8
Turbine Life Extension 8
Increased Combined-Cycle Efficiency 9
Delayed New Generation 9
Base-Load Efficiency Improvements, Thermal Storage 9
Efficiency Improvements, Base-Loaded Turbines 10
Elimination of Water Injection 10
Other Considerations 10

Chapter 2 Air Cooling Systems

2.1 Types of Cooling Systems 13
2.2 Psychrometrics of Inlet Air Cooling 13
Evaporative Cooling 14
Secondary Fluid Cooling 16
Altitude Effects 16
Secondary Fluid Cooling 18
Direct Refrigerant Cooling 19
2.2.1 Sensible or Latent Cooling 20
2.3 Air Cooling System Equipment 22
2.3.1 Electricity-Driven Chillers 23
2.3.2 Absorption Chilling and Heat Recovery Equipment 24
2.3.3 Evaporative Cooling Equipment 26
2.3.3.1 Wetted Media 26
2.3.3.2 Water Sprays 26
2.3.4 Chilled Water/Air Direct Contact Equipment 27
2.3.5 Engine/Turbine-Driven Chiller Equipment 28

2.3.6 Packaged Turbine and Air Cooling Equipment 29
2.4 Thermal Energy Storage 29
2.4.1 Ice Thermal Energy Storage 32
2.4.2 Chilled-Water Thermal Energy Storage 33
2.4.3 Eutectic Thermal Energy Storage 33
2.5 Combinations of Cooling Equipment 33
2.5.1 Storage and Refrigerating Systems 33
2.5.2 Vapor Compression (or Absorption) and Evaporative Cooling 36
2.6 Heat Rejection Considerations 37
2.7 Heat Exchanger Requirements 38
2.7.1 Refrigerant Coils 39
2.7.2 Secondary Fluid Coil Designs 39
2.8 Pressure Loss Considerations 39
2.9 Potential Icing Conditions 40
2.10 Fluid Pumping Considerations 42
2.11 Controls and Instrumentation 42
2.12 Water Treatment 42
2.13 Generator Cooling 43
2.14 Transformer Cooling 43
2.15 Lube Oil Cooling 44
2.16 Rotor Blade Cooling 45
2.17 Maintenance 45
2.18 Other Considerations 45

Chapter 3 Air Cooling Economics

3.1 Assessing the Benefits of Inlet Air Cooling 47
3.2 Thermodynamic Parameters Affecting Economics 47
3.3 Market and Regulatory Considerations 53
3.4 Preliminary Budgeting 54

Chapter 4 Air Cooling Operational Experiences

4.1 Case Study #1 Utility Peaking Combustion Turbine—Inlet Air Cooling Using Chilled Water (SFC) and Ice Thermal Storage 55

4.2 Case Study #2 Energy Company Combustion Turbine—Inlet Air Cooling Using Direct Refrigerant Cooling 60

4.3 Case Study #3 Utility Peaking Combustion Turbine—Inlet Air Evaporative Cooling System 61

4.4 Case Study #4 Energy Company Combined-Cycle Turbines/Cogeneration—Inlet Air Cooling Using Chilled Water (SFC) and Ice Thermal Storage 64

Chapter 5 Inlet Air Cooling Implementation

5.1 Preliminary Evaluation 67

5.2 Preliminary Economic Evaluation 68

5.3 Project Design 69

5.4 Selecting Design Professionals 70

5.5 Project Implementation 71

5.6 Project Schedule 71

5.7 Sizing the Cooling Load—An Example 72

References and Bibliography 75

Nomenclature 81

LIST OF FIGURES

Figure 1 Typical combustion turbine system.

Figure 2 Typical combined cycle system.

Figure 3 Typical turbine power output and heat rate vs. inlet air temperature.

Figure 4 Schematic of the open Brayton cycle gas turbine system.

Figure 5 Idealized Brayton cycle pressure and temperature cycles.

Figure 6 Turbine efficiency as a function of compressor pressure ratio.

Figure 7 Pressure ratio effect upon efficiency for a combined cycle.

Figure 8 Power output as a function of inlet ambient air temperature for evaporative cooling for a GE 7001B turbine (derived from Oliker 1990).

Figure 9 Effect of inlet air temperature for the frame 7B turbine at Lincoln Electric.

Figure 10 Schematic of evaporative, sensible, and latent cooling processes (ambient air temperature at 100°F (37.8°C) and 30% relative humidity [approximately 74°F (23.3°C) wet-bulb temperature]) for sea level elevation (ASHRAE 1993).

Figure 11 Schematic of an evaporative cooling process from an ambient air temperature at 100°F (37.8°C) and 30% relative humidity (approximately 74°F [23.3°C] wet-bulb temperature) for 5000 ft (1524 m) elevation (ASHRAE 1993).

Figure 12 Schematic of a typical CTIAC system using a mechanical chiller with direct air cooling.

Figure 13 Schematic of a typical CTIAC system using a mechanical chiller with secondary fluid cooling.

Figure 14 Schematic of a typical CTIAC system using absorption chiller with secondard fluid cooling.

Figure 15 Schematic of a typical CTIAC system using evaporative air cooling shown with optional water treatment.

Figure 16 Schematic of a typical CTIAC system using water spray direct contact cooling.

Figure 17 Schematic of a typical CTIAC system using a direct-drive chiller and an HRSG for an absorption chiller in a combined cycle.

Figure 18 Schematic of a typical CTIAC system using ice storage, chilled water SFC air cooling.

Figure 19 Schematic of a typical CTIAC system using chilled water storage SFC.

Figure 20 Schematic of a typical CTIAC system using absorption chiller direct air cooling with a heat recovery steam generator.

Figure 21 Schematic of a typical CTIAC system using a mechanical chiller and SFC air cooling with a heat recovery steam generator in a combined cycle.

Figure 22 Schematic of a typical CTIAC system using an absorption chiller and SFC air cooling with a heat recovery steam generator in a combined cycle.

Figure 23 Schematic of a typical CTIAC system using an absorption chiller direct air cooling with a heat recovery steam generator in a combined cycle.

Figure 24 Reactive capability curves for Rokeby generator.

Figure 25 Approximate capital cost of an ice storage CTIAC system vs. turbine operating hours.

Figure 26 Site plan for peaking CTIAC system at Rokeby station.

Figure 27 Site plan for peaking combined-cycle CTIAC system at Fayetteville.
Figure 28 Simplified site plan for the CTIAC system at Greenwood.
Figure 29 Ice storage scenario for the Gilroy GT site.
Figure 30 Simplified site plan for the Gilroy GT installation.

LIST OF TABLES

TABLE 1 Effectiveness and Performance Index for Some Combustion Turbines
TABLE 2 Relative Benefits and Costs for W501AB Combustion Turbine
TABLE 3 Some CTIAC Design Parameters and Approximate Costs (1991 Costs)
TABLE 4 Inlet Air Temperatures at Rokeby
TABLE 5 Temperature and Capacity Test Results at Greenwood for Some of the Four Combustion Turbines
TABLE 6 Some Test Results for the Gilroy Site
TABLE 7 Relative Incremental Generation Costs
TABLE 8 Installed Cooling Equipment Relative Cost per Ton and Parasitic Power
TABLE 9 Typical CTIAC Design and Construction Schedule

FOREWORD

This design guide is dedicated to my parents, for an engineering vocation and an outdoor life avocation, Betty Jane Hartman Stewart and the late William Edward Stewart... *the hunter home from the hill.*

This design guide is a result of cooperative research between the American Society of Heating, Refrigerating and Air-Conditioning Engineers and InterMountain Research, Olathe, Kansas, under Research Project 902, sponsored by TG 9.CTIC, Task Group on Combustion Turbine Inlet Cooling.

The design guide is intended to be an introduction to the design of combustion turbine inlet air cooling systems, recognizing the benefits and limitations and assisting in the successful design and implementation of combustion turbine inlet air cooling systems. The guide is not intended to be a substitute for competent engineering design professionals. There are many design considerations and options that should be addressed by professional engineers.

The author would like to express appreciation to the Task Group on Combustion Turbine Inlet Cooling for providing the opportunity to perform this research and the assistance and guidance of its members, especially the members of the Project Monitoring Subcommittee, including Brian Silvetti (PMS chair) of Calmac Manufacturing, Jerry Ebeling of Burns and McDonnell Engineering Co., Dave Knebel of Mammoth, Sriram Somasundaram of Pacific Northwest National Laboratory, and Chris Landry of BBA Energy Services. The principal investigator would like to thank Lisa Stickler for technical support and Chuck Saunders for graphics support.

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INTRODUCTION

Combustion Turbine Inlet Air Cooling

Increasing the combustion turbine inlet airflow rate is a common modification to increase the power and net efficiency of power-generating equipment, including automotive engines with inlet air compressors (turbos) and power-producing combustion turbines with supercharging or inlet air cooling. There are many designs available for combustion turbine inlet air cooling. This design guide is intended to provide some of the information that needs to be considered in applying technologies to combustion turbine inlet air cooling (CTIAC) systems. The use of inlet air cooling as a viable design option to increase the capacity of combustion turbines and combined-cycle systems is widely accepted. A presentation of some of the accepted methods and techniques used in CTIAC applications is provided to help designers, engineers, utilities, and customers understand CTIAC fundamental designs. Design parameters, possible equipment options, controls, operation, maintenance, and economics are considered, along with a review of some successful installations.

Some of the parameters that affect the selection, installation, and operation of a CTIAC system include the type of combustion turbine (industrial single shaft or aeroderivative), climate, hours of operation, the ratio of airflow rate to power generation, the rate of generation increase with decreasing temperature, the air cooling method, inlet pressure loss due to cooling coils or wetted media, controls, fuel costs and availability, maintenance costs, pumping requirements, thermal storage type and charging/discharging strategies, the value of power sales, and the cost of purchased power.

Cooling Designs to Increase Turbine Capacity

CTIAC systems are designed to increase the capacity of a combustion turbine/generator for maximum power production and, potentially, to increase overall system net efficiency. CTIAC systems typically decrease heat rate and tend to increase overall system efficiency when all parasitic losses are considered. Some CTIAC designs are intended for combustion turbines that operate only a few hours per year, for demonstrating power reserve or for operating only during peak energy demand. For combustion turbines operating only a few hours per day, thermal storage can be advantageous to allow cooling during turbine operation without the coincident parasitic power of cooling equipment. The cooling coils can use closely spaced fins for maximum cooling, as they require minimum cleaning due