Enhancing the Performance of Combined Cycle Power Plants through Intake Air Cooling

By

Eng. **Anas Abdel-Motaleb Ali Mostafa**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
Mechanical Power Engineering

FACULTY OF ENGINEERING, CAIROUNIVERSITY
GIZA, EGYPT
2018

Enhancing the Performance of Combined Cycle Power Plants through Intake Air Cooling

By

Eng. **Anas Abdel-Motaleb Ali Mostafa**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
Mechanical Power Engineering

Under Supervision of

Prof. Dr. **Mahmoud A. Fouad**

Professor of Mechanical Power Engineering
Faculty of Engineering
Cairo University

Dr. **Taher M. Halawa**

Assistant Professor of Mechanical Power Engineering
Faculty of Engineering
Cairo University

FACULTY OF ENGINEERING, CAIROUNIVERSITY
GIZA, EGYPT
2018

Enhancing the Performance of Combined Cycle Power Plants through Intake Air Cooling

By

Eng. **Anas Abdel-Motaleb Ali Mostafa**

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
Mechanical Power Engineering

Approved By the Examining Committee

Prof. Dr. **Mahmoud Ahmed Fouad** **(Thesis Main Advisor)**
Mechanical Power Engineering Dept., Faculty of Engineering, Cairo University

Prof. Dr. **Samy Mourad Morkos** **(Internal Examiner)**
Mechanical Power Engineering Dept., Faculty of Engineering, Cairo University

Prof. Dr. **Karam Mahmoud Hassan El-Shazly** **(External Examiner)**
Mechanical Engineering Dept., Faculty of Engineering - Shoubra, Benha University

FACULTY OF ENGINEERING, CAIROUNIVERSITY
GIZA, EGYPT
2018

Engineer: **Anas Abdel-motaleb Ali Mostafa**
Date of Birth: 31 / 01 / 1987
Nationality: Egyptian
E-mail: anas.teleb@gmail.com
Phone.: 002 01001981195
Address: 31 Iran St. - Dokki
Registration Date: 01 / 03 / 2018
Awarding Date: / / 2018
Degree: DOCTOR OF PHILOSOPHY
Department: Mechanical Power Engineering

Supervisors: **Prof. Dr. Mahmoud Ahmed Fouad**
Dr. Taher Mohamed Halawa

Examiners: **Prof. Dr. Mahmoud Ahmed Fouad** (Thesis Main Advisor)
Prof. Dr. Samy Mourad Morkos (Internal Examiner)
Prof. Dr. Karam Mahmoud Hassan El-Shazly (Professor, Mechanical Engineering Dept., Faculty of Engineering - Shoubra, Benha University)

Title of Thesis: **Enhancing the Performance of Combined Cycle Power Plants through Intake Air Cooling**

Key Words: Power Generation; Economical Study; Absorption Chiller; Inlet Air Cooling, Thermal Storage.

Summary:
The thesis investigates the effects of entry air cooling on the performance enhancement of combined cycle power plants. Air cooling is achieved by chilled water that obtained by either a mechanical or absorption chiller. The work is applied to 801 MW El-Kuriemat combined cycle power plant, Egypt as a case study. Thermodynamic model was developed to simulate the combined cycle before and after the integration to the proposed cooling systems. Direct data are collected from the plant. Two sets of correlations between the performance parameters and the inlet temperature are developed. The governing equations and the developed correlations are solved using Engineering Equation Solver (EES) and the results are compared with those of each other. The power plant performance without and with the proposed two air cooling systems are obtained at different ambient conditions. Net income due to the power increase and the payback period are obtained. The results of each system are compared with that obtained by the other one as well as the similar results available in the literature. Using the chiller cooling system to reduce the ambient temperature of 30.5 to 15 °C and 100% relative humidity could increase the instantaneous net output power by 8.6 %, and 11% for mechanical and absorption chillers, respectively. The payback periods are 3.3 and 3.85 years for mechanical and absorption chillers, respectively. The internal rate of return is 30.63 % and 25.91%, years for mechanical and absorption chillers, respectively. The net present value is 8.28 and 6.24 MUS$ for mechanical and absorption chillers, respectively. The total electric energy increase is 190,228 MWh/year and the net cash flow is 2.64 MUS$/year obtained after using the mechanical system while the corresponding values produced after using the absorption system are 181,994 MWh/year and the net cash flow 2.38 MUS$/year.

ACKNOWLEDGMENT

Thanks to ALLAH (SWT) who created and guided me to the right path.

The author gratefully acknowledges Prof. Mahmoud Fouad for his sincere and thoughtful guidance and assistance throughout the research undertaken. Sincere thanks are also due to Dr. Taher Halawa for sharing the supervision of the thesis.

Many thanks are due to Prof. Samy Mourad and Prof. Karam El-Shazly the members of the examining committee for all their valuable comments added to this research.

Many thanks to all faculty members of the mechanical power department, faculty of engineering, Cairo university where I learned the principles of mechanical engineering and to my colleagues at Allied, ECG, and DAR companies where I applied my engineering knowledge to produce sound designs of air conditioning systems. Many thanks are also due to the staff of El-Kuriemat power plant for their cooperation and help.

Endless thanks to my father who guided, raised and supported me all the way. Jihan H. Sherief; my great mother deserves special thanks for all what she had given to me. Thanks to all who have brought great joy to my life especially my wife; Marwa Basiouny and my second mother Aml AbdelAkher. It wouldn't have been without you, thank you all so much.

"They said, glory to you, we have no knowledge except what you have taught us, indeed you are the all-knowing and the all-wise", Al-Baqara, verse 32

"And of knowledge, you (mankind) have been given only a little", Al-Isra', verse 85

DEDICATION

To my father .. my backbone in my life .. who gives me direction and support to the sky

To my mother who gives me lovely life

To my wife who shines my heart

To my brothers and sister who gives me support

TABLE OF CONTENTS

LIST OF TABLES

Table Number

LIST OF FIGUERS

Figure Number