ENERGY AND AVAILABILITY ANALYSIS OF THE STEAM POWER PLANTS
CASE STUDY: ABU QIR POWER PLANT UNIT 5

By

Mohamed Sherif Ahmed Ahmed Rabie

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE
in
MECHANICAL POWER ENGINEERING

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Title of Thesis: Energy and Availability Analysis Of The Steam Power Plants, Case Study: Abu Qir Power Plant Unit 5

Key Words: Energy; Exergy; Exergy Destruction; Irreversibility; Thermodynamic Analysis; Efficiency; Availability.

Summary:

In this study, An energy and exergy analysis were made on the Abu Qir power plant unit 5 in Alexandria, Egypt to measure the performance of the unit and to identify the plant components that have the largest amounts of losses.

The analysis was made on the loads 277 MW, 260 MW, 233 MW and it is compared with the design load . The largest amount of exergy destruction was found at the load of 277 MW where the highest exergy destruction was found in the boiler which destroyed 405.6 MW. It is followed by the turbine where 66.3 MW was lost to the environment. The condenser was the third highest source of irreversibility with a value of 13 MW. The 1st and 2nd law net efficiencies in this case were 37.54% & and 35.41% respectively.

In addition, The exergy efficiency of the turbine and boiler decreased when the environment temperature raised (as in the summer) while the condenser efficiency increased. Each decrease in the intermediate turbine steam inlet temperature by 10 degrees will cause the unit load to decrease by 5 MW and the thermal efficiency by 0.73%. Also, each raise in the condenser pressure by 0.01 bar, the unit load decrease by 0.7 MW and the thermal efficiency drop by 0.8%.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Date:

Signature:

Dedication

I dedicate this thesis to the soul of my beloved mother (may god bless her) who was the source of my persistence.

Acknowledgments

In the beginning, I am grateful to God for the good health and well-being that are necessary to complete this thesis. I am also using this opportunity to express my gratitude to everyone who supported me throughout the study. I am thankful for their aspiring guidance, invaluably constructive criticism and friendly advice during the work. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to this thesis.

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Nomenclatures

C_p	Cooling water specific heat (kJ/kg.^{0}C)
h	Specific enthalpy (kJ/kg)
I	Destructed exergy (MW)
ṁ	Mass flow rate (kg/s)
P	Pressure (bar)
Q	Heat (MW)
s	Specific entropy (kJ/kg.K)
T	Temperature (^{0}C)
W	Work (MW)
X	Total exergy (MW)

GREEK SYMBOLS

Ψ	Specific exergy (kJ/kg)
ξ	Ratio of chemical exergy to the LHV
η_I	Energy efficiency (%)
η_{II}	Exergy Efficiency (%)

SUBSCRIPTS

b	boiler
c	condenser
e	exit
f	fuel
h	heater
i	inlet
j	pre-specified point
o	dead state
p	pump
t	turbine

ABBREVIATIONS

DRT	Drain Recovery Tank
FLT	First law of thermodynamics
FWT	Feedwater Tank
HPT	High Pressure turbine
IPT	High Pressure turbine
LHV	Lower Heating Value
LPT	High Pressure turbine
SLT	Second law of thermodynamics

Abstract

In this study, An energy and exergy analysis were made on the Abu-Qir power plant unit 5 in Alexandria, Egypt to measure the performance of the unit and to identify the plant components that have the largest amounts of losses.

The analysis was made on the loads 277 MW, 260 MW, 233 MW and it is compared with the design load. The largest amount of exergy destruction was found at the load of 277 MW where the highest exergy destruction was found in the boiler which destroyed 405.6 MW. It is followed by the turbine where 66.3 MW was lost to the environment. The condenser was the third highest source of irreversibility with a value of 13 MW. The 1^{st} and 2^{nd} law net efficiencies in this case were 37.54% & and 35.41% respectively.

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Chapter 1 : Introduction

1.1 Egypt energy crisis

Egypt energy production sector is confronting in the present a lot of conflicting and hard challenges. This is seen in Egypt's huge efforts to make a balance between production, domestic consumption, and export revenue, while seeking to maintain internal political stability.

Despite that Egypt is the largest non-OPEC oil producer in Africa, the second largest gas producer in the continent and while the country is doing an essential role in regional and global energy markets, the country's energy production status through the last years reflects the opposite on all levels.[1]

This problem is a the result of historical 'mal-planning' as it is the consequence of the country's past years of political disturbance after the 2011 revolution. However, starting from late 2014 investment and economic growth began picking up on the back of political stability. Fixed investment was set to be the primary driver of growth as a result of greater clarity and transparency in Egypt's economic policy. Furthermore, the current government firmly displayed some extreme measures to quickly fix the energy producing sector. This is most likely disclosed under the pillars of the new energy strategy, including:

1. Security, by boosting, diversifying and improving energy efficiency.
2. Sustainability, by addressing debt build-up and phasing out of subsidies in a socially responsible manner.
3. Governance, by improving and modernizing the oil and gas sector's governance and encouraging private sector investment.

1.2 Electricity projects and plans

1.2.1 Power plants projects [3]

1. Five year plan (2012 - 2017)

- The amended seventh five-year plan (2012 -2017) included the addition of 27400 MW from thermal power plants to the unified grid, including the fast-track plan & Siemens projects at an estimated investment cost of USD 17 billion.
- These projects are implemented by the Electricity Sector and funded with soft loans from Arab and international financing institutions.
- Part of the Plan projects with a total capacity of 23311 MW were put to operation by the end of financial year of 2017/ 2018.
- It is scheduled to put in operation another 2790 MW during financial year 2018/2019.
- Another 1300 MW is targeted to be in operation and the whole plan projects to be completed in 2019/2020.