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Performance improvement of the combined cycle power plant by intake air cooling using an absorption chiller

S. Boonnasa[a], P. Namprakai[a,*], T. Muangnapoh[b]

[a]Department of Energy Technology, King Mongkut's University of Technology Thonburi, Thungkhru, Bangkok 10140, Thailand
[b]Department of Mechanical Engineering, College of Technology, 12000, Thailand

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Abstract

This paper studies how to improve the capacity of the combined cycle (CC) power plant which has been operated for 8 years. The most popular way is to lower intake air temperature to around 15 °C (ISO) and 100% RH before entering the air compressor of a gas turbine (GT). Thailand has 3 seasons: winter, summer and rainy season. According to 2003 Bangkok monthly weather data, all year ambient temperature is higher than 15 °C. This research proposes a steam absorption chiller (AC) to cool intake air to the desired temperature level. It could increase the power output of a GT by about 10.6% and the CC power plant by around 6.24% annually. In economic analysis, the payback period will be about 3.81 years, internal rate of return 40%, and net present value 19.44 MUS$.

Keywords: Air cooler; Economics; Monthly analysis; Uncertainty; Gas turbine

1. Introduction

The performance improvement of a power plant has been presented in literature [1,2]. Ameri et al. [3] proposed the improvement of the new power plant (16.6 MW) and focused on the gas turbine (GT) unit. The study showed that the power output could be increased by about 11.3%. Mohanty et al. [4] analytically studied the GT power plant enhancement in Bangkok, Thailand, and found that 11% increase in power was observed. Both used absorption chiller (AC) units without a cooling water storage system to solve their problem. The Toshiba Corporation [3] used a hybrid system: an AC with a thermal energy storage system for a small power plant (5.42 MW). They increased the power output of their systems by cooling the intake air entering the GT unit using a steam AC. Cooling inlet air would increase air mass flow then increase the power output [5]. The existing system in this current study is an 8-year combined cycle (CC) power plant (336 MW, ISO). Unfortunately, the ambient temperature all year in Bangkok is very high. This will lower the system output substantially. So a steam AC will be introduced in order to cool a compressor intake air to the desired condition. The AC has a certain advantage, since it does not need additional power for the compressor as the

*Corresponding author. Tel.: +662 02 470 8622; fax: +662 02 470 8623.
E-mail address: ipicakai@kmutt.ac.th (P. Namprakai).

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Nomenclature

A	size of a heat exchanger (m^2)
F	correction factor (dimensionless)
h	specific enthalpy (kJ/kg)
h_{fg}	latent heat of vaporization of water (kJ/kg)
Q_{CL}	total cooling load (kW, RT)
m	mass flow rate (kg/s)
T	temperature (°C)
U	overall heat transfer coefficient ($W/m^2\,K$)
V	volume of a stored water (m^3)

Greek symbols

η	efficiency (%)
ω	humidity ratio (kg of moisture/kg of dry air)

Subscripts

a,b,c,d	state points
amb	ambient
CHW	chilled water
CHWR	chilled water return
CHWS	chilled water supply
CL	cooling load
e	electrical
ISO	international standards organization
th	thermal

Acronyms

AC	absorption chiller
CC	combined cycle
Comp	air compressor
ECON	economizer
EVAP	evaporator
G	generator
GT	gas turbine
HE	heat exchanger
HP	high pressure
HRSG	heat recovery steam generator
LHV	low heating value
LP	low pressure
NG	natural gas
RT	ton-refrigeration
ST	steam turbine

mechanical chiller does. It has a very few moving parts so that a standby unit is not necessary. Although the AC may use a fraction of low-pressure steam, this amount in term of energy is less than that used by a mechanical chiller. Then we technically analyze the improvement in the output of the combined system after