SUDAN UNIVERSITY
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COLLEGE OF GRADUATE STUDIES

DESIGNOF PRE COOLER FOR GAS TURBINE AT GARRI(1and2) POWER STATION BY USING VAPOUR COMPRESSION REFRIGERATION SYSTEM

تصميم مبرد قبلي للتوربين الغازي في محطة كهرباء قري الحرارية (1،2) بإستخدام نظام التبريد الإنضغاطي

A Thesis Submitted in Partial Fulfillment of the Degree of M.Sc. in Mechanical Engineering (POWER)

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الإفتتاحية

بسم الله الرحمن الرحيم

قال تعالى :

لَا يُكَلِّفُ ٱللَّهُ نَفْسًا إِلَّا وُسْعَهَا ۚ لَهَا مَا كَسَبَتْ وَعَلَيْهَا
مَا ٱكْتَسَبَتْ ۗ رَبَّنَا لَا تُؤَاخِذْنَآ إِن نَّسِينَآ أَوْ أَخْطَأْنَا ۚ رَبَّنَا
وَلَا تَحْمِلْ عَلَيْنَآ إِصْرًا كَمَا حَمَلْتَهُۥ عَلَى ٱلَّذِينَ مِن قَبْلِنَا ۚ
رَبَّنَا وَلَا تُحَمِّلْنَا مَا لَا طَاقَةَ لَنَا بِهِۦ ۖ وَٱعْفُ عَنَّا وَٱغْفِرْ لَنَا وَٱرْحَمْنَآ ۚ
أَنتَ مَوْلَىٰنَا فَٱنصُرْنَا عَلَى ٱلْقَوْمِ ٱلْكَٰفِرِينَ ﴿٢٨٦﴾

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Dedication

To my father who gives me direction to the sky

To my mother who gives me lovely life

To my brothers and sisters who give me support

Acknowledgement

First of all I would like to submit my best greeting to my supervisor Dr. Ali Mohammed Hamdan for his acceptance to supervise my research and for his directions during preparing this research. Also my full respect and appreciation to my all friends, colleagues and co-worker enhanced me in this research and helped me in data collection stage. Finally, a lot of thanks to Garri Power Station Directorate which gave me permeations to apply this research and analysis in the station and has been supplying me by all data I needed throughout the research.

Abstract

Gas-turbine inlet air cooling has been considered for boosting the power output during hot seasons, the gas turbine being a constant volume-flow machine, the power of the gas turbine is directly proportional to the mass flow rate of air passing through it, which is directly proportional to sucked air density. A high ambient temperature reduces the air density. Gas turbines designed to operate at standard conditions of 15^{o}C therefore gas turbine loose a significant portion of their generating capacity when installed in hot climates. Reduce the temperature of inlet air by using chilled water to the design condition increase output power by 8 MW for each turbine in Garri power plant these amount of power equals 25% of the rate power of turbine. This research is the trial to calculate the increase in output power from gas turbine by designing pre cooler system to increase the efficiency and output power of the turbine.

تجريدة

يبرد الهواء عند مدخل التوربينة الغازية لزيادة القدرة الكهربائية المولده فى المناطق الحارة وذلك لان التوربين الغازي يتاثر كثيراً بدرجة حرارة الهواء المسحوب لتغيير كثافته تبعاً لدرجة الحرارة مما يؤثرعلى كتلة الهواء المسحوب للتوربينة الغازية وعادة يتم تصميم التوربينة عند درجة حرارة 15 درجة سليزيوس لتعطى قدرتها القصوى التشغيلية.فى البلدان الحارة تقل هذه القدرة بمقدار 25 % من القدرة التصميمية، كماهوفى السودان خلال شهورالصيف.هذا البحث محاولة لتصميم مبرد يعمل بدورة انضغاطية لتبريد وسيط التبريد (الماء) الذى يبرد الهواء عند المدخل للتوربينة لتعمل التوربينة الغازية على الظروف القياسية لها مما يرفع الكفاءة و يوفر الطاقة.

Contents

Abriviations

CTIAC	combustion turbine inlet air cooling
C*W*T	chilled water temperature
GCPS	Garri Complex Power Station
GE	General Electric
LCWT	Leaving Chiller Water Temperature
PI	Power Input (Compressor Only)
$\mathbf{P-v}$	Pressure - volume Diagram.
RH	Relative Humidty
T. CAP	Total Capacity
T. CAPs	Total Capacity for selected chiller system
$\mathbf{T-s}$	Temperature – Entropy Diagram.
WFR	Water Flow Rate
WPD	Water Pressure Drop

Symbols		Units
$\mathbf{A_o}$	Total Area of Heat Exchanger	m^2
$\mathbf{a_i}$	inlet Area of the small pipe	m^2
$\mathbf{a_o}$	Outlet Area of the small pipe	m^2
$\mathbf{a_s}$	Surface Area of the small pipe	m^2
$\mathbf{Cp_a}$	Specific Heat of air at constant pressure.	$kJ/kg\,K$
$\mathbf{Cp_{cw}}$	Specific Heat of chilled water at constant pressure.	kJ/kg K
$\mathbf{D_i}$	Inner Diameter of large the pipe	mm
$\mathbf{D_o}$	Outer Diameter of the large pipe	mm
$\mathbf{d_i}$	Inner Diameter of the small pipe	mm
$\mathbf{d_o}$	Outer Diameter of the small pipe	mm
F	Correction Factor	**%**
L	Length of the small pipe	m
LMTD	Log Mean Temperature Difference	°C
$\mathbf{\dot{m}_a}$	Air flow rate.	$^{kg}/_{sec}$
$\mathbf{\dot{m}_{ch}}$	Chilled water flow rate.	$^{kg}/_{sec}$
$\mathbf{N_{row}}$	Number of rows in Heat Exchanger	rows
Nst	Number of cooling stages	Stages
$\mathbf{N_{tubes}}$	Total Number of Tubes	Tubes
$\mathbf{Q_a}$	Rate of Heat loss.	kw
$\mathbf{Q_{ch}}$	Rate of Heat gained	kw
$\mathbf{q_{supply}}$	Volume flow rate of chilled water through the large pipe	m^3/sec
$\mathbf{q_{tube}}$	Volume flow rate of chilled water through the small pipe	m^3/sec

$\mathbf{R_T}$	Total Heat Resistance	K/W
$\mathbf{S_L}$	Longitudinal pitch	mm
$\mathbf{S_T}$	Transverse pitch	mm
$\mathbf{T_{ai}}$	Inlet air temperature	°C
$\mathbf{T_{ao}}$	outlet air temperature	°C
$\mathbf{T_{chi}}$	Inlet chilled water temperature	°C
$\mathbf{T_{cho}}$	outlet chilled water temperature	°C
U	Overall Heat Transfer Coefficient	w/m^2K
$\mathbf{V_{ch}}$	Volume flow rate of chilled water	m^3/sec
$\mathbf{v_{tube}}$	Velocity of chilled water through the small pipe	m/sec

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