



**SUDAN UNIVERSITY
OF SCIENCE AND TECHNOLOGY
COLLEGE OF GRADUATE STUDIES**

**DESIGN OF PRE COOLER FOR GAS TURBINE AT
GARRI(1 and 2) POWER STATION BY USING
VAPOUR COMPRESSION REFRIGERATION SYSTEM**

**تصميم مبرد قبلى للتوربين الغازى فى محطة كهرباء قري
الحرارية (1،2) باستخدام نظام التبريد الانضغاطى**

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

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Feb 2016

الافتتاحية
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قال تعالى :

لَا يَكْلِفُ اللَّهُ نَفْسًا إِلَّا وُسْعَهَا لَهَا مَا كَسَبَتْ وَعَلَيْهَا
مَا أَكْسَبَتْ رَبَّنَا لَا تُؤَاخِذنَا إِنْ نَسِينَا أَوْ أَخْطَأْنَا فَارْبَنَا
وَلَا تَحِيلْ عَلَيْنَا إِصْرًا كَمَا حَمَلْتُهُ عَلَى الَّذِينَ مِنْ قَبْلِنَا
رَبَّنَا وَلَا تُحِيلْنَا مَا لَا طَافَةَ لَنَا بِهِ وَاعْفْ عَنَّا وَاغْفِرْ لَنَا وَارْحَمْنَا
أَنْتَ مَوْلَانَا فَانصُرْنَا عَلَى الْقَوْمِ الْكَافِرِينَ

سورة البقرة - الآية 286

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°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.

جريدة

ببرد الهواء عند مدخل التوربينة الغازية لزيادة القدرة الكهربائية المولده فى المناطق الحارة وذلك لأن التوربين الغازي يتاثر كثيراً بدرجة حرارة الهواء المسحوب لتعيير كثافته تبعاً لدرجة الحرارة مما يؤثر على 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، كما هو فى السودان خلال شهور الصيف. هذا البحث محاولة لتصميم مبرد يعمل بدورة انضغاطية للتبريد وسيط التبريد (الماء) الذى يبرد الهواء عند المدخل للتوربينة لتعمل التوربينة الغازية على الظروف القياسية لها مما يرفع الكفاءة ويوفر الطاقة.

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Abriviations

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

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

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

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