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ESTIMATING PERFORMANCE OF AIR-COOLED SCREW CHILLER BY LOWERING CONDENSOR TEMPERATURE

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ABSTRACT

This paper presents performance enhancement of air-cooled screw chiller by using cooling tower exhaust air. The chiller was tripping in peak summer on high discharge pressure. After finding out the reason a additional ducting arrangement was provided from cooling tower exhaust to air- cooled screw chiller condenser. This ducting arrangement can discharge exhaust air from cooling tower to air cooled screw chiller condenser. Study was carried out in various seasons like peak summer, winter, monsoon, and to find the enhancement of Coefficient of Performance (COP) for screw chiller. After providing ducting arrangement the tripping of air cooled screw chiller stopped, also COP improved. The COP can be improved approx. 16 % in peak summer by using this duct arrangement system.

KEYWORDS: COP coefficient of performance,HPC high pressure control,CTC condenser temperature control.

INTRODUCTION

Chiller is a heart of any refrigerating & air conditioning system that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle. This liquid can be circulated through a heat-exchanger to cool the air or equipment as required. The refrigerant media absorb the heat from evaporator and is exhausted to ambient by condenser and cooling tower. Air-cooled chiller systems are commonly used in commercial buildings due to their flexibility. The operation of chillers usually takes up the highest proportion of the total electricity consumption of buildings. Comparing to water-cooled chillers, air-cooled chillers are regarded as energy inefficient. The deficient performance of air-cooled chillers is mainly due to the traditional operation under head pressure control (HPC), whereby ambient temperature varies between 35℃ to 50℃ in day night. By using HPC the set point of discharge pressure is set at high and take high fan power, also, if ambient temperature below 50 ℃ compressor power does not change much. As HPC is regarded energy inefficient, variable condensing temperature control (CTC) has been proposed as an alternative to HPC to lower the condensing temperature for air-cooled chillers. Under CTC, it is essential to decrease the condenser temperature to enhance the COP of chiller by improving the condenser heat transfer rate. A ducting arrangement from cooling tower exhaust to air-cooled screw chiller condenser to reduce the temperature of condenser inlet air. CTC enables the condensing temperature to approach its lower boundary and reduce the compressor power.

In India about 60% electricity consumed by air-conditioners and refrigeration systems by industries and human comfort. A lot of energy can be saved by improving performance and efficiency of air conditioning system by varying operating conditions like evaporator temperature, condenser temperature. In summer season, if we set inside design temperature 27℃ instead of 25℃ which is near to comfortable zone in summer. The evaporator temperature is increased by 2℃, we can save lot of energy in the form of electric energy by varying the evaporator temperature. When condenser temperature is reduced by applying small quantity of cool air, lot of energy in form of electrical energy can be saved. In the night when ambient condition goes below about 30℃ to 28℃ then compressor work is already reduced so lot of power saving can be achieved by setting the evaporator temperature near about 27 ℃. But in monsoon, we cannot increase evaporator temperature because of high latent load of humidity problem. We need 50% humidity @ 25 ℃ for comfort design so evaporator temperature require low temperature as per design criteria the ADP (apparatus due point) and reheat the air. It should be below than wet bulb temperature so condensation is obtained and required design condition achieved, but ambient temperature condition already less than summer temperature so without changing operating point, energy can save from condenser site. In winter ambient temperature is very less than summer temperature, cooling requirement is less than summer so it is required least cooling in winter, while increase evaporator temperature you can take condenser discharge air inside room instead of evaporator. Lot of energy in form of electrical energy can be saved.

In this paper we also achieved power saving from a screw chiller by reducing condenser temperature, applying cooling tower discharge air on screw chiller condenser in summer .This screw chiller was not performing better due to high condenser temperature and COP was very less in summer.

NEED FOR ENHANCEMENT IN COEFFICIENT OF PERFORMANCE

The existing screw chiller is low efficient performance of air cooled chiller. It is mainly due to head pressure controls (HPC) under which the condenser temperature floats around a high set point temperature 50º C based on ambient temperature of 35℃, condenser works between 50ºC to below as per ambient conditions and different chiller loads on weather conditions. Some research has proved that lower condensing temperature can save lot of energy in the form of electrical energy by using variable condensing temperature CTC (condenser temperature controls). It is an alternative of HPC to lower the condensing temperature and change the ambient temperature conditions and variable load conditions. The COP is directly related electrical power, if COP is less means system is consuming high current with refrigeration effect less. In peak summer this chiller tripped frequently with high discharge pressure and over load current. Due to this problem the temperature control is not possible, because after tripping the chiller it takes 30 minutes to re-start. Also temperature of Indus laboratories process rises and parameter of this results get disturb and it has failed on some days.

LITERATURE REVIEW

Yu F *et al*. [1], Kwoktai Chan, Hoyin Chu from The Hong Kong Polytechnic University Hong Kong. Found the efficiency Improvements of Air-Cooled Chillers equipped With High Static Condenser Fans. In this paper present a simulation study on how to increase the co efficient of performance (COP) Jai Yang, K.T. Chan and Xiangsheng [2]Wu from Department of building service engineering, hong Kong Polytechnic University, Hong Kong, China. & Department of Real Estate and Environmental engineering, logistical Engineering University, Chongqing, China. In this research they investigate that chiller efficiency can be improved by enhancing heat transfer rate in condensers.

Wu-Chieh Wu, et al [3] Tzong-shing Lee and chich- Hsiang Chang. By this study a parameter analysis for improving the energy performance of air cooled water chiller by altering the angle configuration of the condenser coil

SYSTEM SPECIFICATIONS AND METHOD

Central Air conditioning Plant (CAP)consist with two centrifugal water chiller each capacity 300 TR and one centrifugal chiller capacity 600 TR using refrigerant R11 gas with complete accessories like 04 cooling tower and condenser pumps , 11chiller pumps capacity 60/50 HP with 720/1120 Gallons/min (GPM). These are used to pump the chilled water in various laboratories in RRCAT Indore. In the CAP an air cooled screw chiller installed which is linked with CAP .The screw chiller is York make , capacity is 2000 kW or 600 TR in two units each capacity is 300 TR. COP of this chiller is approx. 2.4 at 40℃ ambient temperature. The performance data is given on basis of 35 ℃ in USA.

The existing cooling tower is 100000 CFM which cover both chiller by making a duct arrangement, this exhaust air less capacity vise seeing the screw chiller exhaust air capacity.

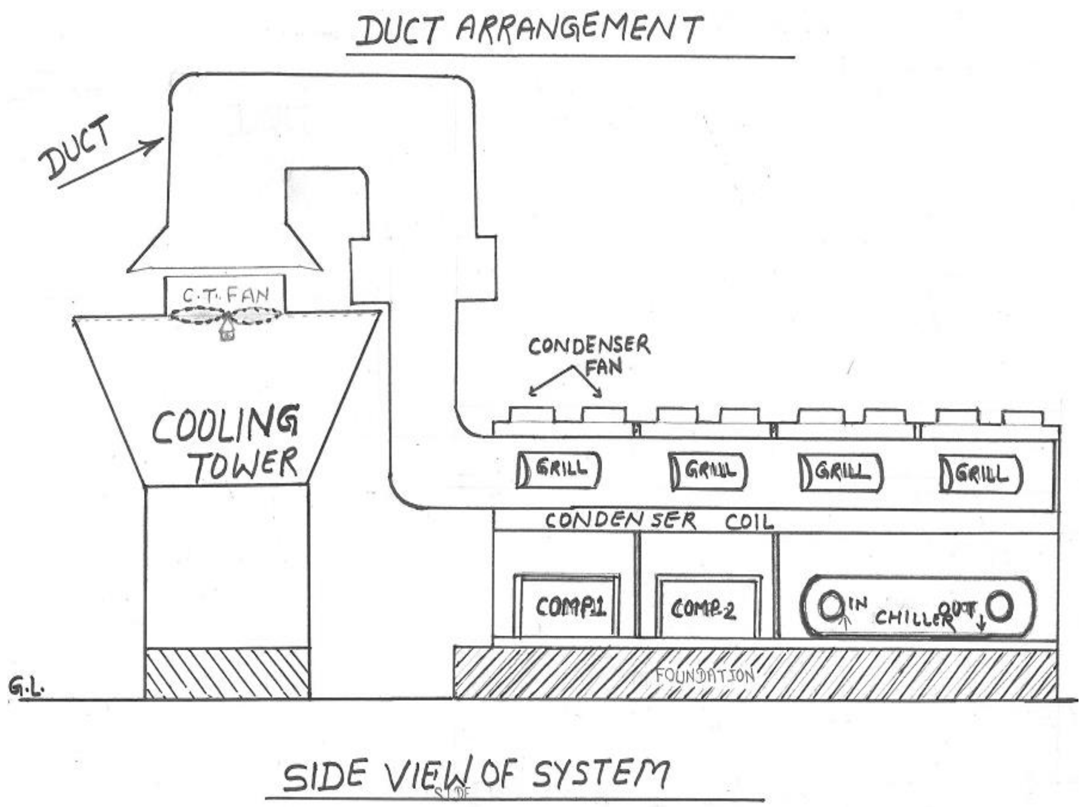
Detail specifications for air cooled screw chiller as given below.
Chiller make & model: York Air cooled chiller, YCAS 1135 EB (USA)

Capacity of chiller: 300 TR or 1000 kW	Condenser fan electric consumption: 2 HP each
Use refrigerant: 407 C	Cooling tower make & model: Paharpur series 368-101
Number of compressor: 04 nos.(90&60 TR)	Cooling capacity of cooling tower: 369 TR
Number of condenser fans:08 nos. with 25000CFM each	Exhaust air capacity of cooling tower: 100000 CFM

METHOD

A duct is fabricated to avoid the tripping problem. The same duct is installed from cooling tower exhaust air to air-cooled screw chiller condenser in whole lengths 11meter (approx) in four side for both units to connect these four branches a plenum is made near cooling tower and collect cooling tower discharge air (approx.), 100000 CFM in this plenum to generate pressure for discharging the air in whole length. This exhaust air quantity is less than screw chiller discharge air from air-cooled condenser but by applying this cooled air on air-cooled condenser the condenser temperature reduced, in this system we take exhaust air by connecting duct on the top of cooling tower exhaust fan with some distance. So additional static pressure not increases and did not increase the cooling tower current. Due to this we did not consider cooling tower fan motor current.

This exhaust air is on low temperature (dry bulb & wet bulb) and less than ambient temperature with drift losses after mixing with ambient air an evaporative cooling process occurs and this gives the better result to reduce dry bulb temperature. It is reduced approx. by two degree Celsius in summer season. Performance of condenser increased, also due to this, C.O.P. was enhanced. By this ducting arrangement cooling tower motor current did not increase significantly because connection taken is from upper side from exhaust fan of cooling tower, it is hung by some distance. Ducting arrangement given below



(Figure no.1) Ducting arrangement Schematic

DATA COLLECTION

Without cooling tower air

Detail parameters data has been collected in peak summer, in month of May, when chiller is tripping, before proposed ducting arrangement. All readings are taken by digital thermometer and digital pressure transducer when the ambient temperature was 42 ℃ and the operating discharge pressure is 390 psi which is near about the high discharge pressure set point. Also note suction pressure which is near about set points. Also COP is 2.03 which is very less. Also system had tripped.

With cooling tower air

The detail parameter data was also collected after providing a ducting arrangement in peak summer near about the ambient temperature previous year temperature after ducting arrangement. After providing ducting arrangement from cooling tower detail reading have taken and recorded in a log sheet and seen all performance at 42℃ ambient temperature and compare the same both parameter the COP is 2.63 it much better than previous. Details of parameter which are taken given in table with its nomenclature.

This chiller is working in three shifts. The readings are taken every hour and a log sheet is maintained. Data is collected when duct arrangement is not available and screw chiller was tripping, also data is taken from present condition when duct arrangement is provided from cooling tower to air cooled screw chiller condenser. All temperature readings are taken by digital thermometer and reading is taken in ˚F and pressures reading are taken in psig by pressure transducer. Detail study in excel table have been prepared at ambient condition in peak summer. Also these data values are find out from ph chart and drawn the same on ph chart also.

Find out the Condenser /evaporator /compressor work in the form of heat transfer after taking parameters in a excel table. The data are collected in for the whole year.

COMPARISON OF CONDITIONS WITH AND WITHOUT COOLING TOWER EXHAUST:

Date 20.5.13 time 16.00 compare table dated 17.05.14 time 14.00 same ambient temperature with and without cooling tower.

Data from screw chiller date 20.5.2013 without cooling tower

time	Ambient temp DBT °C	S.P.(Psia)	S.S.T.	S.T.	D.S.T.F	D.T.	DP.psia (Psia)	Current	Load	h1(btu/lb)	h2(btu/lb)	h3(BTU/LB)	**Compressor work h3-h2 (btu/lb)**	Refrigeration .Effect . BTU/lb	cop
16.00	42	121.7	65	85	160	235	404	**194**	**99%**	56	121	150	28	65	2.30

Table no.1

Data from screw chiller date 17.5.2014with cooling tower air

time	Ambient. temperature	Condenser temp in	S.P. in Pisa	S.S.T.	S.T. F	D.S.T.in	D.T.in	DP Pisa	**Load in %**	**Current** (amps)	h1 BTU/LB	h2 BTU/LB	h3BTU/LB	COMPRESSOR WORK h3-h2	**Refrigeration effect h2-h1**	cop
14.00	42	40	100	58	80	136	206	350	99	188	55	120	143	**23**	**62**	2.68

Table no.2

CONDITIONS OF AMBIENT TEMPERATURE AND CONDENSER AIR INLET TEMPERATURE WITH COOLING TOWER EXHAUST AIR IN WINTER.

An detail study done on it for whole year, details are given below

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Table no. 3 From December 2014 to March 2015

DATE	C.T. EXHAUST AIR			Ambient AIR			CONDENSER AIR			TIME	Remark
	DB	WB	RH%	**DB**	WB	RH%	DB	WB	RH%	AM/PM	
12/12/14	**20**	17	73	**22**	15	43	21	19	82	11.00 A.M	
17/12/14	**17**	15	80	**18**	15	71	17	15	80	11.00 A.M	
23/12/14	**22**	16	50	**24**	15	33	23	17	52	11.00 A.M	
24/12/14	**21**	18	73	**23**	16	45	22	18	66	11.00 A.M	
26/12/14	**17**	14	70	**19**	14	54	20	12	32	11.00 A.M	
31/12/14	**17**	16	90	**18**	16	80	16	13	69	11.00 A.M	

January 2015

DATE	C.T. EXHAUST AIR			Ambient AIR			CONDENSER AIR			TIME	Remark
	DB	WB	RH%	DB	WB	RH%	DB	WB	RH%	AM/PM	
1/1/15	17	17	100	16	15	89	17	16	90	11.00 A.M	**fogging**
5/1/15	17	16	90	15	13	78	18	16	76	11.00	**fogging**
6/1/15	19	16	72	22	12	23	20	16	64	11.00 A.M	
7/1/15	20	18	81	22	13	29	21	16	57	11.00 A.M	
9/1/15	17	15	80	23	13	25	20	15	56	11.00 A.M	
12/1/15	21	16	57	23	13	25	22	16	45	11.00 A.M	
13/1/15	19	16	72	22	14	36	21	16	57	11.00 A.M	
14/1/15	23	17	52	24	14	27	23	16	45	11.00 A.M	
16/1/15	18	16	80	19	15	63	18	16	80	11.00 A.M	
20/1/15	20	16	64	22	15	43	21	16	57	11.00 A.M	

February

DATE	C.T. EXHAUST			Ambient AIR			CONDENSER AIR			TIME	Remark
	DB	WB	RH%	**DB**	WB	RH%	DB	WB	RH%	AM/PM	
3/2/15	**24**	22	83	**27**	17	32	25	20	61	11.00 A.M	
6/2/15	**23**	21	83	**27**	17	32	25	20	61	11.00 A.M	

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10/2/15	**23**	19	67	**22**	17	58	23	18	59	11.00 A.M	
16/2/15	**23**	19	67	**24**	17	46	23	18	59	11.00 A.M	
18/2/15	**23**	19	67	**28**	18	33	25	20	61	11.00 A.M	
March											
DATE	**C.T. EXHAUST AIR**			**Ambient AIR**			**CONDENSER AIR**			TIME	Remark
	DB	WB	RH%	**DB**	WB	RH%	**DB**	WB	RH%	AM/PM	
3/3/15	**20**	16	64	**22**	15	43	**20**	16	50	11.00 A.M	
10/3/15	**22**	20	82	**25**	18	47	**23**	20	75	11.00 A.M	
12/3/15	**24**	23	91	**26**	21	62	**24**	21	75	11.00 A.M	
13/3/15	**21**	**21**	**100**	**19**	**19**	**100**	**21**	**20**	**91**	**11.00 A.M**	**rain**

Table no.3

It is seen from above table the ducting arrangement did not work positively in some months. It works contrary in winter season during rain and fog conditions. It works effectively in summer

After filtering the data, two table are important that is with and without cooling tower exhaust air dated 20.5.2013 and second table is dated 17.05.2014 table no. 1and table no.2

As per both table no 1 and table no. 2 comparison is given below
Ambient temperature on 20.5.2013 is 42℃
Ambient temperature on 17.5.2014 is 42℃ but at condenser it is found 40 ℃
Difference in condenser temperature is (42- 40) = 2℃▪
Work of compressor in BTU/Lb 27 on 20.5.13
Work of compressor in BTU/Lb 24 on 17.5.14
Difference in compressor work is (27-24) =3 BUT/lb.
Current on date 20.5.13 is 194 amps at the full load 99%
Current on date 17.5.14 is 188 amps at the full load 99 %
Current difference 194-188 = 6 Amps.
If we reduce two degree Celsius in ambient temperature (on condenser) approx. 6 amp current may be save in each system.
P= ▪3VI cos Ø , cos Ø is power factor take 0.90 for three phase power supply.
P= ▪3(420x24)0.9 it is approx. 15.70 kW /hrs
Electrical unit rate is Rs. 6.50 Per unit
So Rupees 15.70 x 6.50=102.05 per hours saving. If operate this system for a day or for twenty four hours we can save electric bill 102.05 x 24**=2449 .0 per day.**
Or 2449 x 30=73470 .00 per month (in summer season).
Total power saving is Rs. 73872.00 per month.
If consider COP in peak summer, details given below
Total COP in 24 hrs is 81.51 on dated 17.5.2014
Average COP / hrs =3.39 on 17.5.2014
Total COP in 24 hrs is 69.96 on dated 20.5.2013
Average COP / hrs 2.91 on 20.5.2013
% increased COP 3.39-2.91/2.91
=16 %
It is clear that average COP 16% increased in whole day & night but in fogging day it is not applicable see table below.

RESULTS AND DISCUSSIONS

After filtering the data, two tables are important (table no.1 &2) which is with cooling tower exhaust air dated 17.05.2014 and second is without cooling tower exhaust air dated 20.05.2013. Following results were observed. In summer season cooling tower discharge air temperature is 39 ℃ and ambient temperature is aprox. 42 ℃ in peak time .It is measured in peak summer on screw chiller condenser air inlet temperature after mixing it found 2℃ less than ambient temperature. Due to this reduction in inlet air temperature on screw chiller condenser approx. 6 Ampere in electrical power reduced than previous electrical power. When exhaust cooling tower air was not used the system is taking more current i.e. approx. 6 Amps.

Rs.73470 .00 per month (in summer season).

By using this ducting arrangement other benefits also seen.

By using this arrangement condenser fins not chocked early due this fins cleaning work can be avoided frequently, also cleanness fins condenser heat transfer rate increased and COP increased.

FUTURE SCOPE

By using this arrangement condenser fins not chocked early due this fins cleaning work can be avoided frequently, also clean fins of condenser increases heat transfer rate and COP increased.

By using this duct arrangement condenser discharge pressure set point can be reduced on set points side because condenser pressure vary with condenser temperature which is depend on cooling tower exhaust air. If cooling tower is working properly mixing temperature also found less than two ˚C then condenser pressure reduced. Also when screw chiller is working on condenser temperature controls (CTC) and power can be saved.

Maintenance cost also reduced because fins cleaning are the main problem so same can be reduced frequently.

By using this duct arrangement tripping problem of screw chiller can be stopped as here proved above tables.

Power saving is second opportunity but to avoid system tripping is most important opportunity because after tripping the system process of our beam line has disturbed and resuming the problem it takes more time and matter goes very high level

For small system can be used but very costly

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