To Investigate the Performance of Air Conditioning System Using Glycol-Water Cooled Condenser

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Abstract
Water-cooed air Conditioning System (WACS) are in general more efficient than the Air-Cooled Air Conditioning System (AACS), especially in subtropical climates where the outdoor air is hot and humid. Related studies focused on investigate the performance of air conditioning system by using glycol mixed water cooled condenser instead of only water cooled condenser. Reading of performance will be checked at different ratio of glycol and water i.e. 20%, 30%, 40% and 50% glycol in water. Finally compared that with water cooled condenser air conditioning system..

Keywords
Glycol-Water Cooled Condenser, Coefficient Of Performance, Split Air Conditioner

I. Nomenclature

COP	coefficient of performance	
Q_E	refrigerating effect	(Kw)
M_r	mass flow of refrigerant	(kg/s)
h	enthalpy of refrigerant	(KJ/kg-k)
Q_c	heat rejected by refrigerant in condenser	(Kw)
M_w	flow rate of water	(kg/s)
C_{pw}	specific heat of water	(KJ/kg-k)
T_{wo}	condenser outlet temperature of water	(°C)
T_{wi}	condenser inlet temperature of water	(°C)
M_g	flow rate of glycol	(kg/s)
C_{pg}	specific heat of glycol	(KJ/kg-k)
T_{go}	condenser outlet temperature of glycol	(°C)
T_{gi}	condenser inlet temperature of glycol	(°C)

I. Introduction
Air-conditioning is a process that simultaneously conditions air; distributes it combined with the outdoor air to the conditioned space; and at the same time controls and maintains the required space's temperature, humidity, air movement, air cleanliness, sound level, and pressure differential within predetermined limits for the health and comfort of the occupants, for product processing, or both. The acronym HVAC&R stands for heating, ventilating, air-conditioning, and refrigerating. The combination of these processes is equivalent to the functions performed by air-conditioning.

Annual global average temperature trend continues increasing. One-degree Celsius increase in summer has been correlated with 3.8% increase in peak demand load for air-conditioning (Peck and Richie, 2009).

Air-cooled condensers have contributed large amount of small-scale air-conditioning due to its advantages of easy maintenance with convenient size. However, cooling by sensible heat from air is only expected to get low heat-transfer performance that makes high condensing temperature, i.e. 15 to 20°C above that of the ambient air in some cases. In studies of Chow et al. (2002) and Hajidavalloo (2007), they mentioned that the coefficient of performance (COP) of an air-conditioner decreases about 2 to 4% by increasing each degree Celsius in condenser temperature. In addition, by releasing waste-heat to the surroundings, it further increases temperatures outside, which contributes to heat island problem in urban area. Moreover, hot-air flow of the waste-heat contains exergy, which is available energy that can transfer to work, generally it is not re-used.

Other types of condensers that commonly used in airconditioning system are water-cooled and evaporative condensers. Most of water-cooled condensers reject heat by connected with cooling tower, while evaporative condenser is compact by combining functions of an air-cooled condenser with a water-cooled condenser and a cooling tower.

Water-Cooed Air Conditioning System (WACS) are in general more efficient than the Air-Cooled Air Conditioning System (AACS), especially in subtropical climates where the outdoor air is hot and humid.

We propose a new air-conditioning system using glycol-water cooled condenser air conditioning system instead of conventional water cooled condenser. The possibility for developing a new air-conditioning system will be discussed in this paper. This study aim to investigate the performance of air conditioning system using glycol-water cooled condenser. This action will be done by glycol-water mixture pass through the condenser of air conditioning system. Related studies focused on investigate the performance of air conditioning system by using glycol mixed water cooled condenser instead of only water cooled condenser. Reading of performance will be checked at different ratio of glycol and water i.e. 20%, 30%, 40% and 60% glycol in water, finally compared that with water cooled condenser air conditioning system.

II. Propose Experimental Setup and Procedure
Experimental apparatus for studying the effect of glycol-water cooled condenser on the condenser performance and hence the cycle performance. The general layout of the apparatus is shown in the fig. 1. The performance is implemented with considering suitable data , instrument to measure the different variable affecting the problem.

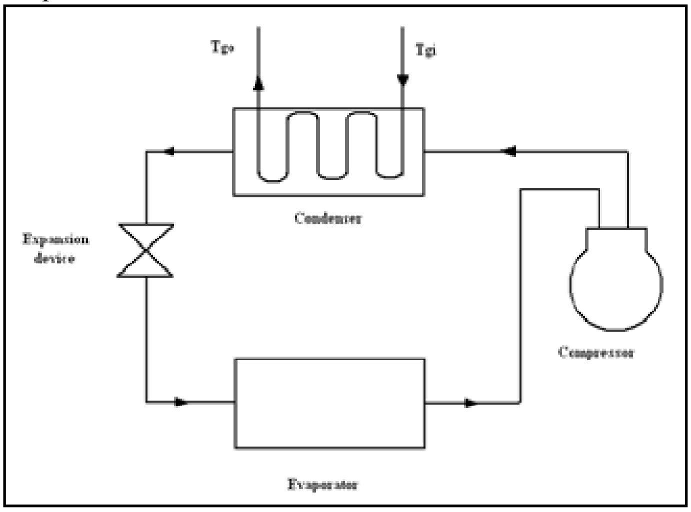

Fig. 1: Schematic View of A/C System With Glycol-Water Cooled Condenser

The A/C system was design for the CAD room area (30x27x12 feet) of Dr. Babasaheb Ambedker college of technology and research, Wanadongari, Nagpur. By calculating heat load of that room it required 6 ton of A/C system so our further calculation will be done on that basis.

A split type, 5 ton nominal capacity, air conditioner using NH3 was employed to exam the modulation of condenser heat rejection and its effect on the conditioner performance. The conditioner contain the basic component of a vapour compression system i.e. compressor, condenser, expansion device and evaporator

III. Heat Load Calculation For CAD Room

Space used for:	cad room				
Area in sq.ft =	660	Length in Ft.	30	Height in ft.=	12.0
Volume in cu.ft	7920	Width in Ft.	27	Contact factor :	0.92
Bypass factor :	0.08			**Btu/hour**	
	Area x	Temp. diff. x	Factor =	Sensible Load	**Latent Load**
SOLAR GAIN-GLASS					
Glass (E)	48	14	0.56	376	-
Glass (E)	48	14	0.56	376	-
SOLAR & TRANSMISSION GAIN-WALLS & ROOF					
Wall (E)	330	30	0.35	3465	-
Wall (S)	242	23	0.35	1948	-
TRANSMISSION GAIN-EXCEPT WALLS & ROOF					
Ceiling	660	38	0.128	3210	-
Floor	660	34	0.5	11220	-
People	30	245	430	7350	12900
Lights (F) - W	200	3.41	1.25	853	-
Equip.Load -W	0	3.41	1.0	0	
Subtotals				28798	12900
Safety Factors (12.5% & 5% respectively)				2160	968
Room Sensible & Latent Loads				**30958**	**13868**
Effective Room Latent Heat (ERLH)				-	13868
Effective Room Total Heat (ERTH)				**44826**	
OUTDOOR AIR (O.A.)					
			Sensible Load	8340	-
Outdoor Air	cfm =	198	**Latent Load**	-	1413
Effective Room Total Heat + O.A Heat				54579	
Other Heat Gains @ 3%				1637	
GRAND TOTAL HEAT				56216	
			TR	5.6216	

IV. Data Collected From Water Cooled Condenser Air Conditioning System

- Condenser pressure = 10 bar
- Evaporator pressure= 2 bar
- Refrigerant NH3 (boiling point=-33deg., freezing point = -77.7 deg.)
- Compressor outlet pressure= 10 bar
- Compressor inlet pressure= 2 bar
- Condenser water inlet temp. =28 deg.
- Condenser water outlet temp. = 32 deg.
- enthalpies of refrigerant at variable point from data book of M.L. MATHUR AND F.S. MEHTA

o h_1=1440 KJ/kg

o h_2=1672 KJ/kg

o h_3=h_4=290 KJ/kg

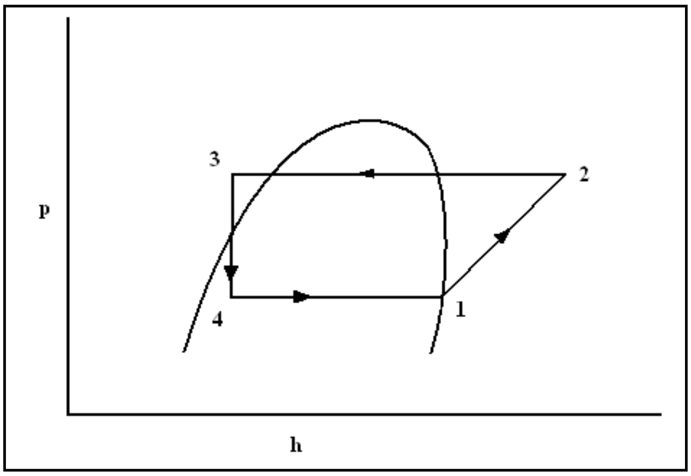

Fig. 2: p-h Diagram for Water Cooled Condenser A/C System

V. Calculation For 5TR Capacity Water Cooled Condenser A/C System

Heat Absorbed By Refrigerant In Evaporator

$Q_E = m_r*(h_1-h_4)$

$210*5=m_r*(1440-290)$

m_r=1.095kg/min

m_r=0.01826 kg/s

heat rejected by refrigerant in condenser

$Q_C = m_r*(h_2-h_3)$

Q_C= 0.01826*(1672-290)

Q_C =25.236 Kw

Heat Rejected By Refrigerant = Heat Absorbed By Water

Q_C= mw*Cpw*(Two-Twi)

25.236=mw*4.187*(32-28)

mw=1.5068 kg/s

Therefore mass flow rate of water required to absorbed the heat of refrigerant is 1.5068 kg/s

VI. Calculation For 5 TR Capacity Glycol-Water 20% By Volume Cooled Condenser A/C System For Same Amount of Heat Rejection

Heat Rejected By Refrigerant = Heat Absorbed By Glycol-Water Mixture 20% By Volume

$Q_C = m_g*C_{pg}*(T_{go}-T_{gi})$

25.236=mw*3.82*(32-28)

mw=1.6515 kg/s

Therefore mass flow rate of glycol-water required to absorbed

the heat of refrigerant is 1.6515 kg/s
$COP_w=(h_1- h_4)/ (h_2- h_1)$
=(1440-290)/(1672-1440)
= 4.956

If We Used Amount of Glycol-Water Mixture Is Equal To The Amount Of Water Used In Water Cooled Condenser For Equal Amount Of Heat Rejection That Time Outlet Temperature Of Glycol-Water Mixture Will Be
$Q_C= m_g*C_{pg}*(T_{go}-T_{gi})$
$25.236=1.5068*3.82*(T_{go}-28)$
Tgo= 32.384 deg.

If we consider inlet, outlet temperature and mass of glycol-water equal to conventional water cooled condenser,
Heat Absorbed By Glycol-Water Mixture = Heat Rejected By Refrigerant
$Q_C= m_g*C_{pg}*(T_{go}-T_{gi})$
=1.5068*3.82*(32-28)
= 23.023 Kw

Enthalpy of refrigerant after condenser
$Q_C= m_r*(h_2-h_3)$
$23.023=0.01826*(1672- h_3)$
h_3=411.32KJ/kg

$COP_g=(h_1- h_4)/ (h_2- h_1)$
=(1440-411.32)/(1672-1440)
= 4.433

VII. Calculation For 5 TR Capacity Glycol-Water 30% By Volume Cooled Condenser A/C System

If we consider inlet, outlet temperature and mass of glycol-water equal to conventional water cooled condenser,
Heat Absorbed By Glycol-Water Mixture=Heat Rejected By Refrigerant
$Q_C= m_g*C_{pg}*(T_{go}-T_{gi})$
=1.5068*3.73*(32-28)
= 22.48 Kw

Enthalpy of refrigerant after condenser
$Q_C= m_r*(h_2-h_3)$
22.48=0.01826*(1672- h3)
h_3=440.81KJ/kg

$COP_g=(h_1- h_4)/ (h_2- h_1)$
=(1440-440.81)/(1672-1440)
= 4.3068

VIII. Calculation For 6 TR Capacity Glycol-Water 40% By Volume Cooled Condenser A/C System

If we consider inlet, outlet temperature and mass of glycol-water equal to conventional water cooled condenser,
Heat Absorbed By Glycol-Water Mixture=Heat Rejected By Refrigerant
$Q_C= m_g*C_{pg}*(T_{go}-T_{gi})$
=1.5068*3.54*(32-28)
= 21.336 Kw
Enthalpy of refrigerant after condenser
$QC= m_r*(h_2-h_3)$
$21.336=0.01826*(1672- h_3)$
h_3=503.52 KJ/kg

$COP_g=(h_1- h_4)/ (h_2- h_1)$
=(1440-503.52)/(1672-1440)
= 4.036

IX. Calculation For 6 TR Capacity Glycol-Water 50% By Volume Cooled Condenser A/C System

If we consider inlet, outlet temperature and mass of glycol-water equal to conventional water cooled condenser,
Heat Absorbed By Glycol-Water Mixture=Heat Rejected By Refrigerant

$Q^C= m_g*C_{pg}*(T_{go}-T_{gi})$
=1.5068*3.33*(32-28)
= 20.07 Kw
Enthalpy of refrigerant after condenser
$Q_C= m_r*(h_2-h_3)$
$20.07=0.01826*(1672- h_3)$
h_3=572.84 KJ/kg

$COP_g=(h_1- h_4)/ (h_2- h_1)$
=(1440-572.84)/(1672-1440)
= 3.73

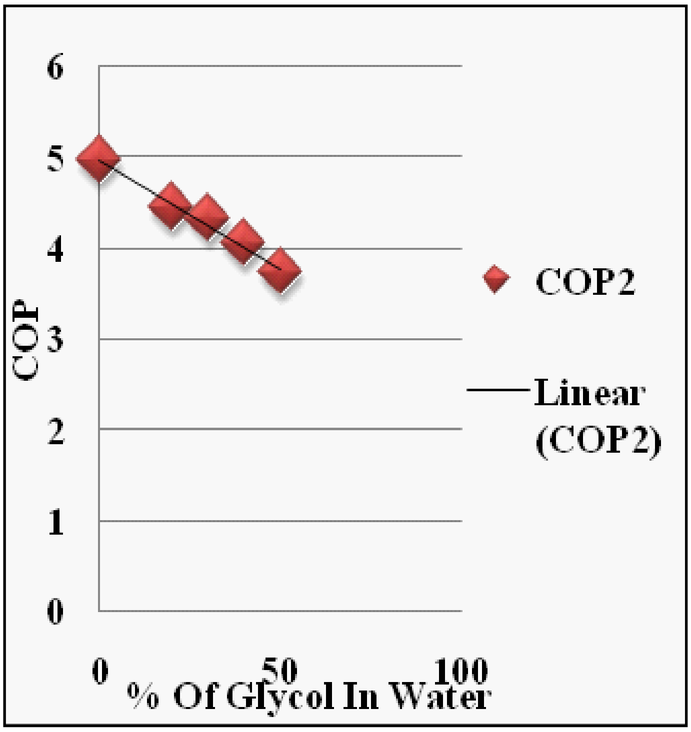

Fig. 3: Glycol % in water Vs COP of the System

X. Conclusion

From the above finding, it can be concluded that

1. The COP of the air conditioning system was decreases by increasing the percentage volume of glycol in water as the 20% glycol water mixture will decreases the COP by 10.15%, the 30% glycol water mixture will decreases the COP by 13.01%, the 40% glycol water mixture will decreases the COP by 18.46%, the 50% glycol water mixture will decreases the COP by 24.64% of conventional water cooled condenser.
2. The constantly increase in the percentage volume of glycol water mixture then the outlet temperature of refrigerant in condenser will increases continuously.
3. But the same time the life of the condenser will increases.

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