PERFORMANCE IMPROVEMENT OF SPLIT AIR CONDITIONER USING EVAPORATIVE COOLING METHOD IN THE CLIMATIC CONDITION OF GUWAHATI, ASSAM

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ABSTRACT - The air conditioning is concerned with controlling the temperature, humidity, and velocity of air motion in an enclosed space to maintain a comfortable environment. Coefficient of performance improvement and reduction of energy consumption occurs in an air-conditioning system when retrofitted with evaporative cooling in the condenser of split AC with a cellulose evaporative cooling pad. The COP enhancement and reduction of power consumption can be done with better performance in the climatic condition of Guwahati, Assam(hot and humid climate) due to good amount of drainage cold water coming out from evaporator (indoor) unit. Experimental work is carried out to indicate the enhancement of COP and to minimize the power consumption.

Keywords: COP, Evaporative cooling, Hot and Humid, Power consumption.

1. INTRODUCTION

Air conditioners are generally used in the buildings for the improvement of comfort levels. To achieve this comfort we need to consume lot of energy around the world. Worldwide buildings consume about 40% of the total energy and most this energy is utilized in the purpose of heating, ventilation and air-conditioning[1].So enhancement of COP of AC and decrease in power consumption will contribute to the reduction of global energy consumption. In an air-cooled condenser the main factor for enhancement is to reduce the average surrounding temperature.

Chainarong Chaktranond and Peachrakha Doungsong [2] in their studies states that if the coil temperature of a condensing unit were raised by 1º C, the COP of the air conditioner would drop by around 3%.

Hazidavalloo and Eightedari[3] and Aglawe et al.[4] performed an experimental test on a window airconditioner with evaporative cooling media around the condensing coil which results 16% decrease in power consumption.

Pongsakorn et al. [5] has done experimental work on an inverter air conditioner with an evaporative cooled condenser. They experimented in multiple water spray rates and with three different temperature scales in fixed ambient temperature. They found 35% enhancement of COP at a lower water spray rate of100 L/hr.

Delfani et al. [6] applied indirect evaporative cooling technique to a packaged unit air conditioner. Under local conditions, they were able to achieve an increase in a cooling load up to 75% and a reduction in electrical energy consumption of 55%.

F.W Yu *et al*. [7] experimented that coefficient of performance (COP) can be improved by using mist to pre-cool ambient air entering the condensers. Here decrease of compressor power occurs from the reduced condenser air temperature with insignificant consumption of water and pump power associated with the mist generation. A simulation analysis of an air-cooled screw chiller operating under head pressure control, shows such mist pre-cooling enables the COP to increase by up to 7.7%

Tianwei Wang et al. [8] experimented of air conditioning system to increase Coefficient of Performance utilizing an evaporative cooling condenser. The results indicated an inverse relation between the condenser inlet dry bulb temperature and the COP. By using the evaporative cooling condenser to precool the air, the saturation temperature drop through the condenser increased from 2.4 ^{0}C to 6.6 ^{0}C. It also resulted in an increase of the mass flow rate of refrigerant that went into the evaporator. This mass increase of liquid entering the evaporator consequently resulted in the increase of COP from 6.1% to 18% and power reduction up to 14.3% on the compressor. The result reveals the relation between water consumption and compressor energy saving regarding to their costs.

P.Martinez et al. [9] done experimental study on energy performance of a split air-conditioner by using variable thickness evaporative cooling pads coupled to the condenser. Experiments are conducted in a split air-conditioning system where the condensing unit is modified by coupling different evaporative cooling pads with variable thickness. The impact of the different cooling pads on the overall performance of the air-conditioning system is experimentally determined by measuring the airflow conditions and the energy consumption of the overall air conditioning system, including both the condenser fan and the feed water recirculation pump of the cooling pads. Experimental results show that the best COP is obtained by adding a cooling pad thickness of about 100 mm. At that point the compressor power consumption is reduced by 11.4%, the cooling capacity is increased by 1.8% and finally the overall COP is increased by10.6%.

2. WORKING PRINCIPLE OF SPLIT AC WITH DIRECT EVAPORATIVE COOLING AND INDIRECT EVAPORATIVE COOLING

Split AC is assembly of two main units. Evaporator or indoor unit and Condenser or outdoor unit. Generally aircooled condensers are used in commercial split type of AC for easy and simple uses. .

A strategy for improving the performance of air conditioning systems when using air-condensed units is to decrease the ambient air flow inlet temperature prior to entering the condenser coil. This is particularly useful and effective in hot, dry climates and also in regions where water scarcity influences the choice of the condensing unit and prevents the use of water-cooled condensers like cooling towers.

There are two methods for evaporative cooling in condensers namely direct and indirect method.

In direct method water is directly injected on the condenser and provides cooling effect. This method has disadvantages of including mineral deposits and corrosion of the condenser coils. Therefore, this method has rarely been used in residential air conditioners.

In the indirect method water is injected on the evaporative cooling pad which is located in the way of air over the condenser and provides cooling effect by evaporation of water. Media pads are cellulose bound cardboard structures which are cross-fluted to increase the contact area between air and water.

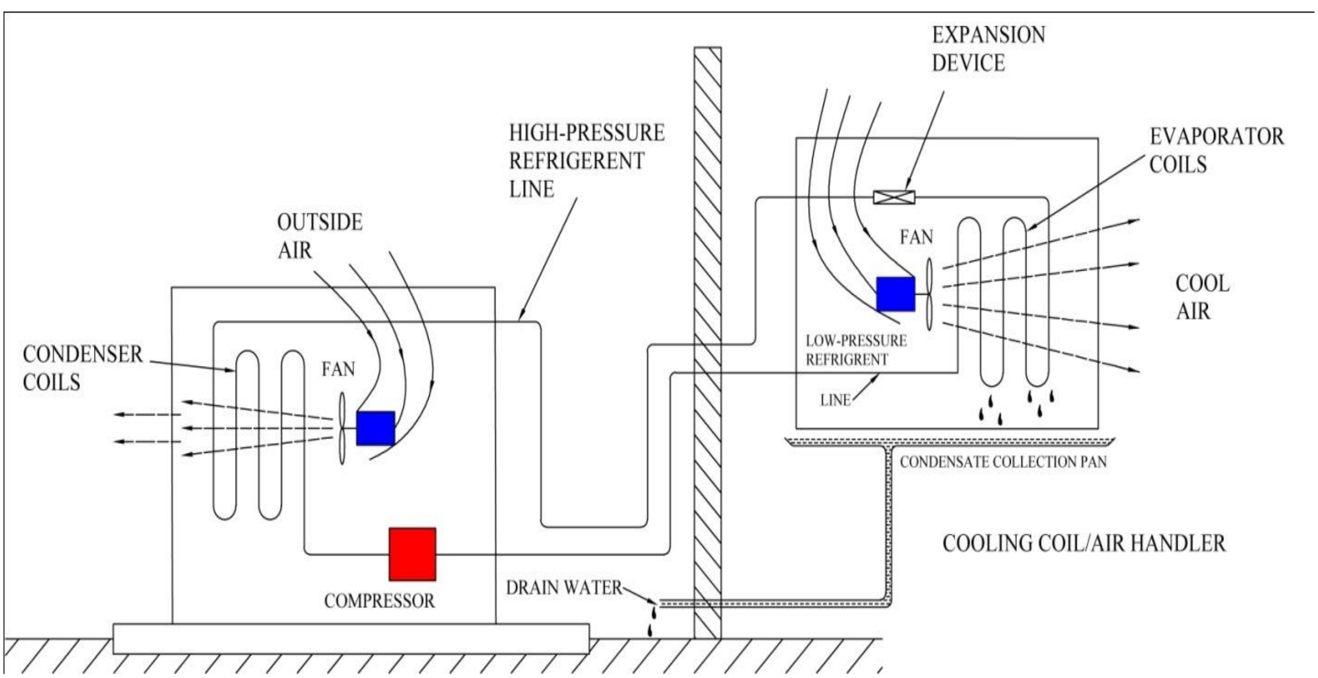

Fig.1.Schematic diagram of working of split air conditioner

3. EXPERIMENTAL SETUP AND PROCEDURE

STEP 1: (CONVENTIONAL)

- At first measured the ambient conditions of the air conditioner.
- Measurement of the temperature of evaporator exit, compressor exit, condenser exit and expander exit are taken by digital thermometer
- Then COP is calculated out.
- Further by using an ampere meter noted down the current utilised by the AC at a particular time and taking the voltage of unit as 220 V, power consumption is calculated.

STEP 2: (INDIRECT COOLING)

- Here evaporative cooling pad is used, and placed at the backside of the outdoor unit (behind the condenser coils).
- The water (10.3°C) coming out of the indoor unit is made to fall through a rubber pipe on the cooling pad.
- Once the whole cooling pad is wet the temperature at the exit of evaporator, compressor, condenser and expander is calculated.
- Then COP is calculated out.
- Further by using an ampere meter noted down the current utilised by the AC at a particular time and taking the voltage of unit as 220 V, power consumption is calculated.

STEP 3: (DIRECT COOLING)

- Now the cooling pad is removed.
- The water is allowed to fall directly on the condenser coil.
- Once the whole condenser coil is wet the temperature at the exit of evaporator, compressor, condenser and expander is measured.
- Finally the COP is calculated out.
- Further by using an ampere meter noted down the current utilised by the AC at a particular time and taking the voltage of unit as 220 V, power consumption is calculated.
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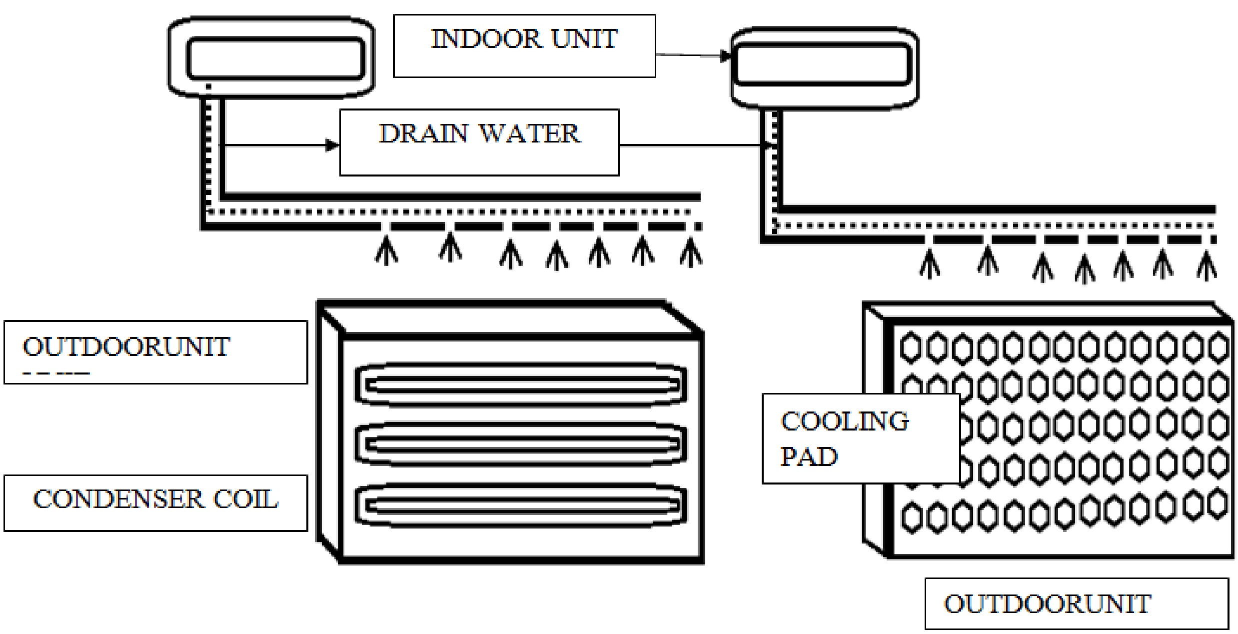

Fig.2.Schematic diagram of direct evaporative cooling **Fig.3. Schematic Diagram of Indirect eeevaporative coog**

Fig.4. Evaporative cooling pad at back side of condenser with the connection of drain pipe

4. RESULTS AND DISCUSSION

As mentioned the experiment is carried out in three steps. Direct cooling, indirect cooling with the cold drainage water and the conventional method. The results obtained in the experiments for one specific air conditioner with technical conditions as given below and the measuring equipments taken as mentioned below are considered

AMBIENT TEMPERATURE OUTSIDE ROOM	27.6°C
TEMPERATURE OF OUTLET WATER	10.3°C
VOLTAGE OF UNIT	220 V
CURRENT OF UNIT	6.8 Amp
STAR RATING OF AC	3
CAPACITY OF AC	1.5 TON

Table.1. Basic conditions of the AC

TEMPERATURE (°CELCIUS)	VOLUME
17	3.8 L
24	3.2 L
30	0.5 L

Table.2 Measurement of water coming out of the indoor unit litre in 1 hour

PARAMETERS	**TEMPERATURE,PRESSURE, ENTHALPY OF**
T 1 , P 1, H 1	EVAPORATOR OUTLET
T 2, P 2, H 2	COMPRESSOR OUTLET
T 3, P 3, H 3	CONDENSER OUTLET
T 4, P 4, H 4	EXPANSION OUTLET

Table.3. Notation of parameters

PARAMETERS	UNITS
TEMPERATURE (T)	DEGREE CELCIUS
PRESSURE (P)	Bar
ENTHALPY (H)	KJ/Kg

Table.4. Units of parameters

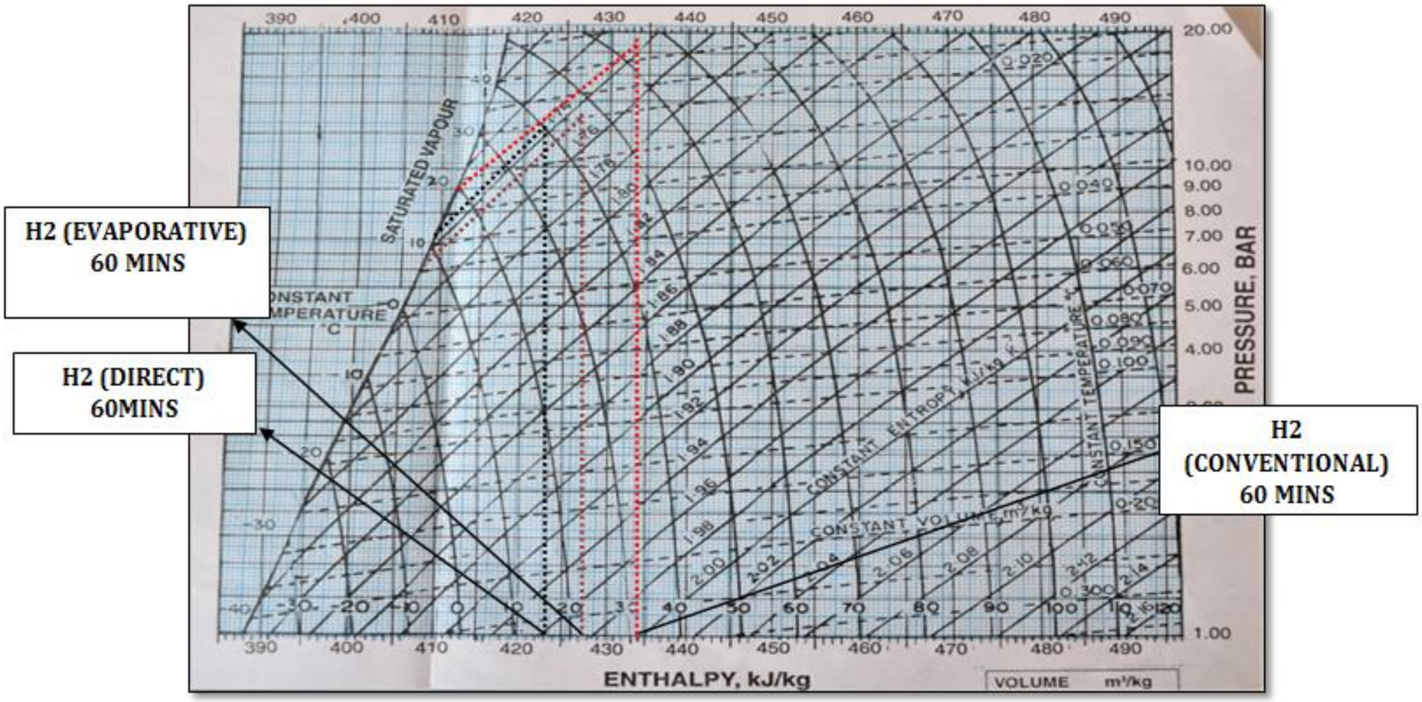

Fig.5. Picture of a refrigerant chart for reference Pressure enthalpy diagram of R22

Table.5. Experiment reading for conventional cycle

TIME	T 1	T 2	T 3	T 4
30 minutes	18	45	17	13
60 minutes	18	49	18	14

TIME	P 1	P 2	P 3	P 4
30 minutes	8.6	18	8.35	7.44
60 minutes	8.6	19	8.6	7.66

TIME	H 1	H 2	H 3	H 4
30 minutes	411.33	430	220.38	220.38
60 minutes	411.33	434	221.61	221.61

Table.6. Experiment reading of indirect evaporative cycle

TIME	T 1	T 2	T 3	T 4
30 minutes	10.2	34	13	8.3
60 minutes	8.4	33	13	7.4

TIME	P 1	P 2	P 3	P 4
30 minutes	6.41	13.21	7.44	6.81
60 minutes	6.50	12.87	7.44	6.31

TIME	H 1	H 2	H 3	H 4
30 minutes	408.84	425	215.50	215.50
60 minutes	408.20	428	215.50	215.50

Table.7. Experiment reading of direct cooling cycle

TIME	T 1	T 2	T 3	T 4
30 minutes	11.4	31	12.5	8.4
60 minutes	10.4	30	12.5	7.3

TIME	P 1	P 2	P 3	P 4
30 minutes	7.10	12.23	7.33	6.50
60 minutes	6.90	11.91	7.33	6.31

TIME	H 1	H 2	H 3	H 4
30 minutes	409.30	421	214.40	214.40
60 minutes	409	425	214.40	214.40

CALLCULATION OF COP

FOR CONVENTION COOLING CYCLE-

For 30 minutes- Power consumption= W =VI =220*6.8= 1.49Kw
Mass flow rate = W/ (H2-H1) = 1.49/ (430-411.33) = 0.079 kg/s
Refrigerating Effect =q = H1-H3 = (411.33-220.38) = 190.95 KJ/s
COP = (H1-H3)/ (H2-H1) = **10.22**

For 60 minutes- Power consumption= W =VI =220*6.8= 1.49Kw
Mass flow rate = W/ (H2-H1) = 1.49/ (434-411.33) = 0.065 kg/s
Refrigerating Effect =q = H1-H3 = (411.33-221.61) = 189.72 KJ/s
COP = (H1-H3)/ (H2-H1) = **8.36**

FOR EVAPORATIVE COOLING PAD CYCLE-

For 30 minutes- Power consumption= W =VI =220*5.8= 1.27Kw
Mass flow rate = W/ (H2-H1) = 1.27/ (425-408.84) = 0.078 kg/s
Refrigerating Effect =q = H1-H3 = (408.84-215.50) = 193.34 KJ/s
COP = (H1-H3)/ (H2-H1) = **11.95**

For 60 minutes- Power consumption= W =VI =220*5.8= 1.27Kw
Mass flow rate = W/ (H2-H1) = 1.27/ (428-408.20) = 0.064 kg/s
Refrigerating Effect =q = H1-H3 = (408.20-215.50) = 192.7 KJ/s
COP = (H1-H3)/ (H2-H1) = **9.73**

FOR DIRECT COOLING CYCLE-

For 30 minutes- Power consumption= W =VI =220*5.5= 1.21Kw
Mass flow rate = W/ (H2-H1) = 1.21/ (421-409.3) = 0.103 kg/s
Refrigerating Effect =q = H1-H3 = (409.3-214.40) = 194.9 KJ/s
COP = (H1-H3)/ (H2-H1) = **16.65**

For 60 minutes- Power consumption= W =VI =220*5.5= 1.21Kw
Mass flow rate = W/ (H2-H1) = 1.21/ (425-409.0) = 0.075 kg/s
Refrigerating Effect =q = H1-H3 = (409.0-214.40) = 194.6 KJ/s
COP = (H1-H3)/ (H2-H1) = **12.16**

COOLING METHOD	TIME	COP
CONVENTIONAL	30 minutes	10.22
	60 minutes	8.36
EVAPORATIVE	30 minutes	11.95
	60 minutes	9.73
DIRECT	30 minutes	16.65
	60 minutes	12.16

Table.8. Comparison of COP

5. CONCLUSION

The application of evaporative cooling in the small size refrigeration system was emphasized for regions of very hot and humid weather condition. The performance of air conditioner was experimentally investigated with and without media pad evaporative cooling on the condenser and it is found that-

- By applying evaporative cooling the condenser pressure of conventional AC of capacity 1.5 ton (3 star) reduces from 18 bar to 13.21bar in 30 minutes and 19 bar to 12.87 bar in 60 minutes.
- The pressure in the evaporator reduces from 7.44 bar to 6.81 bar in 30 minutes and 7.66 bar to 6.31 bar in 60 minutes.
- This pressure reduction is the indication of power reduction in the system and COP increases as following-

   a. In evaporative cooling method COP increases from 10.22 (conventional) to 11.95 in 30 minutes.

   b. In evaporative cooling method COP increases from 8.36 (conventional) to 9.73 in 60 minutes.

   c. In direct cooling method COP increases from 10.22(conventional) to 16.65 in 30 minutes.

   d. In direct cooling method COP increases from 10.22(conventional) to 12.16 in 60 minutes.

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