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Research Article

Performance Improvement of Wind Air Conditioner by using Bottle Neck Arrangement

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Abstract

In present scenario human comfort is the main criteria. For that purpose many Air conditioners are introduced in the market like window AC, split AC and central AC. Not only for human purpose it is become an essential need for Industrial purpose for both small scale and large scale industries. For common household purposes maximum we use Window AC. But during actual use it is not possible to evaluate the performance of an AC with all the parameters like coefficient of performance and cooling effect. Since these are the main parameters for an air conditioner. Without these calculations it is also not possible to know the factors that affecting on the performance of an air conditioner. So in this thesis main concentration is on investigation on performance parameters of air conditioner, for this purpose window AC test rig is prepared. By using this test rig easy to find out the Actual COP. By adding Bottle Neck Arrangement, in order to improve the performance of air conditioner without any extra amount by using of this simple arrangement, with this theses we save the power improve the cooling effect of wind air conditioner especially in summer user can feel more comfort with this type of air conditioner.

Keywords: *Air Conditioner, COP, Performance Improvement, Bottle Neck set up.*

1. Introduction

Air Conditioning

Air conditioning is a combined process that performs many functions simultaneously. It conditions the air and transports it and introduces it to the conditioned space. It provides heating and cooling from its central plant or rooftop units. It also controls and maintains the temperature, humidity, air movement, air cleanliness, sound level, and pressure differential in a space within predetermined limits for the comfort and health of the occupants of the conditioned space or for the purpose of product processing. The term HVAC&R is an abbreviation of heating, ventilating, air conditioning, and refrigerating.

The combination of processes in this commonly adopted term is equivalent to the current definition of air conditioning. Because all these individual component processes were developed prior to the more complete concept of air conditioning, the term HVAC&R is often used by the industry.

2. Refrigerant development

The first air conditioners and refrigerators employed toxic or flammable gases like ammonia, methyl chloride, and propane which could result in fatal accidents when they leaked. Thomas Mid gley, Jr. created the first chlorofluorocarbon gas, Freon, in 1928. The refrigerant was much safer for humans but was later found to be harmful to the atmosphere's ozone layer. Freon is a trademark name of DuPont for any Chlorofluorocarbon (CFC), Hydrogenated CFC (HCFC), or Hydro fluorocarbon (HFC) refrigerant, the name of each including a number indicating molecular composition (R-11, R-12, R-22, R-134). The blend most used in direct-expansion comfort cooling is an HCFC known as R-22. It is to be phased out for use in new equipment by 2010 and completely discontinued by 2020. R-11 and R-12 are no longer manufactured in the US, the only source for purchase being the cleaned and purified gas recovered from other air conditioner systems. Several non-ozone depleting refrigerants have been developed as alternatives, including R-410A, known by the brand name Puron.

Innovation in air conditioning technologies continue, with much recent emphasis placed on energy efficiency and improving indoor air quality. As an alternative to conventional refrigerants, natural alternatives like COR-744) have been proposed. The Carrier Air Conditioning Company of America was formed to meet rising demand. Over time air conditioning came to be used to improve comfort in homes and automobiles. Residential sales expanded dramatically in the 1950s.

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3. Factors affecting Comfort air conditioning

The four important factors for comfort air conditioning are discussed as below:

1) Temperature of air: In air conditioning the control of temperature means the maintenance of any desired temperature with in an enclosed space even though the temperature of the outside air is above or below the desired room temperature. This is accomplished either by the addition or removal of heat from the enclosed space has and when demanded.
2) Humidity of air : The control of humidity of air means the decreasing or increasing moisture contents of air during summer or winter respectively in order to produce comfortable and healthy conditions.
3) Purity of air: It is an important factor for the comfort of a human body. It has been noticed that people do not feel comfortable when breathing contaminated air, even if it is within acceptable temperature and humidity ranges.
4) Motion of air: The motion or circulation of air is another important factor which should be controlled, in order to keep constant temperature throughout the conditioned space. It is, therefore, necessary that there should be equip-distribution of air throughout the space to be air conditioned.

4. Window AC

These types of AC are designed to be fitted in window sills. A single unit of Window Air Conditioner houses all the necessary components, namely the compressor, condenser, expansion valve or coil, evaporator and cooling coil enclosed in a single box. Since a window AC is a single unit, it takes less effort to install as well as for maintenance.

Fig 1 Wind Air Conditioner

Working: A fan draws air from the room first through a cooling device, consisting of metal fins extending from a pipe through which cooling fluid circulates, at a rate determined by the thermostat or by the humidistat. The air next passes over a heater, usually electrical, which is energized on instructions from the room thermostat. Air conditioning has in the past been used where the climate is too hot for comfort. Cooling will increase the relative humidity of the air, so humidification is not usually built into these systems. If it is necessary, the usual method is to inject steam from electrically boiled water.

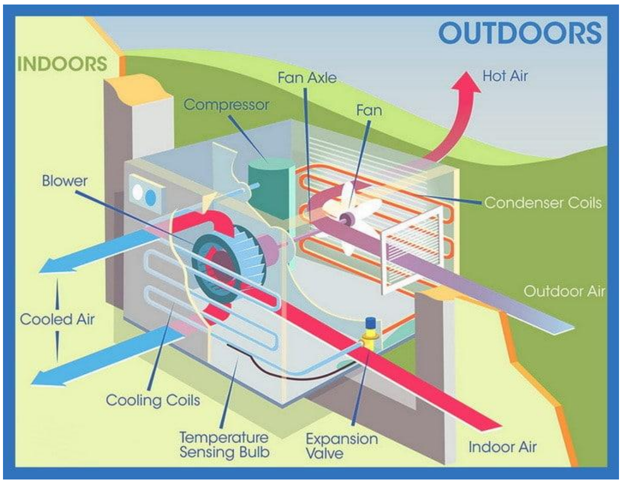


Fig.2 Window Air Conditioner Working

That is all there is to the part of the system in the room. The bit that is more difficult to understand, or at least unfamiliar to most people, is how the cooling fluid is produced and controlled. That is the part on the right of the diagram. The cooling fluid used to be a chlorofluorocarbon compound, and often still is, though they all more or less ravage the earth's ozone layer.

5. Bottle Necks

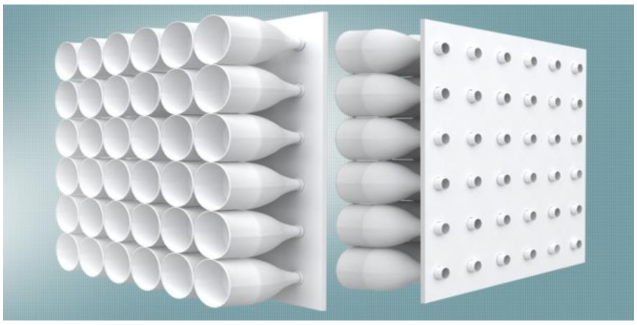


Fig. 3 Bottle Necks attached to Thermocol Sheet

A nozzle is a device that changes the cross-sectional area of a flow from a large area to a smaller area. With the change in area comes an increase in the flow velocity due to conservation of mass. When the hot air passes through the bottle the air gets compressed, for example "blow with your mouth open and feel the air". The compressed air gets cooled instantly. "Now blow with your lips pursed and feel the air". The change in temperature using an Bottle Necks is at least 2 degrees Celsius. That may not seem like much, but when in the summer, it makes some of the difference using with air conditioner.

6. Experimentation and Calculation

6.1 Design of air conditioner

In order to design Air Conditioner we must calculate Heat Load for room which is to be conditioned.

Heat Load

Amount of heat required to be removed within a certain period, usually 24 hours. Usually measured in British Thermal Unit (BTU) or watts.

Heat load calculation

Step -1

Calculate the area in square feet of the space to be cooled and multiply by 31.25.

Area BTU = length (ft.) X width (ft.) X 31.25

= 16 X 16 X 31.25
= 8,000 Btu

Step -2

Calculate the heat gain through the windows don't have shading multiply the result by 1.4.

North window BTU = area of north facing windows (m^2) X 164

= (2 X 2) X 164
= 656 Btu

If no shading Btu = North window BTU X 1.4
South window Btu = area of south facing windows (m^2) X 868
= 4 X 868
= 3,472 Btu
If no shading BTU = south window BTU X 1.4
= 3,472 X 1.4
= 4,860
Total window BTU = north window + south window
= 656 + 4860
= 5,516.8 Btu

Step -3

Calculate the heat generated by occupants, allow 600 BTU / person
= 4 X 600
= 2400 Btu

Step- 4

Calculate the heat generated by each item of machinery – copiers, computers, ovens etc. find the power in watts for each item, add them together and multiply by 3.4.
Equipment BTU = total equipment watts in X 3.4
= (240 X 5) X 3.4
= 1200 X 3.4
= 4080 Btu

Step -5

Calculate heat generated by lighting. Find the total wattage for all lighting and multiply by 4.25.

Lighting BTU = total lighting watts X 4.25
= (36+36) X 4.25
= 306

Step -6

Total heat load BTU = Area BTU + total window BTU + occupants BTU + equipment BTU + lighting BTU

= 8000 + 5516 + 1200 + 4080 + 306
= 18742 / 12000
=1.56 Ton

Step-7

Divide the heat load by the cooling capacity of the air conditioning unit in BTU, to determine how many air conditioners are needed.
Number of a/c units required = total heat load BTU /cooling capacity BTU
=1.56 /1.5
=1.04 ~ 1

Conversion of BTU/hr. to Ton of Refrigeration

To convert BTUs to tons, find the BTU capacity of the air conditioner, and divide the BTUs by 12000. Twelve thousand BTUs equals the amount of heat removed by an air conditioner that would melt 1 ton of ice in 24hours, which is called the chiller refrigeration ton, according to the engineering tool box.

6.2 Product Specifications

Air conditioner: Specification
Nominal capacity: 1.5 TR at rated test conditions
Compressor: Hermetically sealed,
Condenser: Forced convection air cooled
Evaporator: Forced convection air cooled
Expansion device: Capillary tube
Thermostat: On panel
Energy meter: For compressor provided
Pressure gauges: 1 no for suction pressure, 1 no for discharge pressure
Temperature indicator: Digital temperature indicator, 6 no's
Dry bulb temperature and wet bulb temperature measurement: By sling psychrometer

6.3 Principle of Operation

The Air Conditioning Trainer works on Vapour compression Refrigeration cycle using R 22 (HCFC-22) as a refrigerant. The Trainer is having a hermetically sealed compressor, which sucks cold refrigerant vapour from the evaporator. The vapour is compressed to higher pressure and consequently to higher temperature in the compressor. The high pressure and high temperature refrigerant then enters the condenser, where its latent heat is removed by rejecting the heat to the air passing over the forced convection condenser.

Fig. 5 Window Air Conditioner Test rig

The liquefied refrigerant passes through drier (where any residual moisture is absorbed) and enters the expansion device. In the expansion device, (a capillary tube) the refrigerant is throttled to a lower pressure and as a result, the temperature of the refrigerant also reduced. This low temperature wet vapour flows through the evaporator, which is a forced convection air cooled evaporator. Here, the refrigerant picks up heat from air passing over it and gains heat; it evaporates and enters the compressor. This cycle repeats. For measurement of pressures dial type pressure gauges are fitted and to record temperatures digital temperature scanner is incorporate.

6.4 Psychometric Term

1. Dry Air: The pure dry air is mixture of number of gases such as Nitrogen, Oxygen, Carbon Dioxide, Hydrogen, Argon and Helium.
2. Moisture Air: It is the mixture of dry air and water vapour.
3. Saturated Vapour: It is mixture of dry air and water vapour when the air has diffused the maximum amount of water vapour in it.
4. Degree of Saturation: It is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour is same mass of dry air when it is (saturated) at the same temperature.
5. Humidity: It is the mass of the vapour present in 1 kg of water and generally expressed in terms of grams per kg of dry air.
6. Absolute Humidity: It is the mass of water vapour present in 1 m^3 of dry air and is generally expressed in terms of gm / m3.
7. Relative Humidity: It is the ratio of actual mass of water vapour in given volume of moist air to the mass of water vapour in same volume of saturated air.
8. Dew Point Temperature: It is the temperature of air recorded by the thermometer when the moisture present in it begins to condense.

Table 1: Observation Table for Actual C.O.P

Sl. No.	Time Hrs	Inlet Air Temp. ^{o}c		Outlet air Temp. ^{o}c			Voltmeter (volts)	Ammeter (amps)
		DBT	WBT	DBT before bottle necks	DBT after bottle necks	WBT		
1.	10:00	33.9	26.1	25.9	24.9	21.5	220	10
2.	11:00	33.5	27.5	25.1	23.2	20.5	220	10
3.	12:00	33.3	27.5	24.9	23.1	21	220	10
4.	13:00	33.1	27.5	25.2	23.5	21	220	10
5.	14:00	32.5	26.8	24.7	22.8	19.5	220	10

Experimentation

Connect the supply cable to regulated or stabilized power supply.
Switch ON the main switch.
Put ON the AC.
Let the AC run at least for 20 minutes before taking first set of readings.
Record the DBT & WBT at the inlet and at the outlet of the air passage.
Record the volt meter and ammeter reading.

Table 2: Observation Table for Theoretical C.O.P.

Sl. No	Time Hrs	Inlet Air Temp. ^{0}C		Outlet air Temp. ^{0}C		Voltmeter (volts)	Ammeter (amps)
		DBT	WBT	DBT	WBT		
1.	10:00	33	27	26	23	220	10
2.	11:00	32.5	26.5	25.5	23	220	10
3.	12:00	32	26.5	25	22	220	10
4.	13:00	32	26	25.5	21.5	220	10
5.	14:00	31.5	25	24	20.5	220	10

Table 3: Actual C.O.P. Calculation with Bottle Necks

S. No.	Time Hrs	Pressure Gauge Reading		R-22 Refrigerant Temp. ^{0}C			
		LP	HP	T_3	T_4	T_5	T_6
1.	10:00	70	320	31.8	90.1	58.3	5.2
2.	11:00	70	320	31.4	90.5	58.7	5.8
3.	12:00	70	320	31.1	90.3	59.2	6.1
4.	13:00	70	320	30.5	91.2	59.6	6.6
5.	14:00	70	320	31.6	91.5	60.3	7.1

7. Calculation

Calculations

Actual C.O.P.

Inlet conditions
Inlet Dry Bulb Temperature = 33 ^{0}C
Inlet Wet Bulb Temperature = 27 ^{0}C
Outlet conditions
Outlet Dry Bulb Temperature = 26 ^{0}C
Outlet Wet Bulb Temperature = 23 ^{0}C
Inlet air enthalpy h_1 = 85.5 kJ/Kg (Using Psychometric Chart)
Outlet air enthalpy h_2 = 68.5 kJ/Kg
Enthalpy difference = (H_1-H_2) = 17 kJ/kg
Mass flow rate of air m = 0.223 kg/s (Constant Value)
Refrigeration effect (actual), N = Mass flow rate x enthalpy difference
= m X (H1-H2)
= 3792.36 w

Power input to compressor

V = volts from voltmeter = 240 V
I = current in amps from ammeter = 9 A
W= (VI/1000)
= 2200 w
Actual Coefficient of Performance
C.O.P.=N/W=Refrigeration Effect/Compressor input
= 1.72

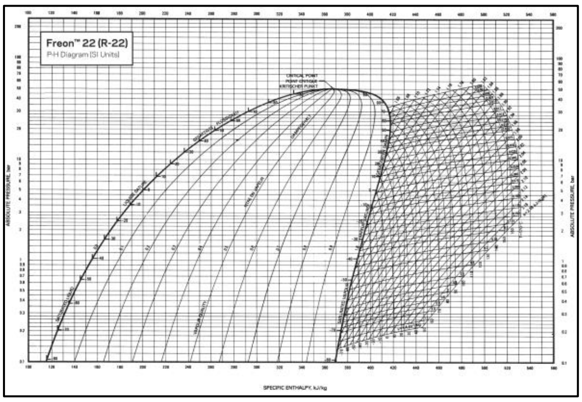
Table 4: Actual C.O.P. Calculation

Sl.No.	Volt meter (volts)	Ammeter (amps)	Power (watts)	Enthalpy kJ/kg		Mass flow rate of air kg/sec	Refrigeration Effect (watts)
				H_1	H_2		
1	220	10	2200	85.5	68.5	0.22308	3792.36
2	220	10	2200	86.2	69.1	0.22308	3793
3	220	10	2200	87.3	70.3	0.22308	3792.5
4	220	10	2200	86.5	69.4	0.22308	3793.5
5	220	10	2200	86.8	69.7	0.22308	3793.7

Theoretical C.O.P. Calculation

To evaluate theoretical C.O.P. of the system, carry out following procedure.

1. For any set of readings at a particular time, note suction and discharge pressures in psi.
2. Divide these pressures by 14.5 to convert them into bar.
3. Add barometric pressure of the present location to obtain absolute pressures in bar.
4. Locate these pressures on "Y" axis of P-H chart. Draw two horizontal lines, one for low pressure and one for high pressure.
5. Locate particular temperatures on these lines and mark 1,2,3,4.



Actual Pressure Enthalpy Chart for R-22 Refrigerant

6. Find out enthalpies at salient points by referring to "X'' axis of P-H chart.
   H_1 = 406.8 kJ/Kg; H_2 = 473.4 kJ/Kg; H_3 = 274.2 kJ/Kg ; H_4 = 274.2 kJ/Kg.
   (Using R-22 Pressure-Enthalpy Chart)
7. N= refrigeration effect = H1-H4 = 132.6 kJ/kg
8. W= Compressor Work = H2-H1 = 66.6 kJ/Kg
9. Theoretical C.O.P. = N / W
   = (H1-H4) / (H2-H1)
   = 1.99

Table 5: Theoretical C.O.P. Calculation

Sl. No.	Enthalpy kJ/kg				Refrig Effect (H_1-H_4)	Compre ssor I\P (H_2-H_1)
	H_1	H_2	H_3	H_4		
1.	406.8	473.4	274.3	274.2	132.6	66.8
2.	404.9	472.1	271.8	271.8	133.1	67.2
3.	402.5	469.4	269.7	269.7	132.8	66.9
4.	404.5	472.1	271.3	271.3	133.2	67.5
5.	405.2	473.4	271.6	271.6	133.6	67.8

Actual COP with Bottle Necks
Inlet conditions
Inlet Dry Bulb Temperature = 33.9 ^{0}C
Inlet Wet Bulb Temperature = 26.5 ^{0}C
Outlet conditions
Outlet Dry Bulb Temperature $_{\text{after bottle necks}}$ = 24.9 ^{0}C
Outlet Wet Bulb Temperature = 21.5 ^{0}C
Inlet air enthalpy h1 = 64.5 kJ/Kg (Using Psychometric Chart)
Outlet air enthalpy h2 = 85.5 kJ/Kg
Enthalpy difference = (H_1-H_2) = 21 kJ/kg
Mass flow rate of air m = 0.223 kg/s (Constant Value)
Refrigeration effect (actual),
N = Mass flow rate x enthalpy difference
= m X (H1-H2) X 1000
= 0.22308 X 21 X 1000
= 4015.44 w

Power input to compressor

V = volts from voltmeter = 220 V
I = current in amps from ammeter = 10 A
W = (VI/1000)
= 2200 w

Actual Coefficient of Performance
C.O.P. = N/W
= Refrigeration Effect / Compressor input
= 1.82

Table 6: Actual C.O.P. Calculation with Bottle necks

Sl.No.	Volt meter (volts)	Ammeter (amps)	Power (watts)	Enthalpy kJ/kg		Mass flow rate of air kg/sec	Refrigeration Effect (watts)
				H_1	H_2		
1	220	10	2200	85.5	64.5	0.22	4015
2	220	10	2200	86.2	67.9	0.22	4074
3	220	10	2200	86.6	68.6	0.22	4005
4	220	10	2200	85.9	67.9	0.22	4010
5	220	10	2200	87.1	69	0.22	4033

Table 7: Psychrometric Properties for Actual C.O.P.

Sl. No.	DBT (⁰C)	WBT (⁰C)	RH (%)	DP (⁰C)	P_V (mm of Hg)	V (m^3kg)	H (kJ/kg)	w (kg/kg of dry air)
Inlet	33.9	26.5	78	23	28	0.90	64.5	0.023
o\l with B.N	24.9	21.5	60	14	17.5	0.84	85.5	0.015

Conclusion

For the experimental purpose on the window air conditioner, a test rig have been prepared with all the required accessories.

Through this test rig the performance analysis on window air conditioner has done i.e.; Both Theoretical COP and actual COP is calculated. In order to increase the COP of the given window air conditioner a bottle neck arrangement is fitted to the test rig. Through this experiment we found that the COP obtained without bottle neck arrangement is 1.72 and after introducing the bottle neck arrangement it changes to 1.85.

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