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Performance Investigation of Window Air Conditioner

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Abstract: *Window Air Conditioner is available on various capacities & various manufactures in global market. During actual use it is not possible to evaluate the performance of window Air conditioner. The effect of condenser temperature on evaporator temperature on performance.*
At present manufacturer specifies the data such as cooling capacity, EER power consumption on the basis of star rating. Energy star rating of window Air conditioner one star less efficient and five star is more efficient as it is regulated by BEE. In this research, for investigation of performance parameter for window AC, Window AC test rig is developed. In this, Psychrometric test chamber is prepared and investigated the parameters with three different operating procedures.
Keywords: *Window AC, Cooling Capacity, EER, C.O.P.*

I. INTRODUCTION

The design itself is a challenging subject, dealing with purposeful activity directed towards the fulfillment of the human requirements. This requires considerable information such as feasibility of the certain systems within the limiting factors namely physical reliability, economic worthwhile, financial feasibility etc. In addition to one has considered factors such as materials, components and their design steps, standard data available, besides its applicability to the end user.
The Air conditioner Test Rig works on Vapour Compression Refrigeration cycle using R-22(HCFC) as a refrigerant. It 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. The liquefied refrigerant passes through drier (where any residual moisture is absorbed) and enters the expansion device. In the expansion device, (either a capillary tube or expansion valve) 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.

II. EXPERIMENTAL SET-UP

Fig.1. Photo of Experimental Setup

III. EXPERIMENTATION

Following performance trials can be conducted on the test rig.
To evaluate the performance of the AC by

1. Computing the cooling out-put by enthalpy difference method.
2. Determining the cooling capacity by applying the 100% heater load. (Sensible load)
3. Determining the cooling capacity by applying the 75% Sensible load & 25% latent heat load.
4. Determining Actual & Theoretical C. O. P in above cases.
5. To plot operating cycle on P-H chart.

Table No 1: 75% Sensible Heat Load + 25% Latent Heat Load

SL	TIME HRS	AMBIENT TEMP. ^{0}C	AVG. CABINET TEMP. ^{0}C	Suction Pressure psig	Discharge pressure psig	Energy meter-Comp. kWhr	Energy meter-Air Heater kWhr	Energy meter-Humidifier kWhr	COMP. WORK WATTS	REFRI. EFFECT WATTS
1	1100	29	24	65	250	32.2	15.4	1.2		
2	1200	30	24	67	255	34.1	18.5	2.2	1900	4100
3	1300	30	24.5	70	265	36	21.6	3.2	1900	4100
4	1400	31	24.5	70	265	37.9	24.7	4.2	1900	4100
5	1500	31	24.5	70	265	39.8	27.8	5.2	1900	4100
6	1600	30.5	24	67	260	41.7	30.9	6.2	1900	4100
7	1700	30	24	67	260	43.6	34	7.2	1900	4100

Table No 2: 100% Sensible Heat Load

SL	TIME HRS	AMBIENT TEMP. ^{0}C	AVG. CABINET TEMP. ^{0}C	Suction Pressure psig	Discharge pressure psig	Energy meter-Comp. kWhr	Energy meter-Heater kWhr	COMP. WORK WATTS	REFRI. EFFECT WATTS
1	1100	29	24	65	250	32.2	15.4		
2	1200	30	24	67	255	34.1	19	1900	3600
3	1300	30	24.5	70	265	36	22.6	1900	3600
4	1400	31	24.5	70	265	37.9	26.2	1900	3600
5	1500	31	24.5	70	265	39.8	29.8	1900	3600
6	1600	30.5	24	67	260	41.7	33.4	1900	3600
7	1700	30	24	67	260	43.6	37	1900	3600

IV. CALCULATION

ACTUAL C.O.P. OF THE SYSTEM

we have = REFRIGERATION EFFECT/ WORK INPUT

C.O.P. = N / W

NOW, N = COOLING EFFECT

= ENTHALPY DIFFERENCE OF AIR AT INLET AND OUTLET.

TO CALCULATE ENTHALPY AT INLET

WE HAVE H_1 = Enthalpy of air at inlet condition

= 87.5 KJ/Kg

Similarly, enthalpy of air at outlet condition

H_2 = 69 KJ/Kg

ENTHALPY DIFFERENCE = $H_1 - H_2$ KJ/kg

=18.5 KJ/kg

REFRIGERATION EFFECT = m (H_2- H_1) kJ / s

Where m = MASS FLOW RATE OF AIR

= 0.22308(18.5)

= 4127 W
To find out work input to the system,
we have Energy meter reading
difference = Final reading – initial reading
= 6 - 4.1 Units
Work input per unit time (input power) = 1.9 kW
Actual C.O.P. = Refrigeration effect / Work input
= 4127 / 1900 = 2.172

THEORETICAL C.O.P. OF THE SYSTEM

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 psig.
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.
6. Find out enthalpies at salient points by referring to "X'' axis of P-H chart.

H1 = 248 KJ/Kg
H2 = 288 KJ/Kg
H3 = 120 KJ/Kg
H4 = 120 KJ/Kg

7. N= REFRIGERATION EFFECT= H1-H4 = 128 KJ/Kg
8. W= COMPRESSOR WORK = H2-H1 = 40 KJ/Kg
9. THEORETICAL C.O.P. = N / W

= (H1-H4) / (H2-H1) = 128/4

= 3.2

V. RESULT AND DISCUSSION

Table No.3: Result Table – Enthalpy Difference Method

AIR INLET TEMP.		AIR OUTLET TEMP.		Enthalpy-H1	Enthalpy - H2	H1-H2	Mass flow rate	Ref. Effect	Comp. Input	EER
DBT	WBT	DBT	WBT	kJ/kg	kJ/kg	kJ/kg	kg/s	Watts	K. Watts	
28	23	21	19	87.5	69	18.5	0.223	4127	1.9	2.17
28.5	23.5	21	19	90	69	21	0.223	4685	*1.9*	2.47
29	24	21.5	20	93	73	20	0.223	4462	1.9	2.35
29	24.5	22	20.5	96	75.4	20.6	0.223	4595	1.9	2.42
30	25	22.5	21	98.4	78	20.4	0.223	4551	1.9	2.40
30	25	23	21	98.4	78	20.4	0.223	4551	1.9	2.40
30.5	26	23.5	22	104	83	21	0.223	4685	1.9	2.47
30.5	26	23.5	22	104	83	21	0.223	4685	1.9	2.47
31	26	23.5	22	104	83	21	0.223	4685	1.9	2.47
31	26	23.5	22	104	83	21	0.223	4685	1.9	2.47
30.5	26	23.5	22	104	83	21	0.223	4685	1.9	2.47
30	25	23	21	98.4	78	20.4	0.223	4551	1.9	2.40

Table No.4: Result Table For 75% Sensible Heat Load + 25% Latent Heat Load

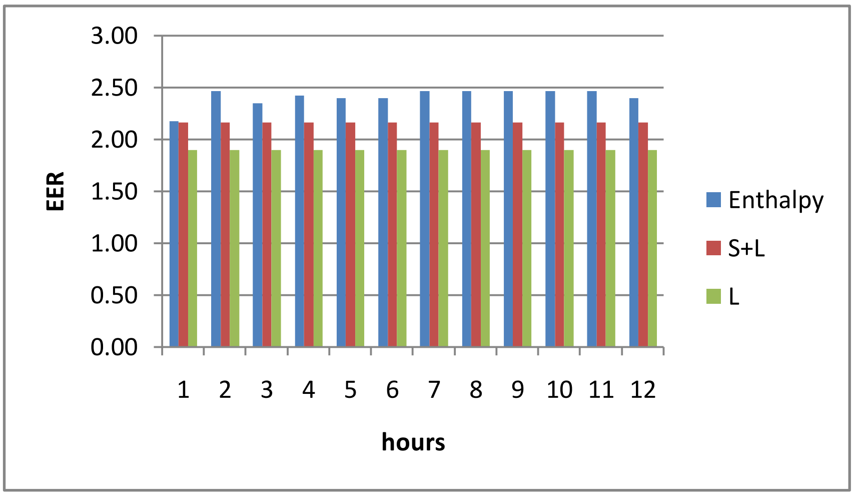
TIME HRS	AMBIENT TEMP. ^{0}C	AVG. CABINET TEMP. ^{0}C	Suction Pressure psig	Discharge pressure psig	Energy meter-Comp. kWhr	Energy meter-Heater kWhr	COMP. WORK KW	REFRI. EFFECT KW	EER

1100	29	24	65	250	32.2	15.4			
1200	30	24	67	255	34.1	19	1.9	3.6	1.89
1300	30	24.5	70	265	36	22.6	1.9	3.6	1.89
1400	31	24.5	70	265	37.9	26.2	1.9	3.6	1.89
1500	31	24.5	70	265	39.8	29.8	1.9	3.6	1.89
1600	30.5	24	67	260	41.7	33.4	1.9	3.6	1.89
1700	30	24	67	260	43.6	37	1.9	3.6	1.89

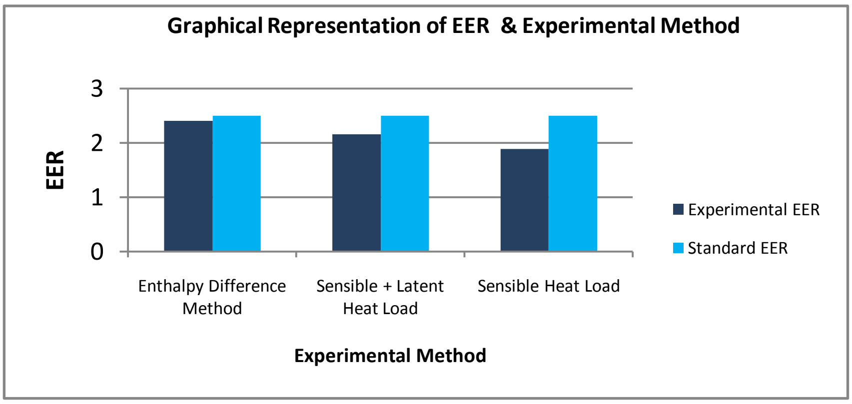
Table No.5: Result Table for 100% Sensible Heat Load Method

TIME HRS	AMBIENT TEMP. ^{0}C	AVG. CABINET TEMP. ^{0}C	Suction Pressure psig	Discharge pressure psig	Energy meter-Comp. kWhr	Energy meter-Air Heater kWhr	Energy meter-Humidifier kWhr	COMP. WORK WATTS	REFRI EFFECT WATTS	EER
1100	29	24	65	250	32.2	15.4	1.2			
1200	30	24	67	255	34.1	18.5	2.2	1900	4100	2.16
1300	30	24.5	70	265	36	21.6	3.2	1900	4100	2.16
1400	31	24.5	70	265	37.9	24.7	4.2	1900	4100	2.16
1500	31	24.5	70	265	39.8	27.8	5.2	1900	4100	2.16
1600	30.5	24	67	260	41.7	30.9	6.2	1900	4100	2.16
1700	30	24	67	260	43.6	34	7.2	1900	4100	2.16

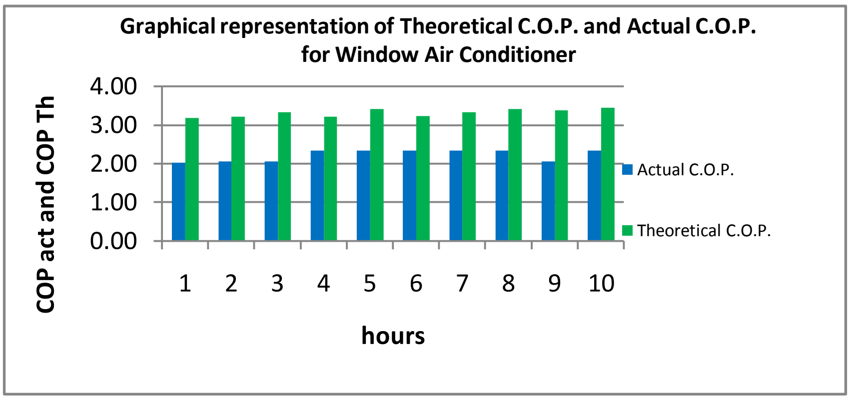
Graph No.1: Graphical Representation of EER for Different Experimentation Procedure



Graph No.2: Graphical Representation of EER Experimental Method



Graph No.3: Graphical representation of Theoretical C.O.P. and Actual C.O.P. for Window Air Conditioner



DISCUSSION:

For Capacity of the Air Conditioner 1.5 ton.

- EER by Enthalpy difference Method is 2.41.
- EER by 75% Sensible Heat Load + 25% Latent Heat Load is 2.13.
- EER by 100 % Sensible Heat Load is 1.9.
- EER for Non Star AC is up to 2.1 by Enthalpy Difference Method.
- The graphs are drawn of three methods with respect to EER and Actual COP and Theoretical COP Versus Time.

VI. CONCLUSION

The current project work is to demonstrate the working of window air conditioner to evaluate the performance parameter. During experimental investigation, it is found that the system is able to produce and maintain the different load condition in the psychrometric test chamber. It is found that the Experimental set up can produce the EER and validate the star rating. Thus, the system can be successfully used for different capacities of Window Air Conditioner, Retrofit or Modified Air Conditioner with some alteration.

With the help of this test rig the performance of Non Star AC has been checked, by Enthalpy Difference method. The EER found is up to 2.1.

It is observed that the performance of the system drastically deviated from the standard EER 2.5 in the 100% sensible heat load method, and performance improves with the 75% sensible heat load and 25% latent heat load, better performance with the Enthalpy difference Method.

By Enthalpy Difference Method averaged EER is 2.41 and as per standards for room air conditioner under standards and labeling program for 2 star rating the energy efficiency ratio is averaged at 2.6. Finally the experimental results well within acceptable limit.

VII. NOMENCLATURE

BTU	=	British thermal unit
VCR	=	Vapour Compression Refrigeration
AC	=	Air Conditioner
BEE	=	Bureau of Energy Efficiency
DBT	=	Dry Bulb Temperature
WBT	=	Wet Bulb Temperature
RH	=	Relative Humidity
EER	=	Energy Efficiency Ratio
TR	=	Tons of Refrigeration
H	=	Enthalpy
H_1	=	Enthalpy of air at inlet condition
H_2	=	Enthalpy of air at outlet condition
COP	=	Co-efficient of Performance.
COP_{th}	=	Theoretical COP.
COP_{act}	=	Actual COP.
N	=	Cooling Effect.
W	=	Compressor work

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