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Cost Benefit Analysis Of Window Air Conditioning System with Evaporative Cooled Condenser

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Abstract: ***This paper shows performance analysis of the possibility of augmentation of Coefficient of Performance and reduced power consumption of a window air conditioning trainer using an evaporatively cooled condenser. In general, during the dry and hot season, performances of without evaporative cooling condenser minimize, and Coefficient of Performance decreases because of condenser heat transfer rate decreases. This hypothesis has been tested by setting an experimental set up of a window air conditioning trainer using evaporative cooling for condensation. The results show a considerable enhancement of Coefficient of Performance of with evaporative cooling condenser as compared to without evaporative cooling condenser. The test however also shows the applicability of evaporative cooling only during the torrid atmospheric conditions.***

Keywords: ***Coefficient of performance, Cost benefit analysis, Energy saving, Evaporative cooling, Window Air Conditioning System.***

I. INTRODUCTION

Energy is extremely necessary for sustainable development of the country. It is very necessary to reduce power consumption by optimization. Fossil fuels are depleting continuously and it will not remain after consumption.

Evaporative cooling condensers designs consisted of a conventional air cooling condenser with cooling pads wrapped around the outside to evaporative pre-cool the air entering the condenser. Evaporative cooling condensers operate by spraying a continuous flow of water through nozzles to the refrigerant lines of the condenser. The refrigerant lines temperature reduces by evaporation of water spray on the condenser tubes[1].

II. BACKGROUND STUDY

Previously several related works reported by many researchers. Some of the important are listed below.

Nasr and Salah [2] found that in vapour compression refrigeration system with evaporative cooling condenser works 20°C lesser than that the without evaporative cooling condenser for heat transfer of 150 W/ m2 with air velocity 3 m/s. Eghtedari and Hajidavalloo [3] used with the evaporative cooling condenser in place of without evaporative cooling condenser to augment the performance of split air conditioning system. The results showed that the coefficient of performance increased up to 50 % and power consumption reduced up to 20 % with the evaporative cooling condenser in a split air conditioning system. Dixit et al. [4] experimented with a 1.5-ton air conditioning system. In this system, cellulose pad is retrofitted between the condenser and fan. Coefficient of performance has been increased from 5.98 to 8.03 and power consumption reduced by using cellulose pad between the condenser and fan. Jia et al. [5] have performed experimental and analytical results on without evaporatively cooled chillers with water spray on condenser by nozzles. The results revealed that the dry bulb temperature of incoming condenser air decreases 9.4 K compared with atmospheric air temperature and coefficient of performance can be increased up to 18.6 % by using water spray on condenser by nozzles.

Wang et al. [6] have done an experimental investigation with an evaporative cooling condenser. The results show that the coefficient of performance can be increased from 6.1% to 18 % and power consumed by the compressor can be reduced up to 14.3 of air conditioning system by using with evaporative cooling condenser system. Islam et al. [7,8] performed numerically and experimentally with an evaporative cooling condenser. The results revealed that the coefficient of performance of with evaporative cooling condenser increases by up to 28 % compared with without evaporative cooling condenser. Martinez et al. [9] conducted an experimental performance of an air conditioning system by using different thickness evaporative cooling condenser pads attached to the condenser. They found that the overall coefficient of performance is increased up to 10.6% by using with an evaporative cooling condenser. Amrat Kumar et al. [10] carried a performance analysis of an air conditioning system with evaporative cooling condenser for energy saving. The results showed that energy saving can be obtained from 5.18 % to 7.39 % using evaporative cooling condenser.

Zaidan et al. [11] performed theoretical and experimental Works on vapour compression refrigeration system using direct evaporative cooler near to the condenser. The results show when vapour compression refrigeration system using direct evaporative cooler then the coefficient of performance is increased up to 15 % and power consumed reduced up to 15%.

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III. EXPERIMENTAL SET UP

The Window Air Conditioning Trainer selected for the test works on vapour compression system and it uses R-22 as a refrigerant. An experiment set up consists of four main components, i.e. sealed compressor 1.5 Ton, tube and fins type conventional cooled condenser, fan motor, capillary expansion valve. The experiments performed in the month of may when torrid atmospheric conditions were prevailing and in the month of July when the weather became sultry. The set up is installed at Samrat Ashok Technological Institute, Vidisha. This experiment test set up retrofitted with evaporative cooling condenser system near to the condenser tubes.

The main components of the with the evaporative cooling condenser are a water tank, water pipe with nozzles, water circulating pump, honeycomb pad as shown in Fig.1

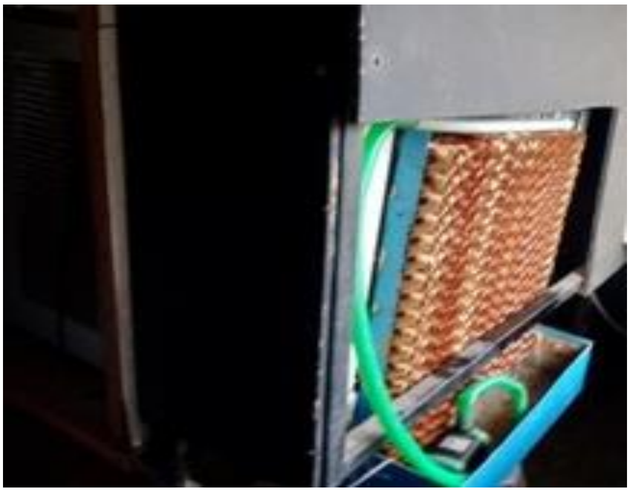

Fig.1 Evaporative cooler attached back side on condenser of Window Air Conditioning Trainer.

Fig.2 Front side of Window Air Conditioning Trainer

In this setup, readings are taken without evaporative cooling and with an evaporative cooling condenser.

Power consumption of compressor without evaporative cooling condenser =Power supplied to air conditioner compressor

Power consumption of the compressor and water pump with evaporative cooling condenser =Power supplied to air conditioner compressor + Power supplied to the water pump

As water pump is consuming less power as compared to compressor then it can be neglected.

Then, the power consumption by the compressor and water pump with evaporative cooling condenser =Power supplied to an air conditioner compressor.

IV. RESULTS AND DISCUSSION

In order to find the effect of with evaporative cooling condenser and compare without an evaporative cooling condenser, experimental tests were conducted in two subsequent stages. The first stage without evaporative cooling condenser was used and later than find the data in the second stage with an evaporative cooling condenser was used. Readings were recorded after the stable situation was reached in the system. The results of tests are taken as shown in Table 1 and Table 2.

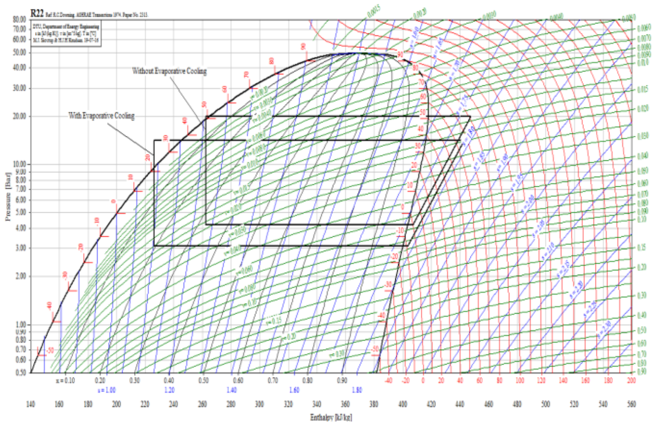

Fig.3 The P-h diagram of with evaporative cooling condenser and without evaporative cooling condenser cycle

Table 1. Coefficient of Performance for without evaporative cooling condenser

Sr. No.	T	Without Evaporative cooling		COP
		P_1 (bar)	P_2 (bar)	
01	0	4.21	20	3.56
02	10	4.34	20.68	3.51
03	20	4.41	20.68	3.56
04	30	4.55	21.92	3.41
05	40	4.41	21.02	3.49

Table 2. Coefficient of Performance for with evaporative cooling condenser

Sr. No.	Time	With Evaporative Cooling		COP
		P_1 (bar)	P_2 (bar)	
01	0	3.1	14.13	4.51
02	10	3.24	13.45	4.91
03	20	3.59	14.48	4.94
04	30	2.97	13.1	4.84
05	40	2.62	12.75	4.41

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Table 3. Comparison of Coefficient of Performance for without evaporative cooling condenser and with evaporative cooling condenser

Sr. No.	Time	COP		% Increased COP
		Without Evaporative cooling	With Evaporative Cooling	
01	0	3.56	4.51	26.69
02	10	3.51	4.91	39.89
03	20	3.56	4.94	38.76
04	30	3.41	4.84	41.94
05	40	3.49	4.41	26.36

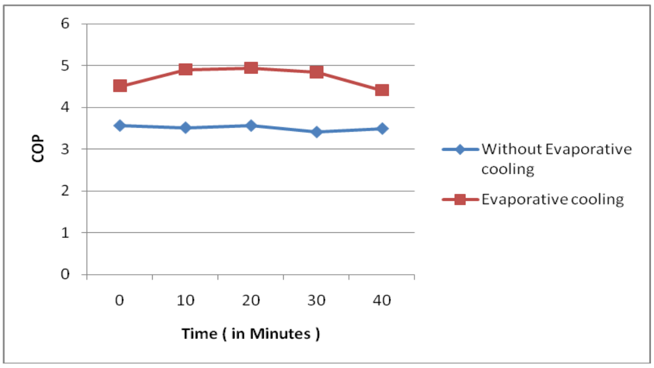

Fig. 4 Graph of Coefficient of Performance and time duration

Fig. 4 show coefficient of performance of with evaporative cooling condenser is higher compared to without evaporative cooling condenser. With evaporative cooling condenser improved the coefficient of performance (COP) from 26.36 % to 41.94 % due to decrease of compressor suction pressure and discharge pressure.

Table 4. Power Consumption for without evaporative cooling condenser

Sr. No.	T	P_1 (bar)	P_2 (bar)	Without Evaporative cooling		Power (in KW)
				V	I	
01	0	4.21	20	216	7	1.466
02	10	4.34	20.68	218	7.22	1.526
03	20	4.41	20.68	217	7.30	1.536
04	30	4.55	21.92	217	7.74	1.629
05	40	4.41	21.02	217	7.5	1.579

Table 5. Power Consumption with evaporative cooling condenser

Sr. No.	T	P_1 (bar)	P_2 (bar)	With Evaporative Cooling		Power (in KW)
				V	I	
01	0	4.21	20	218	5.9	1.248
02	10	4.34	20.68	216	5.4	1.131
03	20	4.41	20.68	216	6.22	1.303
04	30	4.55	21.92	216	5.3	1.11
05	40	4.41	21.02	216	5.15	1.079

Table 6. Comparison of Power Consumption without evaporative cooling condenser and with evaporative cooling condenser

Sr. No.	T	Power=VI Cosø		% of Power Consumption decreased
		Without Evaporative cooling	With Evaporative Cooling	
01	0	1.466	1.248	17.47
02	10	1.526	1.131	34.92
03	20	1.536	1.303	17.88
04	30	1.629	1.11	46.76
05	40	1.579	1.079	46.34

Compressor power consumption with evaporative cooling condenser decreased from 17.47 % to 46.76 % compared without evaporative cooling condenser system due to decrease of compressor suction pressure and discharge pressure.

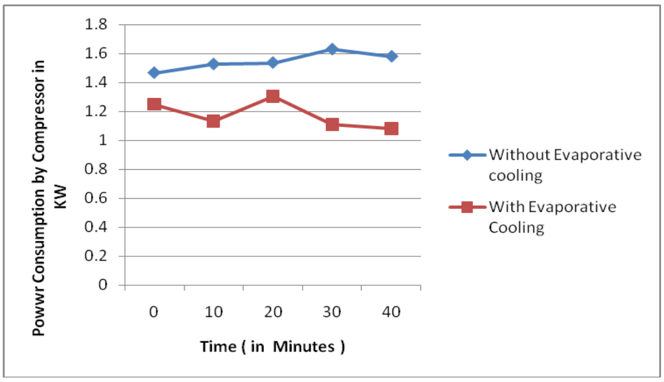

Fig.5 Graph between Power Consumption and time duration

Fig.5 shows power consumption by compressor of with evaporative cooling condenser is lower compared to without evaporative cooling condenser.

Cost Benefit Analysis- The cost benefit analysis has been presented at Vidisha, Madhya Pradesh, in India.

Cost of 1.5 TR window air conditioning system=27000 INR

Approximate cost of water pump, honey comb cooling pad, water tank = 2000 INR

Therefore, overall cost of this system is 29000 INR

Energy saving from March to June and Sep to Nov per year =1252 KWh

Cost of 1 unit electricity (1 KWh) is 7.5 INR

Thus net money saving per year = 1252*7.5=9390 INR

Payback Period = 27000 / 9390 = 2.88 years.

V. CONCLUSIONS

The evaporative cooling condenser is an efficient, cost-effective and reliable method to increase the performance of any conventional vapour compression refrigeration system.

The performance of window air conditioning trainer was experimentally investigated without evaporative cooling condenser and with evaporative cooling condenser system. The experimental results revealed that with evaporative cooling condenser the coefficient of performance (COP) increased up to 41.94% and compressor power consumption decreased up to 46.76 % compared without evaporative cooling condenser system. The cost-benefit analysis of with evaporative cooling condenser has been performed. The results revealed that according to current electricity price in India, the payback period of with evaporative cooling condenser system is less than three years.

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