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Implementaiton of Heat Recovery System to an Air Conditioner

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***Abstract*—In present energy scenario, energy conservation and recovery is essential. Energy conservation in heating, ventilating and air conditioning (HVAC), system is very important because of sharp rise in fuel prices and fuel shortage due to tremendous increase in demand and lack of supply. The annual consumption of window air conditioners has increased and hence huge amount of heat is dumped into environment as waste, even though it could be reused for some useful and economic purpose. Lot of research and development has been carried to reuse this heat at higher levels. Our paper deals with recovery of heat at domestic level. When implemented at domestic level in large numbers large energy savings can be done. Paper presents design and fabrication of air conditioning system with water cooled heat exchanger in minimum constructional, maintenance and running cost**

Keywords*— HVAC, Water cooled heat exchanger; energy conservation

I. INTRODUCTION

A conventional air conditioner works on the vapour compression cycle. In this the heat gained by the refrigerant in the evaporator which is consequently liberated into the atmosphere through the condenser. In conventional air conditioning system it is seen that these condensers are air-cooled. Thus this paper aims at utilizing this heat which is rejected into the atmosphere for the heating of water with the help of a water cooled condenser thereby reducing energy to heat the water and also improving the coefficient of performance.

The basic components of the system are as follows:

1. 1 ton air conditioning system
2. Shell and coil heat exchanger
3. Refrigerant
4. Capillary

Figure1 shows the representation of conventional air conditioner set up. In the figure 2 a water cooled condenser is placed in series with the air cooled condenser in between the air cooled condenser and the compressor. The heat of the refrigerant is rejected partly into the water present in the water cooled condenser. As the time passes the temperature of the water in the tank rises. This slightly heated water may be used in various domestic applications which will help reduce the energy consumption made in other heating systems. Timely replacement of the water in the heat exchanger is an important step to maintain the desuperheating and constant improved COP in the system. [1,4]

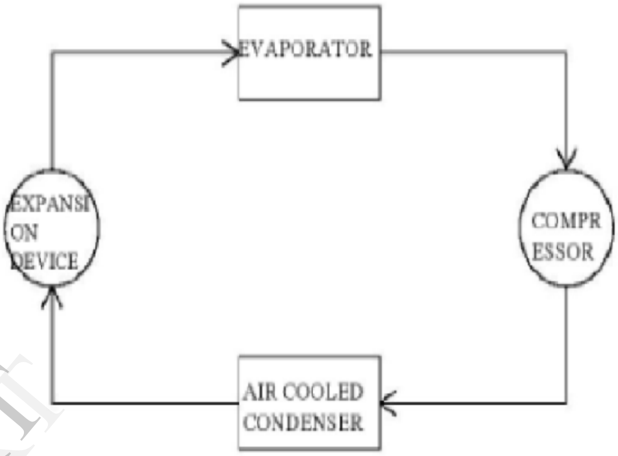

Figure 1. Schematic representation of conventional air conditioner setup

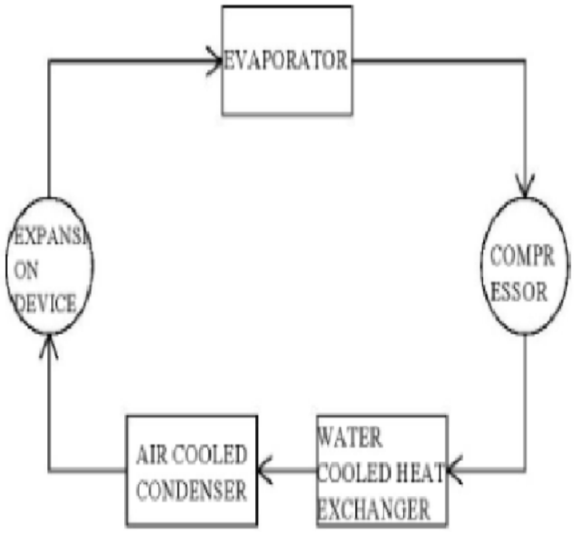

Figure 2. Schematic representation of modified air conditioner setup

Figure 3 shows the actual setup with implementation of heat recovery system to an air conditioner.

Figure 3. Actual Setup

II. DESIGN OF HEAT EXCHANGER

A. *Material Selection*

Piping: The material selected for piping is copper and refrigerant selected is R22. Table 1 and 2 shows properties of copper and refrigerant R22 respectively

Table 1. Properties of Copper

Thermal Conductivity	*Ultimate Tensile stress*	*Thermal Expansion coefficient*	*Exp Range*
402W/m°K	210MPa	$17x10^{-6}$/°C	20-300

Table 2. Properties of R22

Critical Temperature (°C)	*Critical Pressure*	*Latent heat of Vapourization(Kj/Kg)*	*Boiling point (°C)*
96.2	4936	233.95	-40.8

B. *Heat Exchanger Design*

Table 3 shows design of heat exchanger piping.

Table 3. Dimensions of Heat Exchanger

Parameters	*Value*
Diameter of heat exchanger coil	¼ inch
Thickness	0.5mm
Rating of heat exchanget	0.15 TR
Temperature drop	30°C
Length of heat exchanger coil	1.75m

III. FABRICATION

A Heat Exchanger

The heat exchanger fabricated for the air conditioner is a shell and coil type heat exchanger. This type of heat exchanger was selected on account of the ease of fabrication and maintenance. The heat exchanger is of 0.15TR. The components of the system include tank and coil.

- Tank
  The tank is a crate made of plastic, insulated with thermocol to prevent the loss of heat of the water placed in the tank. A coil is placed inside the tank.
- Coil
  The coil carries the heated and pressurized refrigerant from the compressor outlet to the air cooled condenser via the tank filled with water. Figure 4 shows heat exchanger setup and figure 5 shows experimental setup with outdoor unit. The experimental setup consists of a modified window air conditioner in which the evaporator section has been removed and replaced with the fabricated heat exchanger unit.[1,2]

Figure 4. Heat Exchanger setup

Figure 5 –outdoor unit

IV. EXPERIMENTATION

A Observations

Experiment was conducted for period of 50 minutes in a partially closed room of size 21x16 feet and parameters like temperature of water, condenser and evaporator pressures were noted at intervals of 2 minutes as shown in table 4.

Table 4. Observations of water temperature, discharge and suction pressure

Time	*Temperature of Water (°C)*	*Pressure at evaporator (Psi)*	*Pressure at condenser (Psi)*
0	28.2	45	230
2	29	46	230
4	30.1	48	230
6	31.1	51	240
8	32.1	55	242
10	33.1	57	251
12	34	60	253
14	34.9	60	255
16	36.1	62	257
18	36.9	62	265
20	38.1	62	261
22	39.1	62	262
24	40.1	64	268
26	40.9	64	270
28	41.9	64	268
30	42.7	65	270
32	43.5	67	275
34	44.4	67	275
36	45.2	67	275
38	46	68	280
40	46.7	68	280
42	47.5	68	280
44	48.2	68	281
46	48.9	69	283
48	49.5	70	285
50	50.2	70	285
52	50.8	70	283

B Heat Recovery Calculations

- Volume of water in heat exchanger = 21.808 litres
- Mass of water in heat exchanger = 21.808 kg
- Initial temperature of water = 28.2°C
- Final temperature of water = 50.2°C
- Time taken for temperature rise = 50 minutes
- Heat recovered by system = m x c_p x ΔT = 2062.129 kJ. [2]

V. RESULTS AND DISCUSSION

A Heat Recovered

On basis of the experiment conducted over the period of 50 minutes, it was calculated that the amount of energy saved during course of experiment is equivalent to 0.573 kWh of electrical units.

B Analysis of temperature versus time

The graph of temperature of water vs time is plotted with reference to the observations mentioned in table no.4.

Figure 6 shows water temperature varies almost linearly with time.

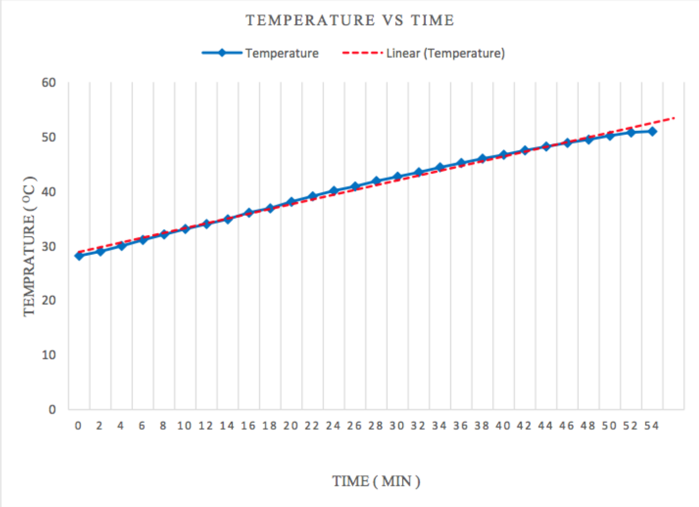

Figure 6 Variation of water temperature with time

C. Analysis of variation of pressure versus time

The graph of condenser and evaporator pressures vs time is plotted with reference to the observations mentioned in table 4.

Fig 7 shows that discharge and suction pressure increases gradually as the experiment proceeds.

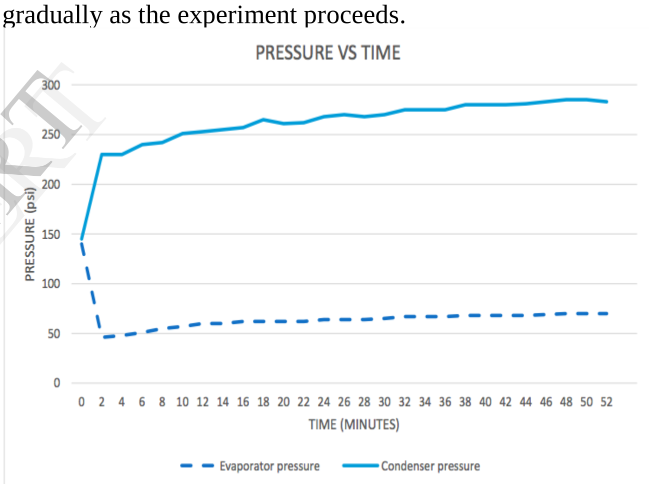

Figure 7 Variation of discharge and suction pressure with time

The maximum allowable standard pressures in the evaporator and condenser, and the initial and final pressures of condenser and evaporator in the experiment are as shown in the table no.5.1.

Table 5.Suction and discharge pressure

	Suction pressure (psi)	*Discharge pressure (psi)*
Maximum allowable	75	275
Initial pressure	50	240
Final pressure	75	285

It is seen that on exceeding this pressure range, the compressor starts drawing more current for doing work against the pressurized refrigerant. As a result the system starts consuming more energy than before. Hence COP of the system starts to drop.
Thus the system can be run at an optimal range of discharge pressure upto 270 psi. Hence final temperature of water at which water should be drained (T_3) = 42.7°C. Time taken for

rise in temperature = 30 minutes and energy rejected into the water = 0.367 kWh.

D. Analysis of Variation of rate of change in temperature with time

It is seen that the rate of change of temperature is higher initially when the water is cold which goes on decreasing as the temperature of water increases as shown in the figure 8.

The average rate of change of temperature of water when the experiment was performed for 50 minutes was observed to be 0.4346°C/min. However this rate of change of water temperature was observed for increased discharge and suction pressures, which is not feasible during operation.

The average rate of change of temperature of water when the experiment was performed for 30 minutes when the discharge and suction pressure are within the specified range is calculated to be 0.4833°C/min.

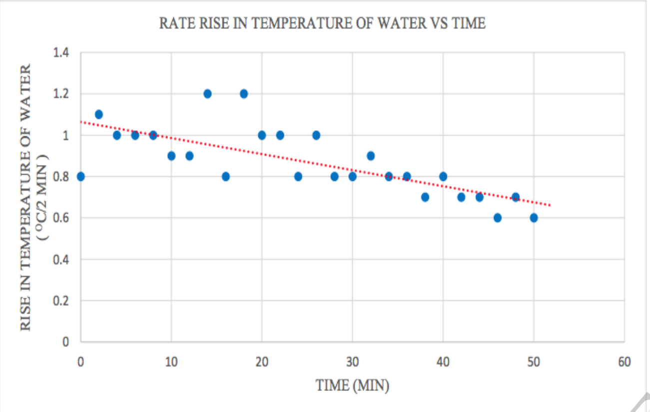

Figure 8 Variation of rate of change in temperature with time during experimentation

VI. Conclusion

The experiment was successfully conducted and following conclusions are made on basis of the results obtained. 0.6873 kW of energy is saved and utilized for heating of water which was equivalent to 0.573 kWh of electricity in one run of 50 minutes in a partially opened room of size 21 x 16 feet.

But it was observed that while heating water from 28.2 °C to 50 °C, current utilized by the machine was increased, as a result more input power was needed to run the air conditioner. Thus, in order for air conditioner to work under standard current range, it should be operated within the range 240-275 psi. Thus the heating of water can only be done up to 42.7°C For this 0.367 kWh of electrical energy was saved. Appropriate measures have to be taken to replace water after it reaches 42.7°C of temperature.

REFERENCES

1. R. B. Lokapure & J. D. Joshi, "Waste heat recovery through the air conditioning system," International Journal of Engineering Research and Development, 2012, pp 87 – 92.
2. M. Joseph Stalin, S. Mathana Krishnan, G. Vinoth Kumar, "Efficient Usage Of Waste Heat From Air Conditioner," July 2012 in International Journal of Advances in Engineering & Technology pp 414 - 421.
3. Fei Liu, Hui Hang, Yingjiang Ma, Rong Zhuang, "Research on Air Conditioning Water Heater System," in International refrigeration and Air Conditioning conference 2210 , 2008, pp 1 - 9.
4. 'Condenser theory and selection' by Carrier Refrigeration Pvt. Ltd in 2007 pp 6 - 18.
5. 'Performance Rating Of Desuperheater/ Water Heaters' by AHRI in 2006 pp 1 - 9.