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EXPERIMENTAL INVESTIGATION ON RECOVERY OF WASTE HEAT FROM WINDOW AIR CONDITIONER

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Abstract

Nowadays, besides the air conditioning unit, another comfort providing equipment that can be found in many homes in India is the instant water heater system which is often used when both the air and water temperature are low. However, the instant water heater consumes a considerable amount of electricity. There is still a possibility to obtain hot water without using any extra electric power if the air conditioning and water heating systems are integrated.

In the present work, condenser of the air conditioning unit is attached to a co-axial copper pipe in the form of a spiral coil which is connected to water tank through the pipes to warm up the water to be used for domestic purposes. The results showed for AC (air conditioner) of 1.5 TR are; temperature of the water in the heating tank can be raised from initial water temperature 28°C to 57°C within 15 to16 minutes, the temperature of the evaporator can be lowered down within few minutes. By using this type of heat recovery devices, compressor efficiency can be improved and at the same time, warm water for domestic purposes can be continuously obtained. The end result is faster cooling and prolonged compressor life and also the AC system was found to be higher COP than that of conventional AC. This system is simple and inexpensive and able to save the water heating cost and at the same time, safe in environmental aspects, i.e., less heat is rejected to the environment.

I. INTRODUCTION

Energy is a basic requirement for the existence and development of human life. Primarily the commercial sources of energy are fossil fuels (coal, oil and animal gas), hydroelectric and nuclear power plants which provide for the energy needs of the country. The fear of release of radio activity into the atmosphere in the event of accident or from nuclear waste has forced people to reconsider the use of nuclear power. In view of this problem associated with conventional energy sources. The focus is now shilling to conservation and efficient utilization of energy.

The annual energy consumption of window mounted room air conditioners has increased as those have become are liable means for providing zoned space cooling of residential and commercial buildings, this new system having a water cooled condenser reduces power consumption of AC by extracting more heat from the refrigerant resulting in faster cooling of refrigerant and reducing load on compressor, that saving power.

The purpose of this experimental apparatus is to develop multi utility air conditioning system to produce air conditioning effect (cooling of space) and generation of hot water (by using extracted heat from cooling space) simultaneously. This project presents an experimental set up which uses waste heat from a window type air conditioner to heat water for residential and commercial use.
WHRS from AC of 1.5TR, the main aim is to utilize the heat released from the condenser to heat water, which can be used for domestic purpose like laundry, bathing etc. Usually higher the temperature, higher the quality and more cost effective is the heat recovery. This system employs cooling of condenser by water, thus extracting more heat from the condenser per unit time, thus there is a chance of increase in air conditioner efficiency.
After carrying out the experiment it was found that it takes about 12 minutes to raise the temperature of water above 52°C in winter and above 55°C in near summer in 8 to 9 minutes. The COP of the AC system was found to be higher with more quantity of water in recovery tank and the AC showed better COP m winter than in summer due to lesser load.

II. BACKGROUND INFORMATION

Now a day the present world is feeling a serious problem of energy crisis, so there is a necessity to generate new energy or minimize power consumption by making modifications to the present systems so that the consumes lesser power and are also easy to operate. Making modification to the present system can be incorporate easily than from a newer technology because it would take a lot of time to come in the market and make it available to common man and also economic point of view on one would part away from there working systems to a newer system as it will be costly.
The main idea to make water heater from an AC came to us in refrigeration an Air Conditioning subject where we observed that there was lot of heat being thrown to the atmosphere at condenser and heat energy thrown out was greater than the input electrical energy which was the heat due to compression of refrigerant and the heat extracted from room, so we tried a design a heat reclamation system to utilize the heat being wasted.
In this project we have mainly tried to save the power consumption for heating water by geyser and also found that the power consumed by AC would reduce as water had higher heat capacity and the refrigerant would cool faster giving better cooling and reducing load on compressor.

III. COMPONENTS OF HEAT RECOVERY SYSTEM

The components required making heat recovery system from domestic refrigerator are

1. Co-axial copper pipes.
2. Well insulated tank.
3. Water Pump.
4. Plastic pipes.

Co-axial copper pipes: The co-axial copper pipes act as water cooled heat exchanger. The heat from the refrigerant is transferred to flowing water here.

Fig No: 4.1 co-axial copper pipe

Fig No: 4.2 Water collecting tank

Water collecting tank: The water collecting tank is used to store the water that is heated using the heat recovery system.

The water in the tank is circulated as a closed loop system until the desired water temperature is obtained.

Water pump: Water pump is used to circulate water from the tank to heat recovery unit and then back to the tank.

Water pump

Plastic Pipes

Plastic Pipes: The plastic pipes are used as an intermediate connection between heat recovery unit and tank.

IV. WORKING OF HEAT RECOVERY SYSTEM

In a simple air conditioning system, process starts with compressor where pressure and temperature of the refrigerant are increased. This hot and high pressure refrigerant vapour passes through the condenser where heat is rejected to the atmosphere. In the present work the hot line of the AC system is bypassed to a heat recovery unit.

In this project 1.5 TR AC condenser cooled by air is being attached by parallel water cooled condenser, so that it can be bypassed whenever it is required by means of valves. When hot water is required, the refrigerant flow is bypassed from air cooled condenser to water cooled condenser, thus releasing heat to the water in the tank. When hot water is not required, the original system works by releasing heat to the atmosphere by air cooled condenser.

Thus we are saving power by reducing the running cost of AC and also providing free hot water without consuming additional electrical power required for geyser.

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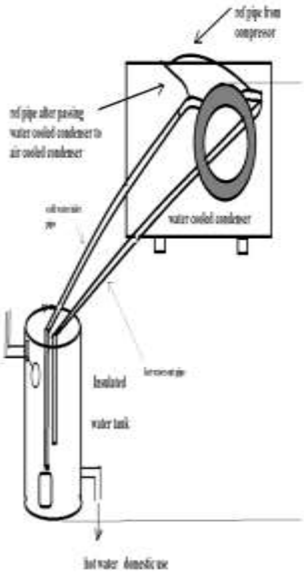


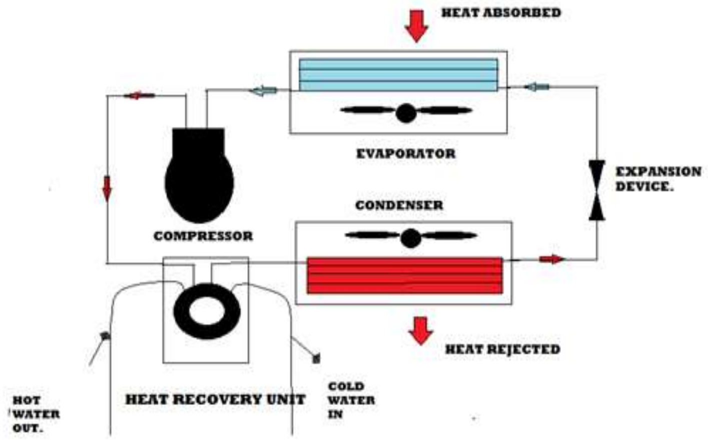
V. EXPERIMENTAL PROCEDURE

The potential source of heat to be reclaimed comes from the refrigerant leaving the compressor. In the original design of a conventional air conditioning system, the copper tube containing the superheated refrigerant from the compressor is diverted directly into the condenser coil for heat removal. In order to reclaim the potential heat source from the super heated refrigerant series water cooled condenser is arranged, the refrigerant is passed through the copper pipe.
For carrying out the experiment

- Initially the tank is filled with 5 liters of water.
- Initial water temperature is noted.
- The AC is switched on.
- The amperes consumed are noted by using digital clamp type multimeter.
- Temperature of water is measured by using the thermometer.
- The experiment is calculated for 12 minutes.
- The same procedure is carried out for5, 10,15,20,25 liters of water.
- Similarly the power consumption of conventional AC is found out by using digital clamp type multimeter.

COP=Net refrigeration effect / Compressor work
COP is always greater than 1 as refrigeration effect (heat taken from room) is more than compressor work.

Heat rejected to water is greater than heat rejected to air as specific heat at constant for water for water is 4.2 KJ/Kg K while for air is 1 thus there is a chance of increased air conditioner efficiency.



Line Diagram

VI. APPLICATIONS

- **Residential Building and Complexes**
  Simultaneous space cooling, water heating for bathing, dish washing, cloth drying,etc.
- **Commercial--- Hotels, restaurants, Hospitals, etc.**
  Space cooling, water heating/preheating and simultaneous production of cold and hot water streams, sea water desalination or water purification, liquid desiccant regeneration.
- **Industrial – Dairy, Pharmaceutical, Textile, Chemical Process, etc.**
  1. Water heating/preheating, air conditioning and simultaneous generation of cold and hot water streams, condenser to re-boiler heat pumping.
  2. Cogeneration of air conditioning and hot water for process heating, boiler feed water heating or preheating.
  3. Cogeneration of air conditioning and hot water for heating/preheating dryer air, sea water desalination o water purification, liquid desiccant regeneration.

ADVANTAGES

1.Makes free hot water
2.Power consumption is less
3.Compressor life is increased
4.Cooloing effect is more

DISADVANTAGES:

1. Crude design.
2. Requires de scaling of water cooled condenser coil.
3. Chances of leakage are more due to many joints.
4. Requires frequent changing of water in tank.

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WATER INTAKE (LTS)	INITIAL TEMPERATURE OF WATER(T_I)	TIME TAKEN FOR HOT WATER								AVERAGE OF AMPERES	$\Delta = T_4 - T_I$
		3 MINUTES		6 MINUTES		9 MINUTES		12 MINUTES			
		T_1	A_1	T_2	A_2	T_3	A_3	T_4	A_4		
5	28	41	7.83	48	8.15	51	8.38	58	8.58	8.23	30
10	28	39	7.69	45	7.89	48	8.26	54	8.54	8.09	26
15	28	37	7.38	43	7.75	45	8.09	51	8.41	7.90	23
20	28	34	7.36	41	7.69	42	8.02	47	8.32	7.84	19
25	28	32	7.30	38	7.69	40	8.00	43	8.25	7.79	15

READINGS OBSERVED IN THE MORNING:

COMPRESSOR WORK (KILO WATT)	$mc_P \Delta T$ (KILO JOULE)	COP
1.890	627	2.78
1.860	1086.8	2.83
1.817	14421.	2.837
1.803	1588.4	2.92
1.791	1567.5	2.97

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FOR 5 LITRES OF WATER

Average amperes consumed = 8.23A
Voltage =230V
Compressor work = power *amperes/1000
=230*8.23/1000
=1.892 Kilo Watts
Heat absorbed by water =mcPΔt.
=5$\times$4.18$\times$30
=627KJ

COP CALCULATIONS:

Cooling capacity = 18000 BTU/Hr
1BTU=1.05 KJ
1KJ=0.000287 KWH
18000 BTU/Hr=18000*1.054 KJ/Hr
=18972 kj/Hr.
=5.27 Kw (Net Refrigeration Effect)
COP = Net refrigeration effect/ compressor work
=5.27/1.860
=2.78

FOR 10 LITRES OF WATER

Average amperes consumed = 8.09A
Voltage =230V
Compressor work = power *amperes /1000
=230*8.09/1000
=1.860 Kilo Watts
Heat absorbed by water =mcPΔt.
=10$\times$4.18$\times$26
=1086.8 KJ
COP = Net refrigeration effect/ compressor work
=5.27/1.860
=2.83

FOR 15 LITRES OF WATER

Average amperes consumed = 7.90 A
Voltage =230 V
Compressor work = power *amperes /1000
=230*7.908/1000

=1.817 Kilo Watts

Heat absorbed by water =mcPΔt.

=15×4.18×23

=14421 KJ

COP = Net refrigeration effect/ compressor work

=5.27/1.817

=2.837

FOR 20 LITRES OF WATER

Average amperes consumed = 7.84 A

Voltage =230 V

Compressor work = power *amperes/1000

=230*7.84/1000

=1.803 Kilo Watts

Heat absorbed by water =mcPΔt.

=20×4.18×19

=1588.4 KJ

COP = Net refrigeration effect/ compressor work

=5.27/1.803

=2.92

FOR 25 LITRES OF WATER

Average amperes consumed = 7.79 A

Voltage =230 V

Compressor work = power *amperes/1000

=230*7.79/1000 =1.7917 Kilo Watts

Heat absorbed by water = mcPΔt.

=25×4.18×15

=1567.5 KJ

COP = Net refrigeration effect/ compressor work

=5.27/1.791

=2.97

READINGS OBSERVED IN THE AFTERNOON:

WATER INTAKE (LTS)	INITIAL TEMPERATURE OF WATER(T_I)	TIME TAKEN FOR HOT WATER								AVERAGE OF AMPERES	$\Delta = T_4 - T_I$
		3 MINUTES		6 MINUTES		9 MNUTES		12 MINUTES			
		T_1	A_1	T_2	A_2	T_3	A_3	T_4	A_4		
5	28	43	9.1	49	10.05	54	10.83	62	10.94	10.23	34
10	28	40	9.06	46	9.58	52	10.06	59	10.35	9.76	31
15	28	39	8.49	43	8.59	49	8.62	54	8.68	8.59	26
20	28	37	7.67	41	7.89	46	8.31	52	8.50	8.09	24
25	28	35	7.40	38	7.91	44	8.25	49	8.43	7.99	21

COMPRESSOR WORK (KILOWATT)	$mc_P \Delta T$ (KILO JOULE)	COP
2.35	3553	2.24
2.24	2194.5	2.35
1.97	2717	2.67
1.86	2717	2.83
1.83	2194	2.87

FOR 5 LITRES OF WATER

Average amperes consumed = 10.23 A
Voltage =230 V
Compressor work = power *amperes /1000
=230*10.23/1000
=2.35 Kilo Watts
Heat absorbed by water =mcPΔt.
=5×4.18× 34
=3553KJ
COP = Net refrigeration effect/ compressor work
=5.27/2.35
=2.24

FOR 10 LITRES OF WATER

Average amperes consumed = 9.76 A
Voltage =230 V
Compressor work = power *amperes/1000
=230*9.76/1000
=2.24 Kilo Watts
Heat absorbed by water =mcPΔt.
=10×4.18×21
=2194.5KJ
COP = Net refrigeration effect/ compressor work
=5.27/2.24
=2.35

FOR 15 LITRES OF WATER

Average amperes consumed = 8.59 A
Voltage =230 V
Compressor work = power *amperes /1000
=230*8.59/1000
=1.97 Kilo Watts
Heat absorbed by water =mcPΔt.
=15×4.18×26
=2717KJ
COP = Net refrigeration effect/ compressor work
=5.27/1.97
=2.67

FOR 20 LITRES OF WATER

Average amperes consumed = 8.09A
Voltage =230 V
Compressor work = power *amperes/1000
=230*8.09/1000
=1.86 Kilo Watts
Heat absorbed by water =mcPΔt.
=25$\times$4.18$\times$26
=2717KJ
COP = Net refrigeration effect/ compressor work
=5.27/1.886
=2.83

FOR 25 LITRES OF WATER

Average amperes consumed = 7.99 A
Voltage =230 V
Compressor work = power *amperes/1000
=230*7.99/1000
=1.83 Kilo Watts
Heat absorbed by water =mcPΔt.
=25$\times$4.18$\times$21
=2194.5KJ
COP = Net refrigeration effect/ compressor work
=5.27/1.83
=2.87

VII. CONCLUSION

By conducting the experimental test on WHRS, the following conclusions were made,

- Better cooling is obtained at lower running cost.
- This waste heat recovery device is environmental friendly because it reduces the amount of heat discharged to the environment by an air-cooled condenser.
- Heat rejection of refrigerant to water is faster than that of air, thus faster cooling of refrigerant and reducing load on compressor.
- The major disadvantages are scaling of water cooled condenser and leakage of refrigerant due to many joints.
- Further modifications can be done to automate the Heat Recovery System.
- Free hot water is obtained while using AC (air condition)
- Electrical power consumption cost for heating water is less when compared with geyser.

SCOPE

- **Improve Life Cycle Cost**
  1. Lower operating cost due to higher overall energy efficiency.
  2. Peak demand for domestic water heating can be reduced.
  3. Co-production of multiple utilities using a single system helps reduce space, initial cost and maintenance.
- **Energy Conservation**
  1. Co or tri-generation of cold, hot and / or dehumidification utilities.
  2. Heat recovery with chillers and improvement of COP.
  3. Preheating of boiler feed water, which is free if primary useful effect is cooling and vice versa.
- **Environmental Friendly**
  1. Co-production of multiple utilities helps improve cooling capacities/COP and reduce refrigerant charge.
  2. Thermal pollution reduced by gainfully recovering heat rejection from the condenser in air cooled or water cooled mode.

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