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Utilization of waste heat of condenser from domestic refrigerator (whirpool, 165 ltr.) using R134a & R60

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ABSTRACT

Refrigeration is a process where the heat moves from low temperature reservoir to high temperature reservoir. Heat which is rejected by the condenser of a refrigerator is of low quality which means the temperature is low. So in this current project an attempt is made to utilize this waste heat from the condenser of a household refrigerator. Waste heat from the condenser is directly rejected to the atmosphere. Though it is impossible to recover the entire energy lost by the waste heat of the refrigerator, this project aims at minimizing the losses and recovery of maximum heat from the system by using water cooled condenser. This helped in saving of energy as no extra electricity was used for heating water. In this paper we are using R134a and R600a as refrigerant and compare the time required to heat the water and the actual and theoretical COP of the refrigerator using both refrigerants.

Key Words: Waste heat recovery, domestic refrigerator, water cooled condenser.

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I. INTRODUCTION

In the refrigeration cycle heat absorbed in the evaporator and the compressor work is released back in the condenser. This heat is generally the waste heat. Waste heat is generally the energy associated with the waste streams of air, gases, and liquids that leaves the boundary of the system and enter into environment. Waste heat which is rejected from a process at a temperature enough high above the ambient temperature permits the recovery of energy for some useful purposes in an economic manner. The essential quality of heat is not the amount but its value. Waste heat recovery and utilization is the process of capturing and reusing waste heat for useful purposes. Not all waste heat is practically recoverable. The strategy how to recover this waste heat depends on the temperature of the waste heat sources and on the economics involved behind the technology incorporated.

Instead of wasting this heat quantity by dissipating it to the environment, appropriate measures can be implemented in order to put this heat flow to meaningful use for heating purposes because of its temperature level. Though it is impossible to recover entire energy lost by the waste heat of the refrigerator, this project aims at minimizing the losses and recovery of maximum heat from the system.

In this paper we will study how we can use the waste heat to heat water which can be used further used for different applications. Also we will study and compare the refrigeration effect and the recovery of waste heat using R134a refrigerant and R600a refrigerant. Thus using this method we can eliminate this waste heat entering into the environment as well as save the energy consumption which will be used to heat the same amount of water at that temperature.

II. LITERATURE REVIEW

[1] **Stinson**: Conducted research in dairy refrigeration by recovering the heat from condenser. They found out that by using the water cooled condenser COP of the system is enhanced by 10% to 18%. They also found that increase in condenser pressure reduces COP, and inclusion of heat recovery heat exchanger reduces head loss. Waste heat recovery and utilization is the process of capturing and reusing waste heat for useful purposes. Not all waste heat is practically recoverable. The strategy of how to recover this heat depends on the temperature of the waste heat sources and on the economics involves behind the technology incorporated. .

[2] **Rane:** Developed sensible heat recovery unit and carried out experiments. Waste heat recovered is utilized for water heating. Their findings are: (i) chiller cooling capacity enhanced by 30% and COP by 20%. Waste heat which is rejected from a process at a temperature enough high above the ambient temperature permits the recovery of energy for some useful purpose in an economic manner. The strategy of how to recover this heat depend not only on the temperature of the waste heat sources but also on the economics involves behind the technology incorporated. A typical vapour compression system consist of four major components viz. compressor, condenser, expansion device and an evaporator

[3] **Dr. S. B. Barve**: Discussed in studies on to heat water by recovering the heat released on the level of the condenser of the cooling systems such as refrigerator, air-conditioner, cold room etc. They have also shown that such a system is economically viable. Energy consumption by the system and environmental pollution can still further be reduced by designing and employing energy saving equipments. Heat is energy is ,so saving of energy and point of furl consumption and for the protection of global environment .It uses refrigerator of 165 lit, cop of refrigerator, refrigerating effect.

[6] **Romdhane Ben Slama (2009):** Innovated coupling of refrigerator to a cumulus to heat water by yielding heat from the condenser of the refrigerator system. The original condenser of the system is replaced by spiral heat exchanger immersed in water kept in a tank. With this arrangement the quantity of energy transferred by the water-cooled condenser is sufficient enough to raise the temperature of heating water up to 60°C in approximately 5 hours. The recovery process enhances the performance of the refrigerator in terms of increased COP and power savings.

[7] **Sreejith, Sushma and Vipin**: Have done a comparative study between the air-cooled and water-cooled condenser at different load conditions. Results showed that when water-cooled condenser was used the performance of the system increased. Also when the air-cooled condenser was replaced by the water-cooled condenser the energy consumption went down at different loads. There was a reduction in the energy consumption by approximately 8% - 11%. Experimental results also proved that there was considerable enhancement in the COP of the refrigerator. The construction of the system was modified by retrofitting it, instead of air-cooled by making a bypass line. The quantity of water obtained at 58°C from this system was around 200 litre.

[8] **Y.A. Patil ,H.M. Dange** : Refrigerator has become an essential commodity rather than luxury item. The heat absorbed in refrigerated space and the compressor work added to refrigerant is too rejected to ambient through a condenser. Our aim is to recover waste heat from condenser unit of a household refrigerator to improve the performance of the system. The heat recovery from the household refrigerator is by copper tube. . From the experimentation it was found that after recovering heat from the condenser of the conventional refrigerator its performance get improved than conventional refrigerator. The maximum temperature achieved in water tank with 100 litre of water is 45ºC at the full load condition. If the water tank contains 50 litre water then it gets heated to 45 ºC in just 5 to 6 hrs. After that performance of the system gets decreased. So it needs regular use of that hot water.

III. EXPERIMENTAL SETUP

Fig -3.1: Winding of copper coil around condenser

Fig -3.2: Water container with pump

In this project we have used a 165 Ltr Whirlpool refrigerator. A copper tube of 4mm inner diameter is wounded along the condenser tubes as shown in **Fig -2.1**, such that the heat from the condenser tubes is transferred to the copper tube. A pump is immersed in a container containing water as shown in Fig **Fig -2.2**. One end of the copper tube is attached to the outlet of the pump and other end is inside the water container.
Thus the water is pumped into the copper coil which flows throughout the length of the tube and exits into the water container again. The heat gained by the copper coils from the condenser is transferred to the water flowing through it.

Specifications of copper coil: Inner diameter- 4 mm.
Outer diameter- 5 mm.
Length- 3 m.

3. Properties of refrigerants

3.1 Properties of R134a:

i. Boiling point- -26.1 ^{o}C
ii. Auto ignition temperature: 770 ^{o}C
iii. Ozone depletion potential: 0
iv. Solubility in water: 0.1170 by weight at 25 ^{o}C
v. Critical temperature: 122 ^{o}C
vi. Cylinder colour code: Light Blue
vii. Global Warming Potential: 1200

3.2 Properties of R600a:

i. Boiling point: -11.6 ^{o}C
ii. Auto ignition temperature: 460 ^{o}C
iii. Ozone Depletion Potential: 0
iv. Critical temperature: 134.7 ^{o}C
v. Global Warming Potential: 3

IV. OBSERVATIONS

Table 1: R134a Refrigerant Reading

Sr. No	Time (Min)	Temperature	Temperature time taken reading
1	0	33.1 (T1)	4.02 (PM)
2	5	33.3 (T2)	4.07 (PM)
3	10	33..6 (T3)	4.12 (PM)
4	15	33.9 (T4)	4.17 (PM)
5	20	34.00 (T5)	4.22 (PM)
6	25	34.2 (T6)	4.27 (PM)
7	30	34.3 (T7)	4.32 (PM)
8	35	34.5 (T8)	4.37 (PM)

Table 2: R600a Refrigerant Reading.

Sr. No	Time (Min)	Temperature	Temperature time taken reading
1	0	38.00 (T1)	3.14 (PM)
2	5	38.9 (T2)	3.19 (PM)
3	10	39.1 (T3)	3.24 (PM)
4	15	39.2 (T4)	3.29 (PM)
5	20	39.9 (T5)	3.34 (PM)
6	25	40.7 (T6)	3.39 (PM)
7	30	41.8 (T7)	3.44 (PM)
8	35	42.8 (T8)	3.49 (PM)

4.1 Sample Calculations

Temperature Difference= T_2-T_1= 38.9-38.0 = 0.9 ^{o}C.
Supplied Heat= Q1 = m C_P (T_2-T_1) = 3*4.186*(0.9) = 11.3022 kJ.
Total Heat Recovered= Q = Q1 + Q2 + Q3 + Q4 + Q5 + Q6 + Q7
= 11.3022+2.5116+1.2558+8.7906+10.0646+13.8138+12.558
= 60.27 k J

V. RESULTS AND DISCUSSION

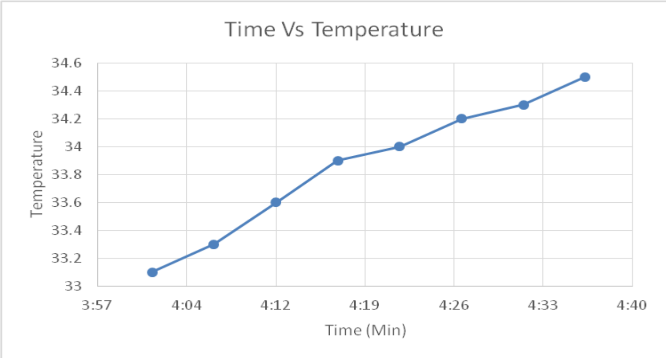

Chart -1: Time Vs. Temperature of refrigerant R134a

In the above graph we can see that for refrigerant R134a the temperature of the water increases with the time. After 35 minutes the temperature of the water is 34.5 ^{o}C. Thus after 35 minutes the temperature of the water in condenser increases by 1.4 ^{o}C. Thus the increase in temperature after 35 minutes is not significant. Hence it is necessary to get the temperature readings at larger interval of time.

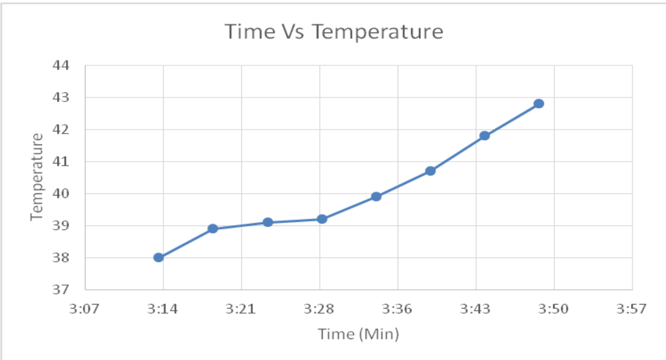

Chart -2: Time Vs. Temperature of refrigerant R600

In the above graph we can see that for refrigerant R600a the temperature of the water increases with the time. After 35 minutes the temperature of the water is 42.8 ^{o}C. Thus after 35 minutes the temperature of the water in condenser increases by 4.8 ^{o}C. Thus the increase in temperature after 35 minutes is not significant. Hence it is necessary to get the temperature readings at larger interval of time.

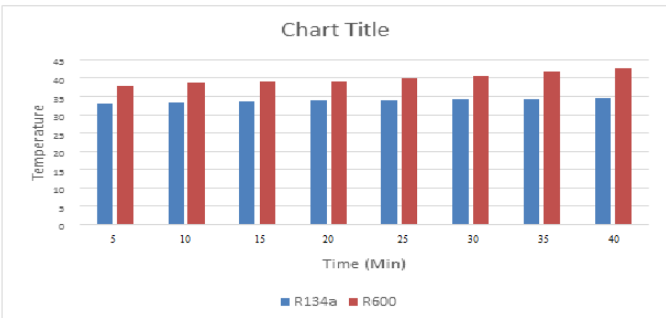

Chart -3: Comparison of refrigerant R143a & R600 (Time vs. Temperature)

In the above graph we can see that the temperature of water is more is by R600a refrigerant. The temperature of the water after 35 minutes by R600a is 42.8 ^{o}C while by R134a the temperature after 35 minutes is 34.5 ^{o}C. Thus we can say that the heat recovered in refrigerator condenser using R600a is more.

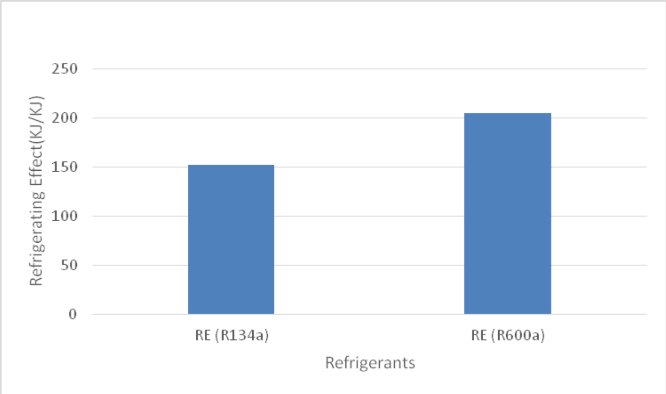

Chart -4: Comparison of refrigerating effect of R134a & R600a

From the above chart we can conclude that the refrigeration effect of R600a is significantly higher than that of R134a.

VI. CONCLUSIONS

From the above paper we can conclude that the heat rejected from the condenser can be utilized. This utilized heat is used to heat water. We can conclude that R600a gives more refrigeration effect as compared to R134a. Also more heat can be recovered using R600a giving higher temperatures of water.

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