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Experimental Investigation on Refrigerator Using Air Cooled Condenser and Coolant Cooled Condenser

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***Abstract*: The aim of this project was to investigate experimentally compare the effect of coolant-cooled condenser and air cooled condenser in a household refrigerator. The experiment was doing buy using refrigerant HFC134a as the refrigerant. In this the coolant cooled condenser is retrofitted with household refrigerator. Coolant used in the condenser is polyalkaline glycol. The pressure gauge and energy meter device was attached to the test rig. The temperature was measured by digital thermometer and all readings note at each load. The performance of the household refrigerator with air cooled condenser and coolant cooled condenser have been compared for different load conditions. The graph plotted by COP with load and work done with load. The results showing that the COP is greater when the system is working with coolant cooled condenser and work done by compressor is also reduced by coolant cooled condenser, thus the energy consumption can be reduced. The results indicate that the refrigerator performance had improved when coolant-cooled condenser was used instead of air-cooled condenser on all load conditions.**

Keywords: **Experimental investigation on a refrigerator using air cooled and coolant cooled condenser.**

1. INTRODUCTION

Refrigeration is the process of removing heat from where it is not wanted. Heat is removed from food to preserve its quality and flavor. A household refrigerator is a common household appliance that consists of a thermally insulated compartment and which when works, transfers heat from the inside of the compartment to its external environment so that the inside of the thermally insulated compartment is cooled to a temperature below the ambient temperature of the room. Heat rejection may occur directly to the air in the case of a conventional household refrigerator having air-cooled condenser or to coolant in the case of a coolant-cooled condenser. Tetrafluoroethane (HFC134a) refrigerant was now widely used in most of the domestic refrigerators and automobile air- conditioners and are using POE oil as the conventional lubricant.

Heat can be recovered by using the coolant in the coolant-cooled condenser. in this system the water-cooled condenser is designed as a tube in tube heat exchanger of overall length of 7m.coolant used in the condenser is polyalkaline glycol. The refrigeration means a continued extraction of heat from a body whose temperature is already below temperature of its surroundings. In a refrigerator, heat is virtually pumped from a lower temperature to a higher temperature. According to Second Law of Thermodynamics, this process can only be performed with the aid of some external work. It is thus obvious that supply of power is regularly required to drive a refrigerator. Theoretically, a refrigerator is a reversed heat engine or a heat pump which pumps heat from a cold body and delivers it to a hot body. The substance which works in a pump to extract heat from a cold body and to deliver it to a hot body is known as refrigerant.when the refrigerator working on coolant cooled condenser it will be cooled very faster as compared to air cooled condenser and delivery pressure of compressor will be low as compared to delivery pressure of compressor as working on air cooled condenser.as the result of our project c.o.p of the refrigerator increased when the refrigerator working on coolant cooled condenser and energy consumption will be also reduced.

2. EXPERIMENTAL SET UP

The refrigerator was of 190L capacity, single door, manufactured by whirlpool. The system was retrofitted with a coolant-cooled condenser instead of the conventional air-cooled condenser by making a bypass line. coolant-cooled condenser is a tube in tube heat exchanger having an inlet for the coolant and an exit.the inlet and exit of the coolant cooled condenser is attached with a pump was attached for circulating the coolant when the coolant become hot,the pump starts to circulatind as the help of a timer.The time setted in the timer is six hour. The modified household refrigerator was properly instrumented with temperature indicators, pressure gauges and energymeter.coolant used in the condenser is polyalkaline glycol.

Fig: 2: Experimental Set Up

The temperature readings are measured with temperature sensors and pressure is measured with pressure gauges. Evaporator and condenser pressure are noted using calibrated pressure gauges. The power consumption of the domestic refrigerator was measured by using a digital energymeter.

3. EXPERIMENTAL PROCEDURE

After the integration of the components, the valve V 3 and V 4 was closed to make the system work only with the air-cooled condenser and V 1 and V 2 was closed to make the system work only with the coolant-cooled condenser. The system was operated at four load conditions namely, No load,4litre of water,8litre of water,12litre of water. At each load conditions temperature and pressure at salient points were noted down at every five minutes interval. The energy consumption of the system is measured using a digital energy meter. The performance of the refrigerator with air-cooled and coolant-cooled condenser was measured. Draw the tabular column based upon above all readings such as P1 suction pressure,P2 delivery pressure of compressor, T1 temperature at inlet of compressor,T2 temperature at outlet of compressor,T3 temperature at outlet of condenser,T4 temperature at inlet of evaporator, energy consumption in kw. Reading taken with both condensers and test results of air-cooled and coolant-cooled condensers were compared.

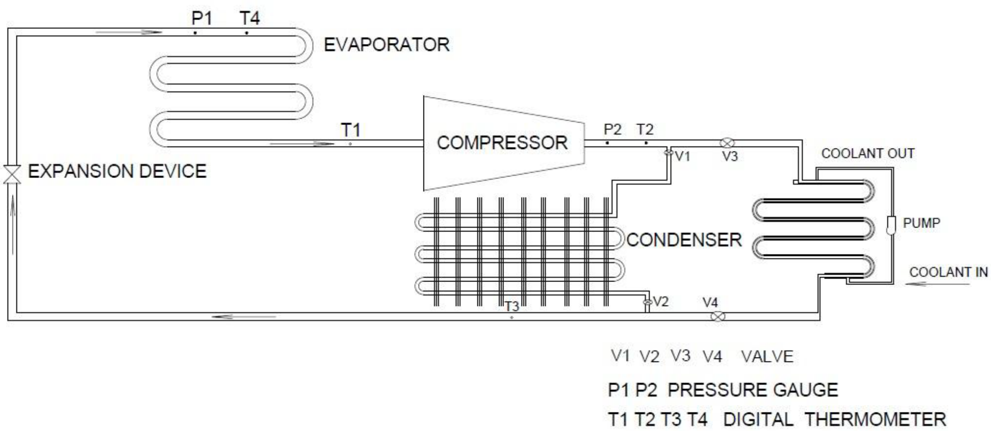

Fig 3.1: Schematic Diagram Experimental Apparatus

Sl no	Load (l)	P1 Pressure at inlet of compressor (psi)	P2 Pressure at outlet of compressor (Psi)	T1 Temperature at inlet of compressor ℃	T2 Temperature at outlet of compressor ℃	T3 Temperature at outlet of condenser ℃	T4 Temperature at inlet of condenser ℃	Energy consumption In kw
1	2	4	250	12.5	44.1	39.9	10.1	0.0468
2	4	4	250	12.9	46.2	40.8	10.9	0.0625
3	8	5	250	13.1	48.3	42.5	11.1	0.0669
4	12	6	250	13.9	50.1	43.1	12	0.0852

Coolant cooled condenser

Sl no	Load (l)	P1 Pressure at inlet of compressor (psi)	P2 Pressure at outlet of compressor (Psi)	T1 Temperature at inlet of compressor ℃	T2 Temperature at outlet of compressor ℃	T3 Temperature at outlet of condenser ℃	T4 Temperature at inlet of condenser ℃	Energy consumption In kw
1	0	4	190	11.9	41.1	38.2	8.5	0.0375
2	4	4	192	12.5	43.3	39.4	8.9	0.03906
3	8	5	195	13	44.2	41.1	9.5	0.0446
4	12	6	200	13.5	48.1	42.3	10	0.0625

Fig 3.2: Tabular Column Air Cooled Condenser

4. COEFFICIENT OF PERFORMANCE OF REFRIGERATOR

The coefficient of performance is the ratio of heat extracted in the refrigerator to the work done on the refrigerant. It is also known as theoretical coefficient of performance.

Theoretical C.O.P = Q/W

Q= Amount heat extracted from the refrigerator

W= Amount of work done

All data’s are taken from refrigeration table written by R.S KHURMI(refrigerant hfc134a) and vapour compression cycles with superheated vapour after compression

SAMPLE CALCULATION:

Air cooled condenser

$$C.O.P = \frac{Q}{W}$$

$$= \frac{h1 - hf3}{h2 - h1}$$

$$h2 = h2' + cp(T2 - T2')$$

$$= 421.28 + 1.09(44.1 - 39.9)$$

$$= 428.85\, kj/kg$$

$$h1 = 405\, kj/kg$$

$$hf3 = h3 = 254.86$$

$$C.O.P = \frac{405 - 254.86}{425.85 - 405}$$

$$= 7.20$$

SAMPLE CALCULATION

$$C.O.P = Q/W$$

$$= \frac{h1 - hf3}{h2 - h1}$$

$h2 = h2' + cp(T2 - T2')$

=419.58+1.09(41.1-38.2)

=422.74 kj/kg

$h1 = 405.5 kj/kg$

$hf3 = h3 = 253.34$

C.O.P= $\frac{h1-hf3}{h2-h1}$

= $\frac{405.5-253.37}{422.74-405.5}$

=8.32

Table 5.1 : Tabular Column With C.O.P And Work Done Of Air And Coolant Cooled Condenser

S l.no	C.O.P of air cooled condenser	C.O.P of coolant cooled condenser	Work done by air cooled condenser	Work done by coolant cooled condenser
1.	7.20	8.32	20.85	19.39
2.	6.46	7.77	22.98	21.3
3.	6.16	7.43	23.7	23.8
4.	6.2	7.21	26.2	25.3

5. COST OF ESTIMATION

SL NO	COMPONENTS REQUIRED	NO. OF COMPONENTS REQUIRED	RS.
1	Refrigerator	1	2200
2	copper tube (5/8)	-	2500
3	copper tube(3/16)	-	1200
4	Pump	1	1050
5	Accumulator	1	450
6	energy meter	1	850
7	brass service valve	4	1200
8	Thermometer	1	280
9	pressure gauge	2	1600
10	Timer	1	350
11	Hose	-	100
12	Filter	1	40
13	134a gas	-	400
14	welding gas	-	110
15	Coolant	2 bottle	500
		TOTAL	13160 RS.

Transportation cost=1800

Manufacturing cost=3000

Total cost=transportation cost +manufacturing cost+material cost

= 1800+3000+13160

=17960 RS.

6. RESULTS AND DISCUSSION

Fig 7.1 shows the COP variation of air-cooled and coolant-cooled condenser. The COP was greater for the coolant-cooled condenser than the air-cooled condenser. This may be due to the inverse proportionality of COP to work done on all load conditions. These results confirmed that the performance of household refrigerator with coolant-cooled condenser was better than that of the air-cooled condenser.

Fig 7.2. gives the comparison of the work done by the compressor with air-cooled and coolant-cooled condenser. On all load conditions, the work done by the compressor was greater for the air-cooled condenser than water-cooled condenser. This was because the condenser-evaporator pressure difference was high for the system when operating with air-cooled condenser than the coolant-cooled condenser. As the work done by the compressor increases the power consumption of the house hold refrigerator also increases as the refrigerator working on coolant cooled condenser the delivery pressure of the compressor is low as compared to the system working as on air cooled condenser. The outlet temperature of the compressor is high on the refrigerator working on air cooled condenser and the outlet temperature of the compressor is low as the refrigerator working on coolant condenser. As the result from above figures shows that coolant condenser is more efficient than air cooled condenser.

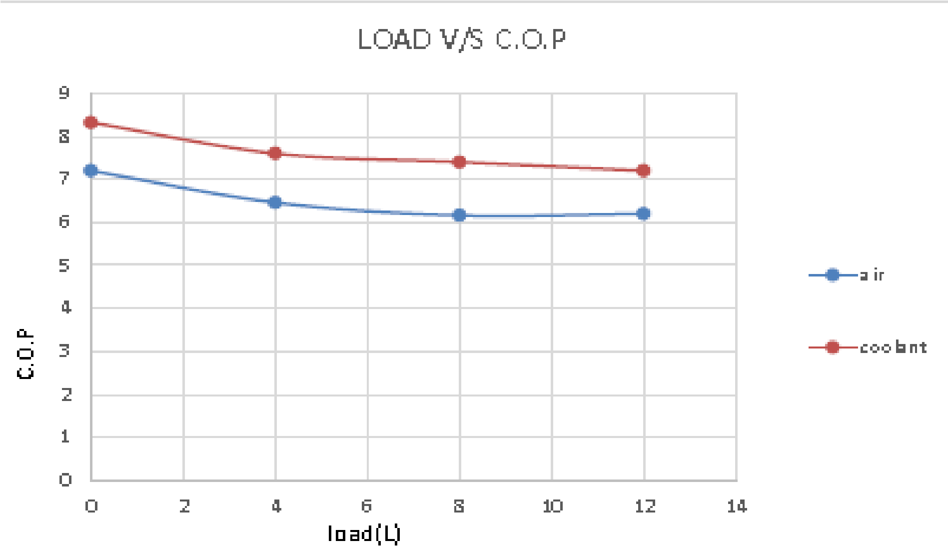

Fig 7.1 : Load V/S Cop Graph

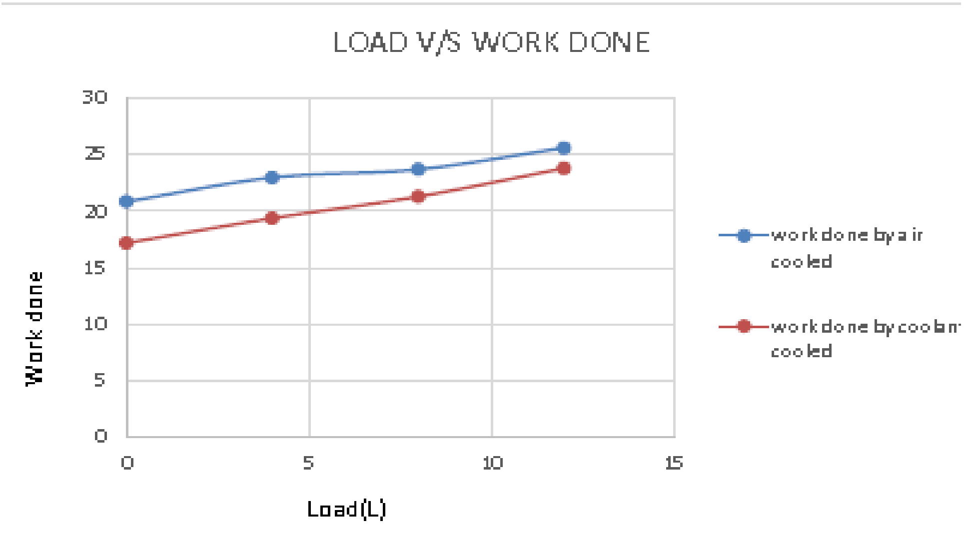

Fig 7.2 : Load V/S Work Done Graph

7. CONCLUSION

Heat rejection may occur directly to the air in the case of a conventional household refrigerator having air-cooled condenser or to coolant in the case of a coolant-cooled condenser. Tetrafluoroethane (HFC134a) refrigerant was used in our experimental test rig and coolant used in the coolant cooled condenser is polyalkaline glycol. Heat can be recovered by using the coolant in the cooled condenser in the experimental test rig the coolant cooled condenser is retrofitted to refrigeration system. The temperature and pressure readings are taken by digital thermometer and pressure gauges and energy consumption reading taken by digital energy meter. The four different loads are applied and the readings taken on each load. And graph plotted with variation of COP with load and variation of work done with load. The COP with load graph shows that COP increased when the refrigeration system working with coolant condenser. And the graph plotted of work done with load shows that the work done of the compressor decreased, so the power consumption will be also reduced. When the refrigeration system working on coolant cooled condenser The household refrigerator worked normally and efficiently with coolant-cooled condenser, On using coolant-cooled condenser the energy consumption of the household refrigerator reduced. The results confirmed that the performance of refrigerator with the coolant-cooled condenser was better than that of the air-cooled condenser.

REFERENCES

[1] Experimental Investigation of a Household Refrigerator using Air-cooled and Water-cooled Condenser 1Sreejith K., 2Sushmitha S., 3Vipin Das 2014

[2] H.I. Abu-Mulaweh, “Design and performance of a thermosiphon heat recovery system”, Applied Thermal Engineering 26 (2006) 471–477.

[3] Douglas T.Reindl, Todd B. Jekel, “Heat Recovery In Industrial Refrigeration”, ASHRAE Journal, August 2007.

[4] M. M. Rahman, Chin Wai Meng, Adrian Ng, “Air Conditioning and Water Heating- An Environmental Friendly and Cost Effective Way of Waste Heat Recovery”, AEESEAP, Journal of Engineering Education 2007, Vol. 31, No. 2.