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COMPARISON OF PERFORMANCE OF VCRS WITH DIFFERENT MODES OF CONDENSER COOLING WITH DIFFERENT REFRIGERANT

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ABSTRACT

This thesis compares the performance of refrigeration system employing two types of condensers,namely the air-cooled condenser and the water-cooled condenser.The experiment was done using R-134a and HC(mixture of R290 and R600a) as the refrigerant.The performance of the refrigeration system with air-cooled and water-cooled condenser was compared with refrigerant R-134a and HC.The results indicate that the refrigeration systems performance had improved when water-cooled condenser was used with refrigerant HC.Water-cooled condenser reduced the energy consumption when compared with the air-cooled condenser. The water-cooled heat exchanger was designed and the system was modified by retrofitting it, instead of the conventional air-cooled condenser by making a bypass line and thus the system can be utilized as a waste heat recovery unit. The hot water obtained can be utilized for household applications like cleaning, dish washing, laundry, bathing etc.

Keywords: condenser, refrigerant,R134a, HC.

I. INTRODUCTION

A refrigerator is a common household appliance that consists of a thermally insulated compartment and which when works, transfers heat from the inside of the refrigerator to its external environment so that the inside of the thermally insulated compartment is cooled to a temperature below the surrounding 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 water in the case of a water-cooled condenser. Tetrafluoroethane (R-134a) and HC 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 water-cooled condenser and the system can work as a waste heat recovery unit. The recovered heat from the condenser can be used for bathing, cleaning, laundry, etc. The modified system can be used both as a refrigerator and also as a water heater. Therefore by retrofitting a water-cooled condenser it produce hot water and even reduce the utility bill of a small family. It consists of an inlet for the cooling water and an exit for collecting the hot water. The hot water can be used instantly or it can be stored in a thermal storage tank for later use.

1.1 Vapour Compression Cycle

The vapour compression cycle is the most widely used method of refrigeration in the modern application. Household refrigerator, water cooler, deep freezer, air-conditioner etc., all run on vapour compression cycle. The

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cycle is called as vapour compression cycle, because the vapour of refrigerant are compressed in the compressor of the system to develop the cooling effect.

1.1.1 Working

1.1.1.1. Compression

The vapour refrigerants enter the compressor and get compressed to high pressure and high temperature. During this process the entropy of the refrigerant ideally remains constant and it leaves in super-heated state.

1.1.1.2. Condensation

The super-heated refrigerant then enters the condenser where it is cooled either by air or water due to which its temperature reduces, but pressure remains constant and gaseous state gets converted into liquid state.

1.1.1.3. Expansion

The liquid refrigerant then enters the expansion valve or capillary tube when sudden expansion of the refrigerant occurs, due to which its temperature and pressure falls down. The refrigerant leaves expansion valve or capillary tube in partially liquid state and partially in gaseous state.

1.1.1.4. Evaporation or Cooling

The partially liquid and partially gaseous refrigerant at very low temperature enters the evaporator where the substance to be cooled is kept. It is here where the refrigeration effect is produced. The refrigerant absorbs the heat from the substance to be cooled and gets converted into vapour state. Here are the various process of vapour compression cycle (refer the figure)

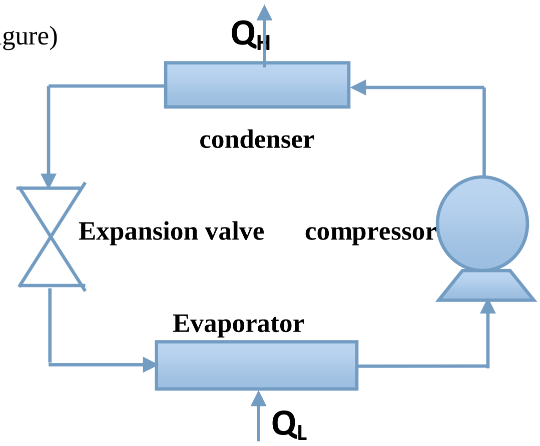
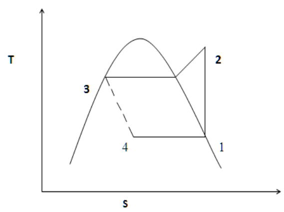


Fig.1.1: Schematic diagram of refrigeration system



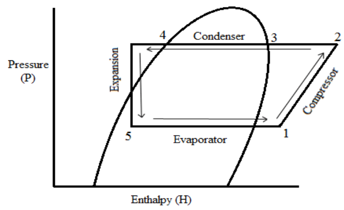


Fig1.2: T-S diagram of VCR system

Fig1.3: P-H diagram of VCR system

II. EXPERIMENTAL SETUP

The experimental setup has been fabricated in the heat engine laboratory at BIT, Sindri,Dhanbad. This system was modified with a water-cooled condenser instead of the conventional air-cooled condenser by making a bypass line. Water-cooled condenser is a heat exchanger having an inlet for the cooling water and an exit for collecting the hot water. The modified refrigerator was properly instrumented with temperature indicators and pressure gauges . The temperature at various points was noted using digital thermocouples .Pressure gauges used in this experiment are of bourdon tube type gauges. Dead weight pressure gauge tester using the principle of Pascal's law was used as the calibration equipment. Evaporator and condenser pressure are noted using calibrated pressure gauges. The refrigerator specifications are given below

2.1 Technical details:

- Cooling Capacity : 280Watts
- Compressor : 1/6 HP Hermetically sealed.
- Manufacture : Godrej and Boyce Mfg.Co.Ltd.
- Mode of cooling : Air cooled condenser and Water cooled condenser.
- Evaporator : Copper/M.S.
- Refrigerant : R-134 a and HC.

Schematic diagram of the experimental apparatus is shown in Figure 2.1. After the integration of the components, the valve V_3 and V_4 were closed to make the system work only with the air- cooled condenser and V_1 and V_2 were closed to make the system work only with the water-cooled condenser. Refrigerants are charged one by one into the refrigerator. The refrigerator is initially provided with R-134a. Then after removing this refrigerant, HC is charged into the system and reading were taken of the refrigerant R-134a & HC by keeping the evaporator temperature -15ºC. The time is noted for all refrigerants when the compressor cuts off. The compressor has power rating of 1/6 HP.

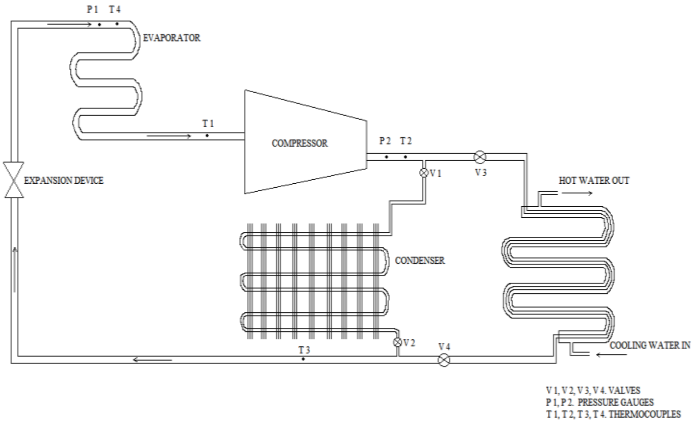


Fig.2.1 : Schematic diagram of the experimental apparatus.

III. OBSERVATION

Table-3.1 : Experimental data of simple VCRS using air cooled condenser with refrigerant R-134a.

Time (in min.)	Pressure at inlet of compressor in(Psi)	Pressure at outlet of compressor in(Psi)	Temperature at inlet of compressor in (ºC)	Temperature at outlet of compressor in (ºC)	Temperature at outlet of condenser in (ºC)	Evaporator temperature in (ºC)
6	7	190	32.7	44.0	40.9	19.7
12	5	200	29.3	50.1	45.2	0.0
18	5	200	25.6	53.7	46.5	-7.2

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24	5	200	22.3	55.0	46.8	-11.1
30	5	195	18.5	56.1	45.8	-13.8
36	5	200	16.0	57.1	45.2	-16.7

Table-3.2 : Experimental data of simple VCRS using water cooled condenser with refrigerant R-134a.

Time (in min.)	Pressure at inlet of compressor in(Psi)	Pressure at outlet of compressor in(Psi)	Temperature at inlet of compressor in (ºC)	Temperature at outlet of compressor in (ºC)	Temperature at outlet of condenser in (ºC)	Evaporator temperature in (ºC)
6	130	4	32.0	39.4	33.9	16.9
12	130	4	28.5	43.4	34.2	-1.2
18	130	4	25.7	46.1	34.4	-8
24	130	4	22.7	47.2	34.7	-11.9
30	130	4	20.9	48.3	35.0	-15.2

Table-3.3 : Experimental data of simple VCRS using air cooled condenser with refrigerant HC.

Time (in min.)	Pressure at inlet of compressor in(Psi)	Pressure at outlet of compressor in(Psi)	Temperature at inlet of compressor in (ºC)	Temperature at outlet of compressor in (ºC)	Temperature at outlet of condenser in (ºC)	Evaporator temperature in (ºC)
6	260	10	30.5	65	40.1	14.7
12	260	10	25.1	70.2	42.7	-3.1
18	260	10	23.6	76.1	43.9	-10.1
24	260	10	21.6	78.4	45.3	-14.0
27	260	10	19.5	81	46.1	-15.2

Table-3.4 : Experimental data of simple VCRS using water cooled condenser with refrigerant HC

Time (in min.)	Pressure at inlet of compressor in(Psi)	Pressure at outlet of compressor in(Psi)	Temperature at inlet of compressor in (ºC)	Temperature at outlet of compressor in (ºC)	Temperature at outlet of condenser in (ºC)	Evaporator temperature in (ºC)
6	210	4	24.1	53.1	35.7	11.9
12	210	4	22.4	62.8	36.6	-6.2
18	210	4	22.8	77.0	37.9	-13.1
21	210	4	27.7	77.6	38.3	-15.0

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IV. SAMPLE CALCULATION:

1HP = 745.7W

1/6HP =745.7×1/6 = 124.28W

Refrigerant charged one by one into the refrigerator and reading were taken and observed how much time takes by each refrigerant In different modes of condenser cooling to attend evaporator temperature -15ºC.

Total Power consumption = 124.28 × Total running time.

For R - 134a,In air cooled ,Total power consumption = 124.28×0.5666 = 70.425wh

In water cooled,Total power consumption = 124.28×0.48333 = 60.06wh

For HC,In air cooled ,Total power consumption = 124.28×0.4166 = 51.78wh

In water cooled ,Total power consumption = 124.28×0.35 = 43.49wh

1..Now comparison of Power saving using HC in air cooled condenser with refrigerant HC in water cooled condenser = (51.78-43.49)wh = 8.29wh.

% Power saving = 16.01%

2.Power saving using HC in place of R134a in air cooled condenser = (70.425-51.78)wh = 18.64wh.

% Power saving = 26.47%.

3.Now comparison of Power saving using HC in air cooled condenser with refrigerant R-134a in water cooled condenser =(60.06-51.78)wh =8.28wh.

% power saving = 13.78 %

4.Power saving using HC in place of R134a in water cooled condenser =(60.06-43.49)wh =16.57wh

% power saving = 27.58%.

5.Now comparison of Power saving using HC in water cooled condenser with refrigerant R-134a in air cooled condenser =(70.425-43.49)wh =26.935wh.

% power saving = 38.24%.

4.1 For refrigerant R-134a& HC comparison of air cooled condenser and water cooled condenser.

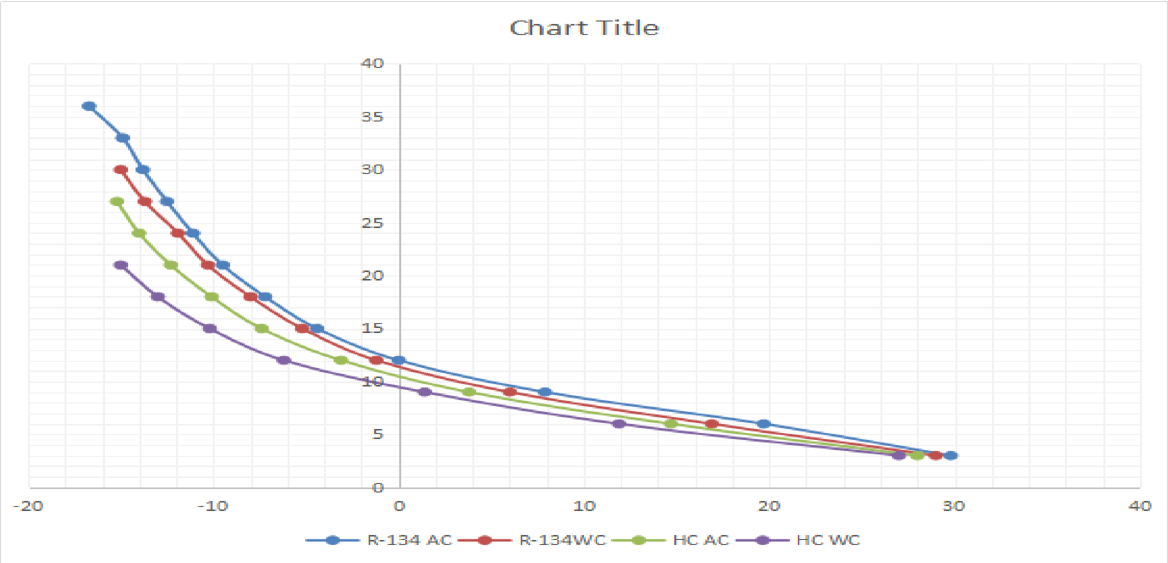

Fig.4.1 : Graphical representation of Time vs.Evaporator temperature

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V. RESULTS :

Sl.No.	Types of system	Refrigerant	Power consumed to attend -15ºC(in wh)	% power saving(compared with water cooled VCRS using HC)
1	Air cooled VCRS	R-134a	70.425	38.24
2	Water cooled VCRS	R-134a	60.06	27.58
3	Air cooled VCRS	HC	51.78	13.78
4	Water cooled VCRS	HC	43.49	

VI. CONCLUSION

- HC provides better refrigeration effect in comparison to R-134a.
- Water cooled condenser consume less power than air cooled condenser.

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