Waste Heat Recovery of Refrigeration Through Water Cooling System

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Abstract*- Heat is an energy, so energy saving is one of the key matters from view point of fuel consumption and for protection of global environment. So it is necessary that and concrete effort should be made for conserving energy through waste hear recovery too. The main objective of this project is "Waste Heat Recovery of Refrigeration Through Water Cooling System". An attempt has been made to utilize waste heat from condenser of refrigeration cycle. This heat can be used for number of domestic and industrial purpose. In minimum constructional, maintenance and running cost, this system is much useful for domestic purpose. It is valuable alternative approach to improve overall efficiency and reuse the waste heat. The study has shown that the system is technically feasible and economically viable.*

Keywords- Waste Heat, Heat Recovery, Water Cooler, Heat Sink

I. INTRODUCTION

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 of how to recover this heat depends on the temperature of the waste heat sources and on the economics involves behind the technology incorporated. Refrigerator has become an essential commodity rather than luxury item. A household refrigerator is a common household appliance that consists of a thermally Insulated compartment and which when works, transfer heat from the inside of the compartment to it external environment so that inside of the thermally insulated compartment is cooled to a temperature below the ambient temperature of 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 (HFC134a) refrigerant was now widely used in most of the domestic refrigerators. Waste heat which is rejected from a process at temperature enough high above the ambient temperature permits the recovery of energy for some useful purpose in economic manner Heat can be recovered by using the water- cooled condenser and the system can work as a waste heat recovery unit. The heat recovery from the condenser can be used for bathing, cleaning, laundry, dish washing etc. Low temperature waste heat may be useful in a supplementary way for preheating purposes Keeping this in mind, a technique or condensing heat of the refrigeration system is proposed in this paper. The proposed system employs a combined air and water- cooling (desuperheating) technique for condensing heat of refrigerator. This new system provides not only the refrigeration effect, but also hot water.

II. LITERATURE REVIEW

It'sRomdhane ben slama [1] developed a system that can recover heat from the condenser of the refrigerator. In this work air-cooled conventional condenser is replaced by another heat exchanger to heat water. The results show that water at a temperature of 60ºC was produced by the system. This paper also analyzed the economic importance of the waste heat recovery system from the energy saving point of view. Sheng shan Bi et al [2] experimentally investigated the performance of a domestic refrigerator using TiO_2- R600a nano-refrigerants. The test results show that refrigerator performance was better than the pure R600a system, with 9.6% less energy used with 0.5 g/L TiO_2- R600a nano-refrigerant.S.S. Hu, B.J. Huang et al [3] conducted an experimental investigation on a split air conditioner having water cooled condensers. They developed a simple water-cooled air conditioner utilizing a cooling tower with cellulose pad filling material to cool the water for condensing operations. The experimental investigation verified that the water- cooled condenser and cooling tower results in decreasing the power consumption of the compressor.H.I. Abu-Mulaweh [4] designed and developed a thermosyphon heat recovery system which can recover heat from a window air conditioner. They design two types of heat exchangers, concentric type heat exchanger & coiled heat exchanger and then it is retrofitted in to the air conditioning system. They analyzed the performance of the system with these two types of heat exchangers. The circulation of water through the heat exchanger is done with the therom syphon effect which completely eliminates the need of pump. For having that, the heat exchangers are connected to a water storage tank and when the water in the heat exchanger get heated up by the superheated refrigerant the hot water flow upward through the connecting pipe into the top of the storage tank and at the same time the cold water from the bottom of the tank will flow into the heat exchanger. The test result show that the concentric heat exchanger produces hot water at a temperature of 45ºC and the coil type produced hot water having 40ºC.

III. WORKING OF SYSTEM

When compressor compresses the refrigerant, the temperature and pressure of refrigerant increased. Further the high temperature and pressure refrigerant will be passed to the water cooled condenser. After that refrigerant passes through expansion device that is capillary tube. Due to sudden expansion of refrigerant the temperature will be decreased After expansion process, lowered temperature refrigerant passes through cooling coil which is kept in evaporator tank i.e. cold sink. So the temperature of water present in cold sink will be decreased due to heat transfer between refrigerant and water. After evaporation process, the refrigerant is passed to suction line of compressor and cycle repeat so on.

Fig.3.1 Front View of Actual System

IV. SYSTEM DESCRIPTION

1) Compressor:

1. Manufacturer of the compressor -L.G.
2. Model no. -LGMAS3LJJ
3. EER(Btu/Whr) -7.5
4. Frequency (Hz) - 50Hz
5. Capacity (Tonne -1/5
6. Power -233W

2)Water cooled Condenser:

1. Size of Sink -5.6lit
2. Copper tube diameter -6mm

3)Expansion device:

1. Name of device -Capillary tube
2. Tube diameter -0.031inch
3. Tube length -3048mm

4) Evaporator:

1. Size of sink -7.6 lit
2. Copper tube diameter -6mm

5)Refrigerator

1. Name of Refrigerant -R134a(Tetrafluoroethane)
2. Chemical Formula -CH_2 FCF_3
3. Density -0.00425gm/cm
4. Freezing Point - -103.3^{0}c
5. Boiling Point - -26.3^{o}c
6. Flash Point -250^{o}c

V. DESIGN CONSIDERATIONS

1) Capacity of evaporative tank -7.6 lit
2) Suction Pressure of compressor -30psi
3) Discharge Pressure of compressor -148psi
4) Refrigerant used -R143a
5) Initial water temperature - 31^0 c

VI. DESIGN CALCULATION

1)Mass of water -7 lit

2)Enthalpy

From P-H chart of R134a

h_1 = 380kJ/kg

h_2 =430kJ/kg

h_3 =h_4 =275kJ/kg

3)Heat rejected by water in 25 min

Qw = Mw ×Cp (T1-T2)

=7×4.187× (31-21)

=293.09kJ

Heat rejected per min,

Qw= 11.72kJ/min

4) Mass flow rate of refrigerant
mass flow rate of refrigerant
Assume heat rejected by water =heat absorbed by refrigerant

11.72=mr×(h1-h4)

mr=0.1161 kg/min

5) Heat rejected in water and atmosphere
Q=mr(h2-h3)
=0.1161(430-275)
=17.99 kJ/min
Total Heat rejected from condenser in 25 min
Qc=1079.4kJ

6) Co- efficient of performance of system (COP)

$$= \frac{h1-h4}{h2-h1}$$

$$= \frac{380-275}{430-380}$$

$$= 2.1$$

VII. OBSERVATIONS &RESULT

This chapter of observations and results of the system working at various load conditions. Calculations for coefficient of performance and refrigeration effects of system at those various working conditions is observed. Graph of COP of system and refrigeration effects is obtained.

Table 7.3 Comparasion of Result

Amount of water(lit)	Refrigeration Effect(kJ/min)	Power(kJ/min)	COP
1	18.5	7.46	2.48
1.5	16.45	7.46	2.2
2	14.25	7.47	1.9
2.5	13.41	7.48	1.81
3	13.81	7.48	1.79
3.5	13.6	7.49	1.78
4	13.5	7.5	1.76
4.5	13.44	7.51	1.71
5	13.42	7.51	1.67
5.5	12.48	7.51	1.65
6	12.12	7.51	1.61
6.5	11.6	7.51	1.52
7	11.93	7.52	1.58

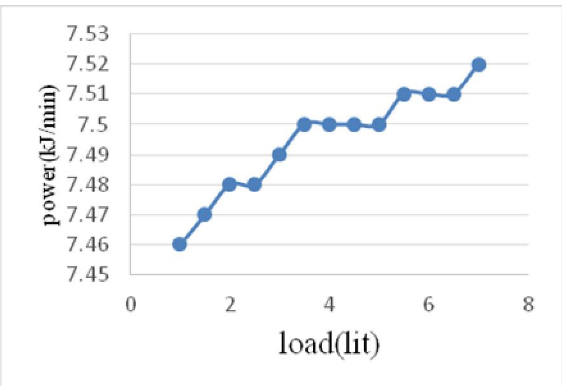

Fig.7.4 Graph of power input

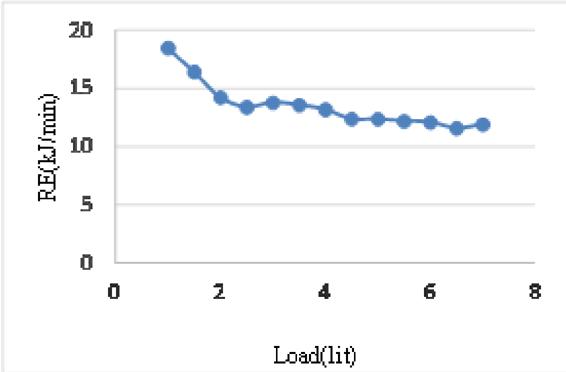

Fig. 7.5 Graph for Refrigeration effect

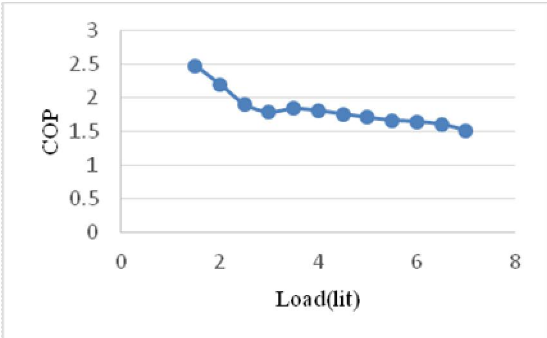

Fig. 7.6 Graph for COP

VIII.CONCLUSION

"Waste heat recovery through refrigeration water cooling system" is an excellent system to converse available energy. An attempt is made to recover the waste heat from vapour compression refrigeration cycle which is used water coolers.AS indicated in this project, recovered heat can be utilized as water heater. So one can save lot of energy. The study provides following conclusions:

1. As load increases COP of refrigeration system decreases.
2. As load increases Refrigeration effect decreases.
3. As load increases power consumption slightly increases.

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