WASTE HEAT RECOVERY SYSTEM FOR REFRIGERATOR

Mr. Sachin A. Narnavre[1], Asst. Prof. Shyam Gupta[2], Prof. Ashvin Jakhaniya[3]

1, Student of B.E., Department of Mechanical Engineering, Venus International College of Engineering,

2, Assistant Professor, Department of Mechanical Engineering, Venus International College of Engineering, Gandhinagar 382420, Gujarat, India.

3, Head of Department of Mechanical Engineering, Venus International College of Engineering, Gandhinagar 382420, Gujarat, India.

ABSTRACT

Waste heat recovery is very important now a day due to energy crisis. All domestic refrigerators use air cooled – finned condenser on backside. As domestic refrigerators reject large heat inside room which make us uncomfortable in summer due to temperature rise inside the room. So it is now essential to reject this heat outside the room or utilize it for different purposes. So energy can be saved. The strategy of how to recover the dissipated heat to develop a waste heat recovery system is relevant. The energy lost in waste heat cannot be fully recovered. However, much of the heat can be recovered and the loss can be minimized. From experimental work carried out in laboratory as mentioned in this paper heat is recovered by increase in temperature of insulated hot box which may be utilized for keeping food and beverages warm, to warm water which may be feed water or other domestic applications such as washing utensils etc.

Waste heat recovery from a domestic refrigerator cycle experiment system is presented in this work. Preliminary calculations showed that, without consuming extra electric power, hot box of about at 55^{o}C- 60^{o}C can be generated by the recovered heat from such domestic refrigerator.

Keywords: *Waste heat recovery, VCR Cycle, Insulated hot box,* Refrigerator*, Save energy. Experimental setup.*

1. INTRODUCTION

All domestic refrigerators backside uses the finned condenser to release heat to atmosphere. As domestic refrigerators reject large heat inside room, it results in high room temperature compared to normal room temperature. The heating effect is more in summer season which make us uncomfortable due to temperature rise inside the room. So it is now essential to utilize the heat for different purposes. It can be used to keep snacks and food warm, to heat the water which can be further used in health care centres, schools and industrial processes, to wash the cans in dairy by hot condensate, to dry clothes, grains etc. thereby saving significant amount of energy. The main objective of this project is to study "Waste Heat recovery system for refrigerator". The Study has shown that such a system is technically feasible and economically viable. The main objective of the study was to effectively utilize the Waste heat generated hence it can be used for heating in various applications.

1.1 PRINCIPLE OF THE VAPOR COMPRESSION REFRIGERATION

The Vapor compression refrigeration cycle is a common method for transferring heat from a low temperature to a high temperature. The purpose of a refrigerator is removal of heat from a low-temperature medium. The purpose of a heat pump is the transfer of heat to a high-temperature medium. When we are interested in the heat energy removed from a low-temperature space, the device is called a refrigerator. When we are interested in the heat energy supplied to the high-temperature space, the device is called a heat pump. In general, the term heat pump is used to describe the cycle as heat energy is removed from the low-temperature space and rejected to the high-temperature space.

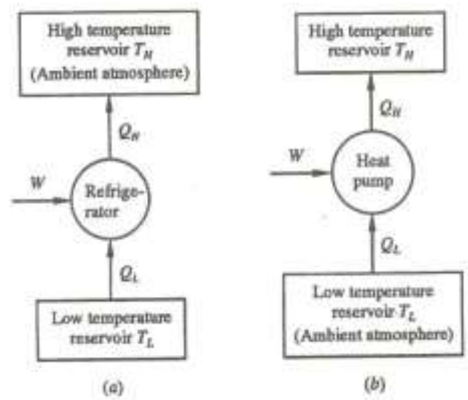

Fig 1. Schematic representation of Refrigerator and Heat pump.

When a household refrigerator is operating, it rejects heat into the environment at the condenser and in warm climates that heat is usually wasted. In this paper, the feasibility of a new system which used the rejected heat at the condenser of the refrigerator to hot box. Steel Alloy was used for Hot and Cold box. Beside this proper marking were done with equal distribution of copper coil loops at regular around the Steel box. More copper coils were placed intentionally on lower side that to get maximum heating effect of box. Brazing welding was used to join different components of System.

2. CONSTRUCTION OF SYSTEM

The Refrigerator with hot box is based on same principle of Vapor compression cycle but there is a small change in cycle. The discharge line of compressor is by passed before it goes to regular condenser, it passed through system (insulated box known as hot box). After passing through system liquid line is connected to evaporator then the compressor. And the cycle is continuing. More copper coils were placed intentionally on lower side that to get maximum heating effect.

2.1 Hot box and Cold box (Evaporator)

Steel Alloy was used for Hot and Cold box. Beside this proper marking were done with equal distribution of copper coil loops at regular around the Steel box. More copper coils were placed intentionally on lower side that to get maximum heating effect of box. Brazing welding was used to join different Components of system.

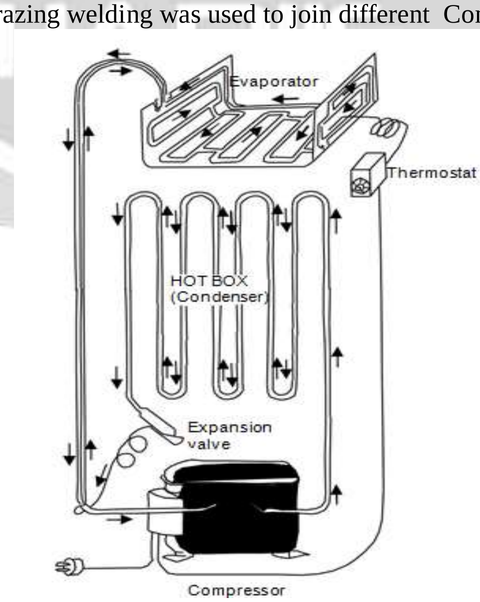

Fig. 2. Conventional VCR cycle

2.2 Refrigerator with Hot box

This System contains Refrigerator (Evaporator), compressor, Valve System, Hot box and Copper pipe line circuit. The discharge line of compressor is connected with Hot box (Condenser). The Refrigerator with Hot box is System which heat the space inside the box known as Hot Box by using waste heat exerted by Condenser. It is done by circulating the hot refrigerant through the pipe wound outside the box. The construction and working of refrigerator with hot box System. The discharge line of compressor is connected to the hot box and the valve. The is based on same principle of vapour compression cycle but there is small change in cycle. The discharge line of compressor is by passes through the System(in insulted box known as hot box).This system is controlled by electricity power.

3. PROTOTYPE EXPERIMENTAL SETUP

3.1 Refrigerator with Hot Box

Vapor compression refrigeration system is a system which is used to transfer heat from low temperature reservoir to high temperature reservoir with the help of working fluid, called refrigerant (R 134-a).

In this system, used an auxiliary condenser called hot box, this hot box is placed between the compressor and condenser, this box is fitted after the compressor outlet and before condenser inlet. Hence in this changed system, some amount of heat is rejected in auxiliary compressor and remaining heat rejected from simple coil compressor. The refrigerant (R 134-a) passed through the compressors discharge line followed by capillary and evaporator and was connected to compressor and thus continued the cycle then as per condenser required to install one coil insulated cabin system called hot box.

In the proposed system, the basic requirement is to utilize more and more energy (waste heat). For that purpose, some calculations are made regarding size and length of condenser and then refrigerator with cold box and hot box. Heat transfer rates approached to the of insulated cabin (hot box) with compact construction and with reasonable cost by using old Steel cabin box. So as to extract more and more heat, we have wound copper tubing on old box and then covered by welding touch (insulation) to avoid heat leakage to the surrounding. This whole assembly is placed on the side of the refrigerator. The main advantage of this design is that we can get maximum heat with minimum losses.

- Power Rating: Single phase 220-240 volt, 50 Hz, A.C. supply. 220 W
- Refrigerant type: R134a Condenser: External

Fig.3 Experimental Setup of Modified VCR Cycle

4. APPLICATON OR ADVANTAGE

Households need both refrigeration and water heating. Refrigeration at temperatures below 4°C is employed for food preservation, while hot water at temperatures around 55°C - 60°C is used for bathing and showering. Though recovered heat from the refrigerator, called Superheat recovery, is able to heat up the water up to desired temperature.

4.1 Advantage of System

- Effective utilization of waste heat recovery due to which global warming can be reduced.
- Increase in overall effectiveness of domestic refrigerator and saving in energy.
- Increase in Coefficient of performance of domestic refrigerator.
- Efficient and economical combination of refrigerator and food / water warmer.
- Simulated for medium to large system or multiple domestic refrigerators.
- Heat load in kitchen due to heat rejected in room is also reduced which indirectly reduced energy required to cool the room.

4.2 Application of System

- Space heating.
- To dry clothes, grains etc.
- Maintaining temperature of substances up to 54^0C-58^0C.
- Keep snacks and food warm.
- Used in health care centres, school etc.
- To wash the cans in dairy by hot condensate.
- Any other application requiring warm air.
- The Serving cooling and heating both the purpose. Machine is multipurpose.

5. EXPERIMENTAL RESULTS

The coefficient of performance (COP) is the ratio of heat extracted in refrigerator to the work done on refrigerant. Readings of temperatures of evaporator, condenser, insulated hot box are taken for time interval of 10 minute.

5.1 Observation table:

Time in Minutes	Insulated Box Temperature ^{0}C
0	26
10	30
20	35
30	40
40	45
50	51
60	56

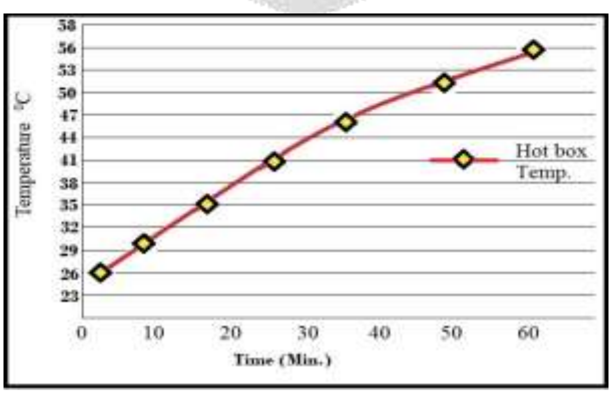

Fig.4 Hot box Temperature

5.2 COP Calculation of System

- Time required for reading, Δt = 105 min
    - Initial temperature of water $T_1 = 26^0C$
    - Final temperature of water $T_2 = 43^0C$
    - Temperature difference $\Delta T = 17^0C$
    - Mass of water in the box, m = 1000 gm
    - Specific heat of water, Cp = 4.184 KJ/Kg K
    - Heat Absorbed By Water, Q = m x Cp x $\Delta T/\Delta t$

      = 11.29 J/s
    - Heat recovery achieved, Q = Heat Absorbed by Water

      = 11.29 W
    - Refrigerator cooling capacity = 85 kcal/hr

      = 85×4.187×1000/3600

      = 98.859 W
    - Power required for running the compressor = Work done on refrigerant

      = 1/8 HP

      = 1/8×746

      = 93.25 W

➢ $$\text{COP actual} = \frac{\text{Heat extracted}}{\text{Work done by compressor}}$$

$$= \frac{98.859}{93.25}$$

$$= 1.06$$

➢ Waste heat of condenser is utilized to heating hot box which is the part of System work. Hence COP of system will improve.

$COP_{improved}$ =

$$\frac{\text{Heat extracted in refrigeration}}{\text{Work done by compressor - Heat recovery achieved}}$$

$$= \frac{98.859}{93.25 - 11.29}$$

$$= 1.21$$

- Improvement(%) in COP =

$$\frac{(COP_{improved} - COP_{actual})}{COP_{improved}} \times 100$$

$$= \frac{(1.21 - 1.06)}{1.06} \times 100$$

$$= 14.15\ \%$$

5.3 System Specifications

Sr no	Part Name	Specifications
1	Refrigerator cycle 1. Compressor 2. Condenser	Domestic Type Hermetically Model no.1365 Copper
2	Hot Chamber Cold Chamber (Evaporator)	Copper Coil Insulated (130*3t x 175mm)
3	Refrigerant	R134a

6. CONCLUSION

The Results were obtained and hence it can be concluded that the temperature in the hot chamber increases and that in the cold chamber decreases with increase in time. The system can be referred as "Waste Heat Recovery System For Refrigerator'' with Hot Box temperature up to 55-60 ^{o}C and it maintains temperature up to 53-58 ^{o}C in Hot Box.

The temperature variation in the hot chamber and the cold chamber is studied considering the various parameters like time, capacity of chamber and load. Heat load in kitchen due to heat rejection in room is also reduced which indirectly reduced energy required to cool the room.

- Increase in overall effectiveness of refrigerator System and saving the energy.
- Increase in Coefficient of performance of refrigerator System.
- Efficient and economical combination of refrigerator and food or water warmer.
- This System is Simulated medium to large or multiple domestic refrigerators.
- Recovery of heat from the condenser reduces heat load to surrounding and it make comfortable.

This type of refrigerator is very useful due to their versatile characteristics as they can be used both for heating and cooling purposes as well as they completely utilize the waste heat which is being rejected at time of cooling of refrigerant.

DRAWBACK OF SYSTEM

The Inside temperature of the hot box depends on the running of the refrigerator.

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BIOGRAPHIES

Mr. SACHIN A. NARNAVRE
B.E. MECHANICAL ENGINEERING,
VENUS INTERNATIONAL COLLEGE OF TECHNOLOGY, GANDHINAGAR.

POST DIPLOMA IN TOOL DESIGN & CAD/CAM (IGTR)
(Emai Id: Sachinan07@gmail.com)

Mr. SHYAM GUPTA

ASST. PROFESSOR DEPARTMENT OF MECHANICAL, VENUS INTERNATIONAL COLLEGE OF TECHNOLOGY,GANDHINAGAR.

(Emai Id: Shyamgupta.me@venusict.org)

Mr. ASHVIN JAKHANIYA

HEAD OF DEPARTMENT - MECHANICAL,
VENUS INTERNATIONAL COLLEGE OF TECHNOLOGY,GANDHINAGAR.

(Emai Id: Ashvinjakhaniya@gmail.com)