

Waste Heat Recovery in Domestic Refrigeration System in the Application of Water Heating

Tejasbhai Pravinbhai Mali
UG Student
Department of Mechanical Engineering
G.H.R.I.E.M, Jalgaon, India

Mahendra Saini
UG Student
Department of Mechanical Engineering
G.H.R.I.E.M, Jalgaon, India

Asst. Prof. Amol Vikas Joshi
Assistant Professor
Department of Mechanical Engineering
G.H.R.I.E.M, Jalgaon, India

Abstract

Heat is the energy, so energy saving is one of the key matters for the protection of global environment. Heat also radiated from our domestic refrigerator. This waste heat from refrigerator will affect the environmental because as heat in the environment will increase it will cause global warming. So it is necessary that a significant effort should be made for conserving energy through waste heat recovery too. So An attempt has been made to utilize waste heat from condenser of refrigerator. This heat can be used for various of domestic and industrial purposes. In minimum constructional, maintenance and running cost, this system is very useful for domestic purpose. It is valuable alternative approach to increase overall efficiency and reuse the waste heat. The study has shown that such a system is technically feasible and economical. This system is a cabin that we are going to install over the head of the simple refrigerator, this cabin will be an arrangement of coils that will work as a heat exchanger for reuse of waste heat. These coils are hot coils of condenser of the refrigerator that will be modified and will put in the cabin. It can serve the purpose of cooking, geysers etc. Besides, the refrigerator may be used as conventional refrigerator. Further COP will also increase. Heat rejection may occur directly to the air in the case of a conventional household domestic refrigerator having air-cooled condenser. This system rejected less heat to the environment so it is safer in environmental aspects also.

Keywords: Waste heat recovery, Domestic refrigerator, COP, Heat Balancing, Air Cooled Condenser, Insulating Storage Tank

I. INTRODUCTION

The waste heat recovery deals with extraction of heat from the source, which can also termed as waste, and utilize it for some useful work. Strategy of how to recover this heat depends on heat potential of the source and the economics involved in recovering such waste heat. System thermal efficiency could be increased by processing, recovering waste heat and utilize these for various applications like water heating. Hot water is required for various applications like processing, cooking and cleaning in any household equipment. In such applications, water is conventionally heated by electrical heating, which is very costly or burning the fossil fuels which pollutes an environment.

Use of waste heat recovery would be very useful technique of reducing total energy costs in a system design. Attachments need to be developed to recover waste heat energy from refrigeration systems. If the heat recovery system is designed optimally and implemented in residential and small-scale commercial systems, the cumulative benefits can be obtained.

For Households, both refrigeration and water heating is needed. Refrigeration at temperatures below 4°C is employed for food preservation and for other applications, while hot water at temperatures around 55°C is used for cooking and cleaning. Though recovered heat from the refrigerator, also called superheat recovery, is able to heat the water up to desired temperature, separate electric geysers are used for heating water. These electric heating equipments consume electricity which leads to high cost. Judicious recovery of heat from the refrigeration cycle and utilizing these for hot water generation will definitely lead to significant energy saving. The main objective of this work is to investigate and assess technical feasibility of the combined refrigerator and hot water system to replace geyser to significant energy savings.

A home's single largest electricity expense is water heating, which typically accounts for about 40% of their electricity usage. The total energy consumption by geysers will continue to increase as the pollution grows. As electricity demand increases, the adverse environmental effects and the economic costs associated with electricity generation will also increase.

II. LITERATURE REVIEW

Clark et al.1996 ^[1] describe the design, construction, and testing of whole an integrated heat recovery system which has been designed both to increase the performance of a residential refrigerator and also to provide preheated water for an electric hot

water heater. A commercial, indirect-heated hot water tank was retrofitted with suitable tubing to allow it to serve as water cooled condenser for a residential refrigerator. This condenser operates in parallel with the air-cooled condenser tubing of the refrigerator so that either one or the other is active when the refrigerator is running. The refrigerator was housed in a controlled-environment, and its performance could be monitored carefully in conjunction with the water pre-heating system.

The system has been tested under a various types of hot water usage protocols, and the resulting data set has provided the significance of commercial implementation of the concept. For the case when no water usage, the system was able to provide a 35 °C rise in temperature of the storage tank after about 100 hours of continuous operation. Preliminary tests with testing of “high water usage,” “low water usage,” and “family water usage” gives a possible 18-20% energy savings for hot water over a long period of operation.

Stinson et al.1987^[2] conducted research in dairy refrigeration system by recovering the heat from condenser. A theoretical energy balance was conducted, condenser heat was estimated recover for up to 60% of the water heating energy requirements. To improve the heat transfer characteristics, preliminary tests with heat exchangers led to the development and testing of a counter flow, tube-in-tube heat exchanger, with fins on the refrigerant side and cores on the water side.

It was fitted between the compressor and the condenser of the refrigeration plant and tested with both air and water condensing systems, together with varying conditions of milk temperatures and condenser pressure at inlet and final cooling. Also in addition, tests on the suction superheat and receiver pressure were performed to determine their effect on the overall system performance characteristic. By increasing the condenser pressure from 6.5 bar to 12 bar increased cooling times and ultimately the average coefficient of performance (C.O.P.) of the refrigerator (with the heat exchanger in the circuit) decreased, varying from 3.0 to 2.3 over this range of pressures for the water cooled condenser system. While values for the air cooled condenser system were 0.3 to 0.4 lower due to fan power consumption.

SanmatiMirji 2006^[3] presented a multipurpose warming device utilizing the waste heat of domestic refrigerator. The multipurpose device was constructed as an additional part of the refrigerator. It used the waste heat produced by the refrigerator and has numbers of household uses like food warming, cooking, cleaning, bathing, domestic fermentation purposes such as curd making, fermentation for Indian food. The maximum temperature attained by the chamber was as high as 50°C and the average temperature was noticed around 40 °C. The main significance of the invention was to keep cooked food warm for a sufficiently long duration. It makes use of the waste heat generated by the domestic refrigerator without any need of additional power supply.

Mills 1986^[4] found several methods of heat recovery as applied to a residence. There were one of the more interesting approaches involved the rectification of heat from water after it has been utilized. Waste water is collected in a 454 l holding tank, which also contains the evaporator for water-to-water heat pump. When the water temperature in the tank rises above a certain level, the heat pump is activated, transferring heat from the tank to the condenser which is placed inside a 272 l fresh hot water storage tank. An experimental prototype of this system was constructed and tested using a water usage pattern. The result of tests indicated that an energy savings of up to 60% over a typical 272 l electric water heater was possible.

Waste Heat Recovery In Domestic Refrigeration System In The Application Of Water Heating

This is a system that can recover heat from the condenser of the refrigerator. In this work air-cooled conventional condenser is replaced by another water-cooled heat exchanger. The results show that water can be heated up to temperature of 60°C by the system. This system also contained the economic importance of the waste heat recovery system from the energy saving point of view as we can see that schematic diagram in following Fig

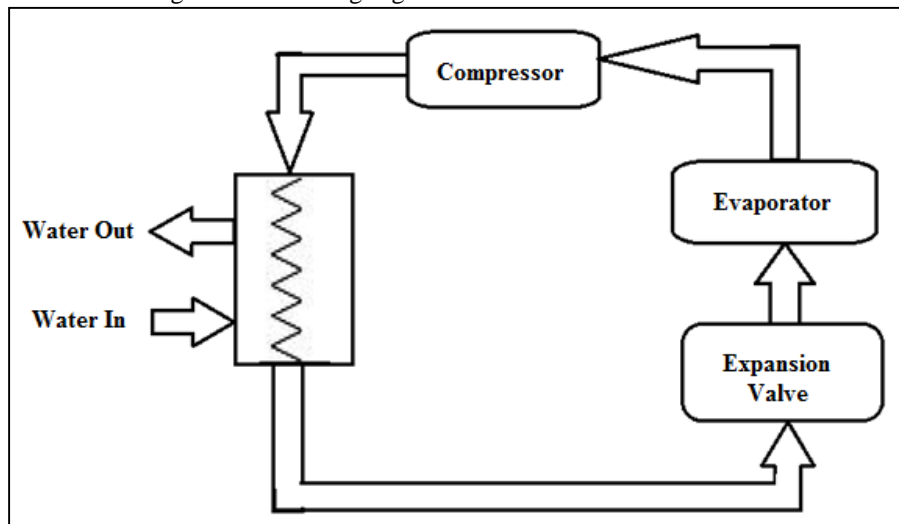


Fig. 1: Heat recovery system for water heating

By study on Super Heat Recovery Water System, from results, it is concluded that the system gives a better COP while operating under full load condition as compared to no load condition. Hence COP can be improved if the system continuously operates under full load. The heat absorbed by water has been observed to be highest during full load.

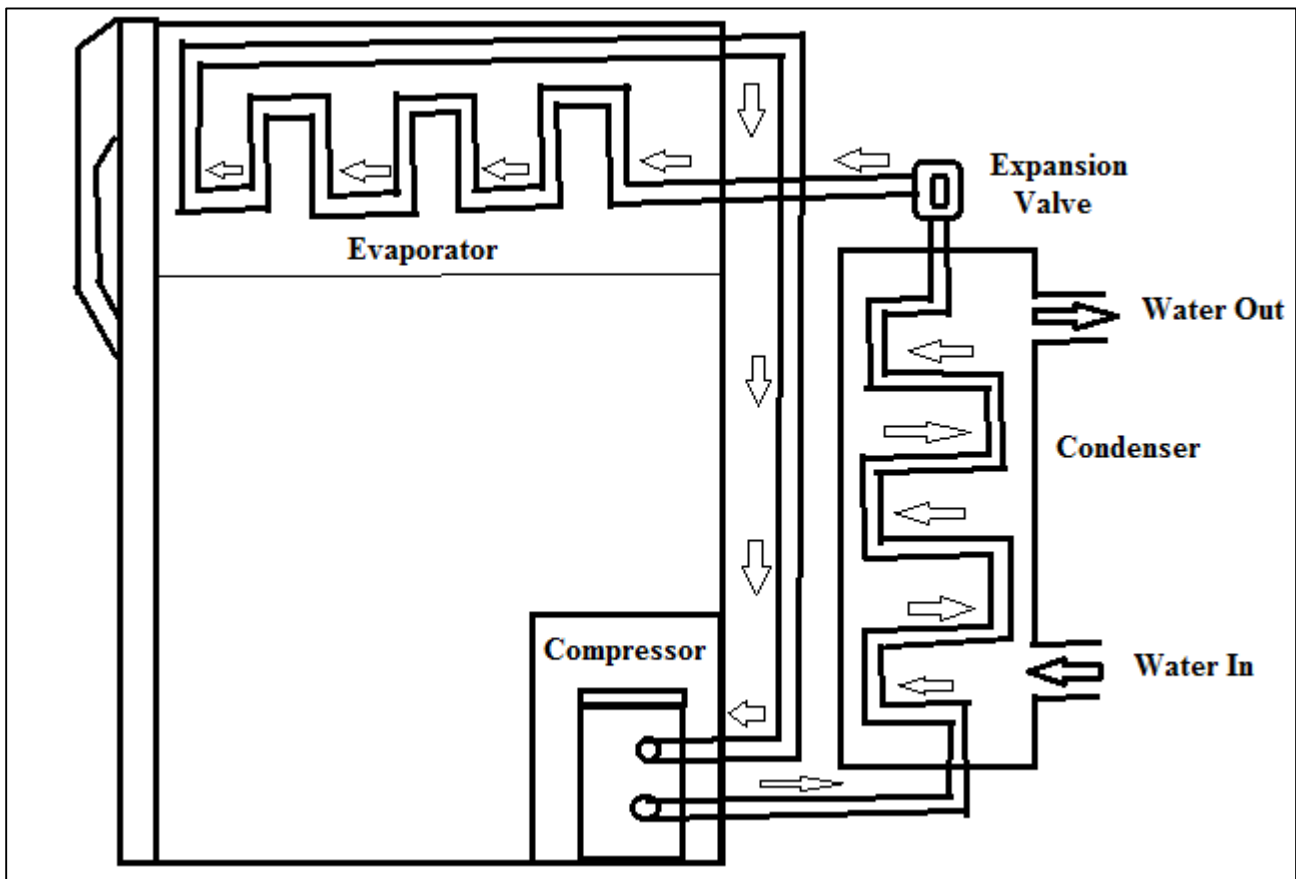


Fig. 2: Heat Recovery in Domestic Refrigerator in Application of Water Heating

The heat recovery technique provides a compound air-cooling and water-cooling in application of refrigeration system. The use of heat recovery system gives the significant improvement in COP and also the reduction in power consumption. The difference in temperature is obtained between the water inlet and outlet exceeds 15°C.

Patil and Dange^[5] modified a domestic 190 l refrigerator to recover the waste heat by simply installing a water tank containing the condenser coils of refrigerator. Experiment result showed that maximum temperature increase was up to 40°C.

The Waste Heat was recovered from the Condenser of a Refrigerator. The quantity of heat to be recovered from the condenser of a domestic refrigerator was theoretically calculated. It is in the range 375 W to 407 W. This depends on the flow rate of water circulated. In this case the water flow rate range is wide. Therefore, there is a wide variation in the results.

By modifying a domestic refrigerator, The COP of Domestic Refrigerator increase by Recovering Heat from the Condenser. It noticed that the maximum temperature achieved in the water storage tank at average load is 60°C. Theoretical COP of the systems when run with water cooled is more than the system run with air cooled condenser.

III. HEAT BALANCING

Since all domestic refrigeration systems today use compressors, we will focus our attention on heat recovery potential from this compression technology. We will explore opportunities to recover heat from compressor discharge. We will not consider heat recovery from reciprocating compressors (head cooling or discharge gas) here due to the limited use of this compression technology. To know how much amount of heat is exchange, heat balancing is carried out. As by Energy Conservation Law 'Energy can neither be created nor be destroyed; only it transfer from one form to another form'.

$$\text{Heat energy release from condenser} = \text{Heat energy gain by water}$$

$$mC_{pr}\Delta T = mC_{pw}\Delta T$$

Where, C_{pr} = Specific heat at constant pressure of primary refrigerant

C_{pw} = Specific heat at constant pressure of secondary refrigerant (Water)

IV. CONCLUSIONS

Now a day, as cost of fuel is continuously increase, heating is increase in refrigeration system. To recover the waste heat generated from condenser, Waste heat recovery in refrigeration system is one of the best way to save waste heat in application of water heating.

Advantages of this option include:

- 1) Allows recovery of high-quality waste heat;
- 2) Multiutilisation of Refrigerator is carried out for cooling as well as heating;
- 3) Performance of cycle increase by using heat of this multipurpose refrigerator;
- 4) Initial cost and maintenance cost is very less;
- 5) Use for both parallel flow and counter flow type heat exchanger condenser.

REFERENCES

- [1] Robert A. Clark, Richard, N. Smith and Michael K. Jensen: "An experimental study of waste heat recovery from a residential refrigerator", Energy Conversion Engineering Conference vol 3, Proceedings of the 31st Intersociety, pp 1887-1892. 1996.
- [2] G. E. Stinson, C. J. Stuman, D. J. Warburton, "A dairy refrigeration heat recovery unit and its effects on refrigeration operation", J. agric. Engng Res. (1987) 36, 275-285.
- [3] Sanmati Mirji: "A multipurpose warming apparatus utilizing the waste heat of domestic refrigerator", Unites States patent, August, 2006.
- [4] Mills, B. E. and Perlman, M., 1986, "Residential Heat Recovery," ASHRAE J., Vol. 28, pp. 28-32.
- [5] Patil Y.A., Dange H.M., Improving the Performance of Household Refrigerator by Recovering Heat from the Condenser. International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064 Volume 2 Issue 6 (2013)