A Review on Waste Heat Recovery from Domestic Refrigerator

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1. ABSTRACT
Heat is energy, so energy saving is one of the key matters from view point of use of refrigerants and for the protection of global environment. This waste heat will affect the environmental conditions because heat in the environment will increases it will cause global warming and also not good for our ozone layer too. So it is necessary that a significant and concrete effort should be made for conserving energy through waste heat recovery too. An attempt has been made to utilize waste heat from condenser of refrigerator. This heat can be used for number of domestic and industrial purposes. 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 such a system is technically feasible and economically viable.
This system is nothing but 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. These coils are hot coils of condenser of the refrigerator that will be modified and will braze in the cabin. It can serve the purpose of cooking (oven), geysers etc. Besides, the refrigerator may be used as conventional refrigerator by keeping the cabin door open in case of absence of heat sink. Further increase in COP is possible.
Heating 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.
This system rejected less heat to the environment so it is safer in environmental aspects.

KEYWORDS: Eco friendly, cost effective design, Global warming, Improve overall efficiency, waste heat recovery, Heat exchanger and condenser.

2. INTRODUCTION
A typical vapor compression system consist of four major components i.e. compressor, condenser, expansion device and an evaporator. In the following Fig – 2.1 the operation cycle consist of compressing low pressure vapor refrigerant to a high temperature vapor (process 1-2); condensing high pressure vapor to high pressure liquid (process 2-3); expanding high pressure liquid to low pressure super cooled liquid (process 3-4); and operating low pressure Liquid to low pressure vapor (processes 4-1). The heat absorbed from evaporator in process 4-1 is rejected to outside ambient during condensation process 2-3 and is generally a waste heat. Condensation process can be divided in 3 stages viz. desuperheating 2-2a, condensation and sub cooling. The saturation temperature by design is anywhere from ten to thirty degree above the heat sink fluid temperature, this ensure the heat sink fluid can extract heat from the refrigerant. This so-called superheat is a part of waste heat that can be recovered for useful purposes through the use of a heat recovery unit.

Fig – 2.1 Pressure-Enthalpy curve
A heat recovery unit is special purpose heat exchanger specifically designed to:

- Remove heat represented by process 2-3 in figure.
- Improved overall system efficiency by using water cooled condenser.
- Use of thermo siphon system to circulate water to minimize pumping cost.
- Protection against contamination of portable water via double wall construction.

3. LITERATURE REVIEW
That waste heat will be used in two applications.

3.1 Waste heat recovery system in the application of water heating.
Romdhane 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 as we can see that schematic diagram in following Fig – 3.1.1.

Shinde, V. Dhanal et al [3] presented a case study on Super Heat Recovery Water and It can be concluded that the system, as in Fig- 3.1.2, while operating under full load condition gives a better COP as compared to no load condition. Hence if the system continuously operates under full load, the COP can be improved. The heat absorbed by water has been observed to be highest during full load.

Fig – 3.1.2 Circuit arrangement in WHRS

The heat recovery technique, which can be applied to a refrigeration system, provides a compound air-cooling and water-cooling. The use of heat recovery system illustrates the improvement in COP and also the reduction in power consumption. The temperature difference obtained between the water inlet and outlet exceeds 10º C.

Patil and Dange [4] modified a domestic 190 liter refrigerator to recover the waste heat by installing a water tank containing the condenser coils of refrigerator. Experiment showed that maximum temperature increment was up to 40 degree centigrade. But major drawback with this type of arrangement was that it had no mobility and cannot be used for domestic purposes.

N. B. Chaudhari [5] discussed Heat Recovery System 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 Watt to 407 Watt. The quantity of heat recovered from the condenser of a domestic refrigerator I is found experimentally and found as 202 Watt to 410. 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.

M. Joseph Stalin et al. [6] designed a prototype efficient usage of waste heat from air conditioner. In this experimental analysis, it has been perceived that by supplanting the normal Air Conditioner by this system will vanguard to rescue 4 numbers of LPG gas cylinders per year. This not only saves the cost but also it bulwarks the environment by

![Fig – 3.1.1 Heat recovery system for water heating](image)
truncating the global warming engendered because of LPG gas.

Anil S. Katarkar, Lenin Dhale [7] developed system in that Coefficient of Performance increment in Domestic Refrigerator showed that, as condenser sub-cooling increases, the COP undergoes a maximum as a result of a trade-off between increasing refrigerating effect, due to the reduction of the condenser exit temperature, and increasing specific compression work, due to the increase in the condensing pressure. The increase in condensing pressure was associated with the reduction of the air-refrigerant temperature difference and the refrigerant-side heat transfer coefficient once the two-phase region in the condenser is shrunken to accommodate the sub-cooled liquid region. This paper also showed that the thermodynamic properties associated with the relative increase in refrigerating effect, i.e. liquid specific heat and latent heat of vaporization, are dominant to determine the maximum COP improvement with water cooled heat exchanger sub-cooling.

G.G. Momin, S.R. Deshmukh, M.T. Deshmukh [8] modified a domestic refrigerator for COP Enhancement of Domestic Refrigerator by Recovering Heat from the Condenser. They observed that the maximum temperature achieved in the water storage tank at average load is 60°C. Theoretical COP of the systems when run with HRU is more than the system run with air cooled condenser.

3.2 Waste heat recovery system in the application of air heating.

Tanmay, Medhane et al [9] conducted an experimental investigation on a Recovering Waste Heat From Condenser Of Domestic Refrigerator and they undertook a review based study into COP Enhancement of Domestic Air Cooled Refrigerator by recovering heat from Condenser in terms of its background, originality, current status, and researches. This all work has great significant for developing new technologies relates to heat recovery from a domestic refrigerator, in order to get cooling at low energy cost, no harmful effect to environment and also having low initial cost. So more attention is required in this area and lot of work has to be done.

S.C. Walawade [10] et al presents an attempt is made to recover the waste heat from 165 L refrigerator used for domestic purpose. As indicated in this paper, recovered heat can be utilized as food and snacks warmer, water heater, grain dryer.

P. Elumalai, et al. [11] recovered waste heat from condenser unit of a household refrigerator to improve the performance of the system by using a thermo siphon. As we can see the schematic diagram in Fig- 3.2.1 it was found that after recovering heat from the condenser of the conventional refrigerator, its performance was improved than conventional refrigerator.

![Fig–3.2.1 Heat recovery system for air heating as hot oven.](image)

It was concluded that the theoretical COP of the system was more than the system running with air cooled condenser.

Douglas T. Reindl, Todd B. Jekel et al [12] discussed Heat Recovery In Industrial Refrigeration and cost of fuels used for heating increases, the opportunities to economically recover heat from a refrigeration system grow. Traditional heat recovery approaches focus on recovering heat from the high stage compressor discharge gas stream (de-super heater). An alternative that should not be overlooked is recovering heat from oil cooling heat exchangers on screw compressor packages.

S. B. Lokhande, Dr. S. B. Barve et al. [13] discussed Design &Analysis of Waste Heat Recovery System for Domestic Refrigerator. And it can be concluded that with time the energy consumption of the refrigerator decreases for certain time and then it remain constant. The refrigerating effect keeps decreasing as the temperature difference between the refrigerator and article placed Is decreased. The C.O.P. remains almost constant though it decreases a little bit.

4 CONCLUSION

The heat recovery technique, which can be applied to a refrigeration system, provides a compound air-cooling and water-cooling. The use of heat recovery system illustrates the improvement in COP up-to 12% and also the reduction in power consumption. The temperature difference obtained between the water inlet and outlet exceeds 10°C.
The hot air by this system gives the temperature up-to 40° C. Thus a more optimum and efficient system can be built to give better results. The heat recovery module can thus be used in various refrigeration applications as well as in air conditioning. By this system consumption of LPG for heating food and water can be eliminated and an ECO system made for these applications without removing human comfort.

5 REFERENCES

[1]. Romdhane Ben Slama. Water-heater coupled with the refrigerator to develop the heat of the condenser. International Renewable Energy Congress November 5-7, 2009; Sousse Tunisia.


