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Effective Utilization of Condenser Heat of a Refrigerator in a Heating Chamber

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Abstract- This paper presents our research to utilize the otherwise waste heat of a domestic refrigerator. Through this investigation we want to suggest a method to improve the efficiency of the current system.

As purchasing power rises, so does the sales of products like refrigerators and air conditioners. With growing income in both rural and urban households the demand for consumer products will multiply. A recent study suggests that the sales of refrigerators increase by 15% every year. Further, a significant amount of energy is spent on cooking and heating purposes across the world and this amount would also increase in the future. This increase in the energy consumption and the growing levels of pollution are the main motivational factors for us. With our system we aim to conserve energy and create an efficient and a simple system which would tackle these issues.

***Index Terms*-** Domestic Refrigerator, Heating chamber, Efficiency, Waste heat, Recovery

I. Introduction

TAll over the world there is a growing consciousness among the consumers and governments alike to employ energy saving measures and reduce the carbon footprint. Our project is a step in this regard. Through this research we would like to present a cost-effective system which could be used both as a refrigerator and a heating chamber or an oven thus improving the efficiency and effectiveness of the existing system. The low cost of this product is possible because of the low investment and effort needed to modify the existing system. We are confident that if this system is incorporated at a OEM level then this impact would also be almost negligible.

The commonly used domestic refrigeration system is based on the vapour compression cycle. The four main parts of the system include the compressor, condenser coils, evaporator and the expansion valve.

Heat rejection in case of a domestic refrigeration system occurs to the ambient air. With growing environmental concerns, the need to utilize energy efficiently is constantly increasing. Waste heat is produced by both the equipment and the thermal processes occurring in the system. We tried to build a waste heat recovery unit in which this waste heat is used for some purpose like for heating water. Therefore, instead of rejecting the heat to the environment which would be nothing but a waste, we try to use that heat in a heating chamber and in a sense, make the refrigeration system more efficient. According to us, this model holds huge potential and further refinements of the model could make mass market adoption easier.

Coming to the units of refrigeration, the amount of heat removed by the refrigeration system is called as the refrigeration ton. It is based on the cooling effect of 1 ton of ice at 32°F melting in 24 hours. The standard refrigeration ton is defined as the transfer of 288,000 BTU's in 24 hours.

II. PROCESS DESCRIPTION

In the improved refrigeration system, we have primarily focused on the effective utilization of heat. Our main focus has been to use the heat from the condenser coils in a productive way. A description of the components of our system is given below:

i) Compressor: The main aim of the compressor is to take the vapour from the evaporator and increase its temperature and pressure so that it could be easily condensed into liquid form. We have not tampered with the OEM setup.

ii) Heating chamber with coils: The air cooled condensing coils of the system are arranged inside a chamber which would be used as a heat box. Further, a certain length of the condensing coil is outside the heating chamber. The heating chamber is constructed using polyurethane foam because of its high insulation capacity. Also, the chamber is lined with aluminium foil to better distribute the heat inside the chamber.

iii) Expansion Valve: Expansion valve serves the purpose of reducing the pressure of the liquid refrigerant so that the liquid refrigerant could easily vaporize at low temperature inside the evaporator.

iv) Evaporator: This is the part of the refrigeration system that is doing the actual cooling. The evaporator is the heat exchanger made up of several turns of copper or aluminium tubing. The refrigerant in the evaporator, absorbs the heat from the substance which needs to be cooled and is evaporated and fed into the compressor and the cycle continues.

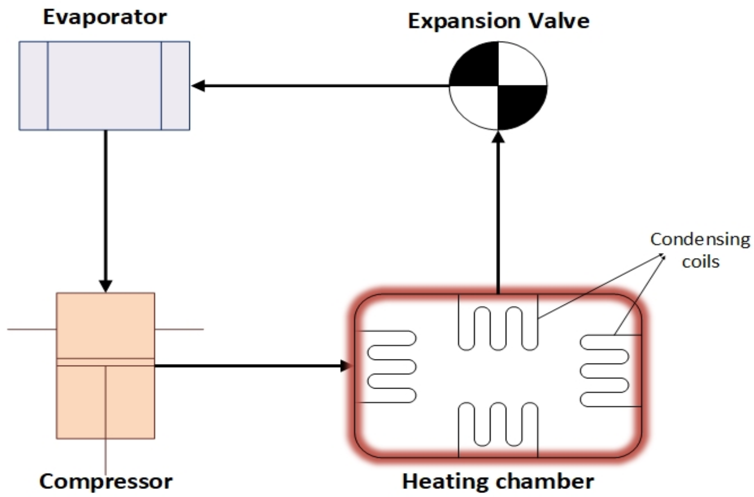

FIG. 1: A simple representation of our system

FIG. 2: Back view of our system

FIG. 3: Front view of our system

III. EXPERIMENT

Since in the refrigerator, the condensing coils are present on the walls of the refrigerator, some amount of heat must be going inside the refrigeration chamber. This would be putting an extra load on the compressor. Thus, the first step in performing the experiment was to get an idea about the amount of heat going inside the refrigeration chamber.
To measure the temperature of the walls, we used a surface temperature measurement device having a least count of 0.1 °C.

Observations:
Ambient Temperature of the surrounding was 27°C
The k factor of the PU foam is 0.025W/mK.
Dimensions of foam are: 0.7*0.695*0.027 m³
To calculate the amount of heat going inside the refrigerating compartment **Fourier's Law of heat conduction** was used.
Mathematically, it can be represented by the equation:

$$\mathbf{Q = -k * A \frac{dt}{dx}}$$

Where, 'Q' is the heat flow rate by conduction ($W \cdot m^{-2}$)
'k' is the thermal conductivity of body material ($W \cdot m^{-1} \cdot K^{-1}$)
'A' is the cross-sectional area normal to direction of heat flow (m^2)
'dT/dx' is the temperature gradient ($K \cdot m^{-1}$).
The '-ve' sign of equation is to take care of decreasing temperature along with the direction of increasing thickness or the direction of the heat flow.
First, we calculated the temperature at the inside and outside of the two walls of the refrigerator and the compressor.

The following calculations were made:

I. Area of the foam

A=Length*Breadth
A=0.695*0.7
Area=0.4865 m^2.

II. Heat going inside on right side

Q2= [kA(t2-t1)]/L
Q2= [0.025*0.4865(36.9+1.95)]/0.027
Q2= 17.500 W/m^2

III. Heat going inside on left side

Q1= [kA(t2-t1)]/L
Q1= [0.025*0.4865(35.55-2.6)]/0.027
Q1= 14.843 W/m^2

Total Heat going into the refrigerating compartment

Q= Q1+Q2
Q= 32.343 W/m^2

Dimensions of the heating chamber:

Length: 0.35m Breadth: 0.35m Height: 0.25m
Thickness of each wall: 0.025m Volume of the cavity: 0.018m^3

Ambient Temperature of the room: 30.2^{0}C.

S.no	**Left wall(inside) (°C)**	**Left wall(outside) (°C)**	**Top (°C)**	**Right wall(inside) (°C)**	**Right wall(outside) (°C)**	**Compressor Temperature (°C)**
1.	3.2	35.2	27.3	-1.3	37.5	59.1
2.	2.0	35.9	26.5	-2.6	36.3	59.4
Mean	**2.6**	**35.55**	**26.9**	**-1.95**	**36.9**	**59.25**

TABLE 1: Observations for heat going inside the refrigerator

S. No	Time(minutes)	Temperature(^{0}C)
1	0	26.2
2	10	30.2
3	20	34.2
4	30	38.2
5	40	42.3
6	50	46.8
7	60	49.9
8	65	51.6

TABLE 2: Observation for heat gained by the water

Heat absorbed by 200mL of water in the heating chamber:

Calculations: -

Heat absorbed by water, $Q= mc_p\Delta T$

Where, m=mass of water in grams =200g

c_p=specific heat of water =4.179J/g^0C

ΔT= temperature difference= (51.6-26.2) =25.4^{0}C

∴, Q=200*4.179*25.4 J

Q=21229.3 J or 5.443 W in 65 minutes

IV. CONCLUSION

With this paper we tried to take a look at a possible method of increasing the efficiency of the present refrigerator. An estimate of the amount of energy that could be recovered from the improved system is presented. More calculations and study are necessary to make a system which could be implemented easily on the refrigerators available in the domestic market. Going further, the system could be improved by installing a water chamber in which the condenser coils are placed. This would ensure that heated water is easily available. Such a system would be suitable for cold countries.

REFERENCES

[1] "Refrigeration and Air-Conditioning", a textbook by Er. R.K. Rajput, Katson Books, ISBN-10: 9350142554.

[2] "Heat and Mass transfer", a textbook by Er. R.K. Rajput, published by S. Chand, ASIN: B010WA6ZBK.

[3] Tarang Agarwal , Manoj Kumar , Praveen Kumar Gautam, "Cost-Effective COP Enhancement of a Domestic Air Cooled Refrigerator using R-134a Refrigerant", International Journal of Emerging Technology and Advanced Engineering.

[4] Sukani Sunny , Savaj Jayesh ,Cop Improver Group, "To Improve Cop of Domestic Refrigerator with the Help of Water Cooling Condenser", International Journal of Innovative Research in Science, Engineering and Technology.

[5] N. B. Chaudhari, P. N. Chaudhar, "Heat Recovery System from the Condenser of a Refrigerator – an Experimental Analysis", ISSN (Print): 2319-3182, Volume -4, Issue-2, 2015.

[6] Tanmay Patil, Nitesh Medhane, Yogesh Mahapure, Kalpesh Nagmoti, Prof. Anil Dube, "A Review on Recovering Waste Heat from Condenser of Domestic Refrigerator", International Journal of scientific research and management (IJSRM), ISSN (e): 2321-3418.

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