EFFECT OF TEFLON COATING ON EVAPORATOR TO REDUCE FROST FORMATION AND COMPARING WITH R134A, R600A, AND R290A REFRIGERANTS

Chintha Praveen Kumar, M. tech student, Department of Mechanical Engineering, Refrigeration and Air Conditioning, Jawaharlal Nehru Technological University College of Engineering Anantapur, Constituent college of Jawaharlal Nehru Technological University, Anantapur, Andhra Pradesh, India.

Dr.K. Kalyani Radha, Assistant Professor, Department of Mechanical Engineering, Jawaharlal Nehru Technological University College of Engineering Anantapur, Constituent college of Jawaharlal Nehru Technological University, Anantapur, Andhra Pradesh.India.[2]

452praveen@gmail.com[1], radha.mech@jntua.ac.in[2]

Abstract:

Nowadays, most of the research finds that refrigerators have become indispensable for both dispersed domestic and industrial purposes. The improvement in the standard of living and manufacturing improves the coefficient of performance by improving the thermal physics properties of the pure fluid, resulting in lower energy consumption. Consumers today want the best product design and quality, so the industry must focus on such critical things. A well-designed refrigerator consumes less energy for a given storage volume, and improving the evaporator heat transfer performance is one of the most important ways to reduce energy consumption and maintain a better temperature. However, very few techniques are available to reduce the accumulation of frost itself in the evaporator. The primary focus of the present work is on reducing the quantity of frost. Here we focus on two methods: one without coating with Teflon and one with coating with Teflon. The coating that sustains the low temperatures and is non-wettable is chosen so that the formation of frost on the evaporator is reduced. A domestic refrigerator of 210 liters capacity working with refrigerant without Teflon coating, R-134a, and with Teflon coating, R-134a, R-600a, and R-290a has formed the experimentation. The results are obtained and compared of both the coating and the non-coating of Teflon. From the experiments, it was observed that frost formation is drastically decreased when the coating is used and that power is saved when the evaporator is coated.

Key words: Refrigerator, Teflon coating, Frost, Evaporator

I. INTRODUCTION:

Refrigeration may be defined as the process of removing heat and maintaining the temperature of a body or space below the surrounding temperature. The most used refrigeration system is VCRs. In this, the refrigerant is used as the working fluid, and it may change phase from vapor to liquid continuously in a cyclic process [1]. James M. Calm analyzed that the usage of refrigerants from the beginning of refrigeration technology may change due to some aspects. Vapor compression refrigeration systems are commonly utilized for a variety of industrial applications, ranging from small refrigerators to large air conditioning facilities. The working fluid in a vapor compression refrigeration system (VCRS) transition from the liquid line to the vapor line at the evaporator, then back to the liquid line at the condenser. CFCs and HCFCs were first used as refrigerants in domestic refrigerators in the 1930s due to their suitable properties such as stability, non-flammability, and non-toxicity, which led to their widespread use as refrigerants in refrigeration and air-conditioning systems by both consumers and industries around the world. However, multiple experts have discovered that the stratosphere's ozone layer is being depleted due to the presence of chlorine and fluorine. Several papers have reported that the replacement for conventional refrigerants will be hydrocarbon refrigerants due to their good thermodynamic properties, (ii) being easily fitted to traditional systems with the replacement of an HC-compressor, (iii) There is no potential for ozone depletion and less than a five-fold increase in global warming (iv). non-toxic, with low moisture content, and less harmful when exposed to the skin (v). Although it is flammable, we use the refrigerant with a limited charge of up to 150 gms (vi). Operating pressures are high.

II. THE MOTIVATION FOR THE PROJECT:

Various refrigerator models are available in the market, and the models that survive the completion must have energy absorption, a low noise level during operation, a low price, and a large storage capacity. Component modeling of the refrigerator is done to see the effect on the overall performance of the refrigerator. It contains four components that directly influence the evaporator's performance: the evaporator, compressor, condenser, and capillary tube. At low temperatures below zero degrees, water vapor in the air condenses and forms frost on the evaporator surface. This gradual accumulation of frost inhibits heat transfer from the evaporator to the surroundings. The effect of heat transfer and the cooling capacity of the evaporator is of prime importance, and this is the motivation of the project.

2.1 Evaporator:

The function of the evaporator is to provide a heat transfer surface through which heat can pass from the refrigerated space or product into vaporizing refrigerant flowing through the evaporator coil. The evaporator is one of the four basic and necessary hardware components of the refrigerator system. In the evaporator, the refrigerant is evaporated by the heat transferred from the products to be cooled.

2.2 Teflon Coating:

Teflon was discovered by Roy J Plunkett (1910-1944) in 1938 and was used as a commercial product in 1946 they found that a tank of gaseous Tetrafluoroethylene refrigerant had polymerized to a white powder. scientifically Teflon is called Polytetrafluoroethylene. It is composed of carbon and fluorine.

1. Resistance to low temperature
2. Nonstick in nature
3. Very smooth surface finish
4. Nonwetting in nature
5. Shouldn’t affect foods and the refrigerator material and also should be able to be used continuously.

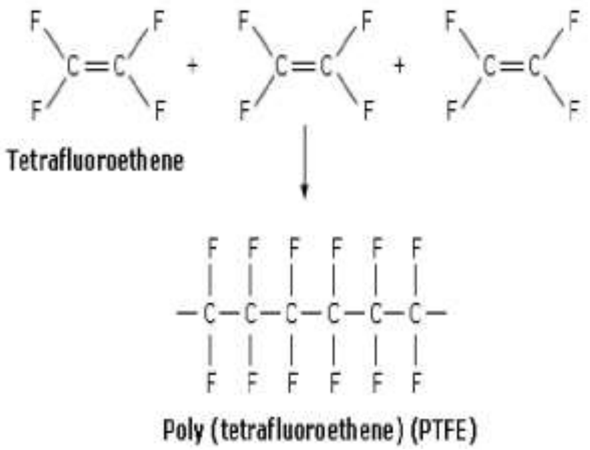

Fig: 1. Chemical composition of Teflon

2.3 Frosting:

Condensation happens on any surface exposed to moist air whenever the temperature of that surface is below the dew point of the moist air that comes into contact with it. A coating of frost will develop on the surface as the condensate freezes. This process is ongoing on the evaporator coil of every refrigerator and freezer, and it can also happen on the heat pump's evaporator during the winter. This coating can develop and impair performance in evaporators made of plate fins and tubes. Frost can slow down heat transmission in two different ways as it develops. First, compared to the metal of the evaporator, the frost may serve as an insulator to heat flow. Second, reduce the airflow over the coil to lessen heat transmission if the growth becomes significant. The total evaporator efficiency will be lower because maintaining a constant flow requires more power from the fan motor, which increases energy usage.

Fig.2: Frost Formation

III. Vapour Compression Refrigeration System:

Low-pressure vapor refrigerant from the evaporator is passing through the suction line, and the refrigerant compressed is entropic; the high-pressure vapor refrigerant is discharged to the condenser through the discharge valve, where the refrigerant heat rejection occurs isothermally at constant pressure.

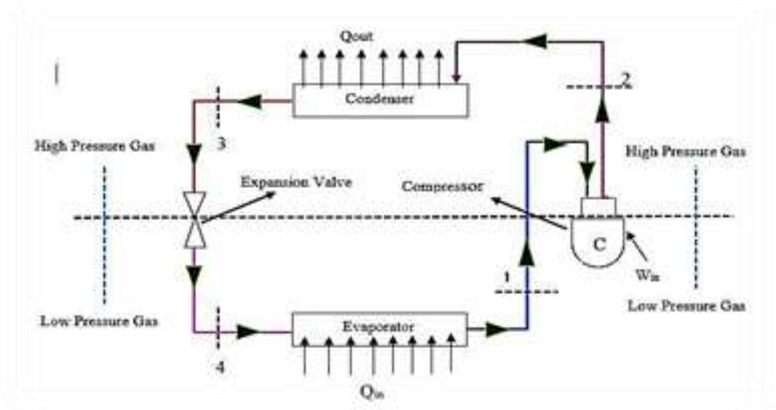

Fig.3: VCRS Refrigeration Cycle

The high-pressure liquid refrigerant from the condenser enters the filter, the contaminated particles in the refrigerant are filtered here and the high-pressure liquid refrigerant undergoes an expansion process and is converted to low-pressure and low-temperature liquid refrigerant undergoes evaporation process, heat absorption takes place and refrigerant phase change to low-pressure liquid to low-pressure vapor refrigerant and process continues in a cyclic process.

IV. EXPERIMENTAL PROCEDURE:

The experimental test rig used for the experiment is a 210-liter domestic refrigerator. The system was properly flushed with a vacuum flusher. The mechanical device was separated from the system by cutting the suction and discharge valves, removing the lubricant oil already present in it, and injecting the writer's lubricant with an acceptable amount in it. The pressure gauges are fixed to the compressor inlet and outlet, and the compressor is fixed to the system by brazing suction and discharge valves. After the temperature of the valves decreases, the required amount of refrigerant is injected into the compressor through the compressor charging port by connecting the craft manifold gauge and the refrigerant tin with the valve connected to it and injecting the refrigerant in the required amount. connecting the thermocouples at the compressor inlet and outlet, the condenser outlet, and the evaporator cabin. The experiment was conducted, and the values of suction and discharge pressures and temperatures of the compressor inlet, outlet, condenser outlet, and evaporator cabin were recorded.

- The System without a coating of Teflon R134a as a refrigerant
- The system with a coating of Teflon R134a as a refrigerant

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- The system with a coating of Teflon 600a as a refrigerant
- The system with a coating of Teflon R290a as a refrigerant

Study of frosting characteristics, power consumption, and evaporator temperature of the refrigerator for 12 hours and 24 hours. Frost quantity is measured by converting the frost formed into water. After switching off the refrigerator, the frost will be converted into water and collected in the tray below the evaporator. The water is then measured with the measuring jar.

Fig.4: Refrigerator

5. RESULTS AND DISCUSSION:

In the present work, a domestic refrigerator operated on a vapor compression refrigeration (VCRS) cycle was used for the experimentations. without Teflon coating R-134a, with Teflon coating R-134a, R-600a, R-290a refrigerant was used in this refrigeration system having zero ozone depletion potential and negligible global warming potential.

Table 1: Parameters of all refrigerants with a comparison of both coated and non-coated

S.NO	Parameters	R134a without Teflon coating	R134a with Teflon coating	R600a with Teflon coating	R290a with Teflon coating
1	Net Refrigeration Effect in kJ/kg	157	163	280	312
2	Compressor Work in kJ/kg	43	42	70	72
3	Power Consumption in kW	0.9585	0.9016	0.875	0.8076
5	Coefficient of Performance	3.6511	3.8809	4	4.33
6	Frost Formed quantity (ml) 12hrs &24 hrs.	507.898	100.44	199.91	101.91
		1150.900	510.834	516.560	509.366

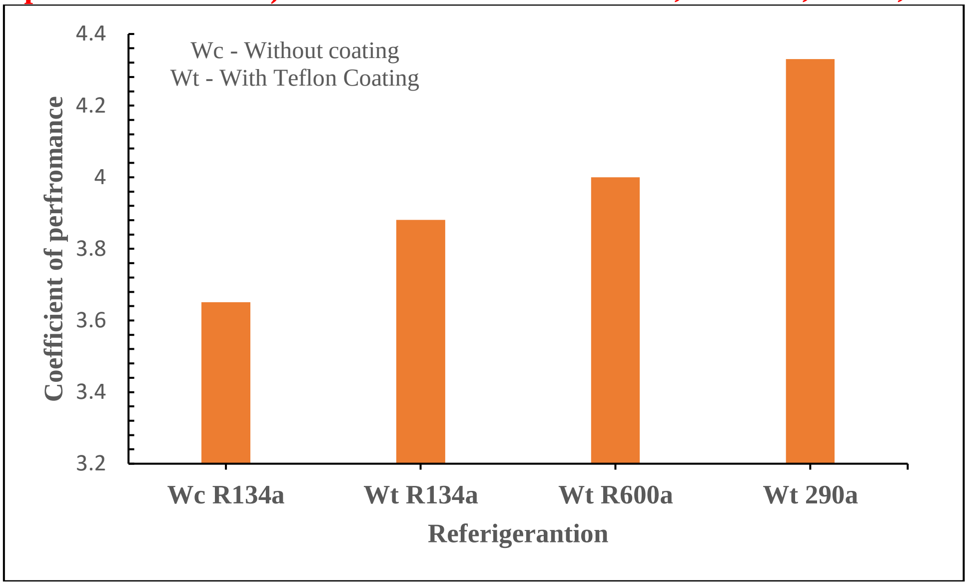

Fig.5: Refrigeration vs Coefficient of performance

From the above figure, 5 shows the comparison of without Teflon coating R-134a, with Teflon coating R-134a, R-600a, and R-290a refrigerants. The refrigerant R290a shows that higher COP than other refrigerants. The COP of the system increases the net refrigerant effect of the system and decreases the work done by the system

Comparison of 290a with R134a, R600a

- R290a with Teflon coating is 0.6% increased without Teflon coating of R134a
- R290a with Teflon coating is 0.4% is increased with Teflon coating of R134a
- R290a with Teflon coating is 0.3% is increased with Teflon coating of R600a

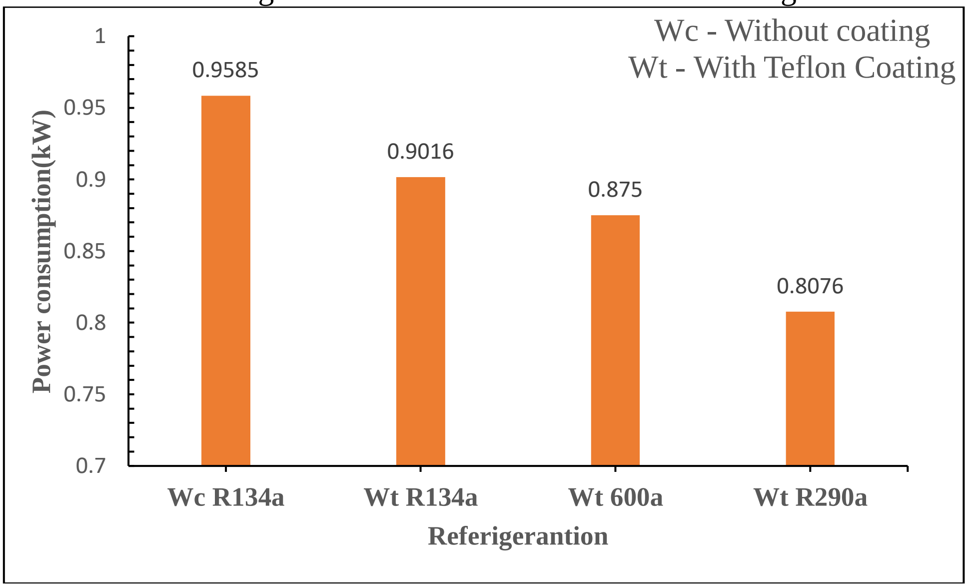

Fig.6: Refrigeration vs power consumption

From the above figure, 6 shows the comparison of without Teflon coating R-134a, with Teflon coating R-134a, R-600a, and R-290a refrigerants. The refrigerant R134a without Teflon coating refrigerant shows higher power consumption than other refrigerants. The decrease in compressor work results in reducing the power consumption of the system.

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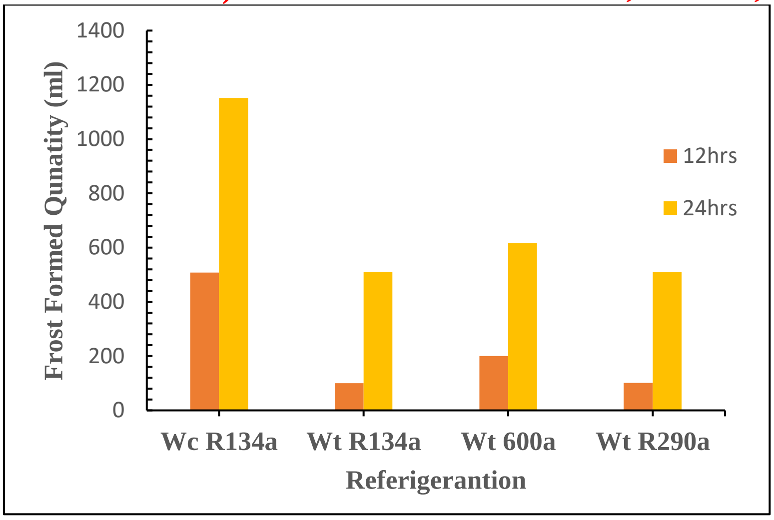

Fig.7: Refrigeration vs Frost formed quantity

From the above figure, 7 shows the comparison of without Teflon coating R-134a, with Teflon coating R-134a, R-600a, and R-290a refrigerants. At 12hrs and 24 hrs. of span, the frost formation without Teflon coating of R134a is higher compared to all refrigerants. the frost formation decreases by nearly 36% (Wc R-134a), 37% (Wc R-600a), and 50% (Wc R-290a).

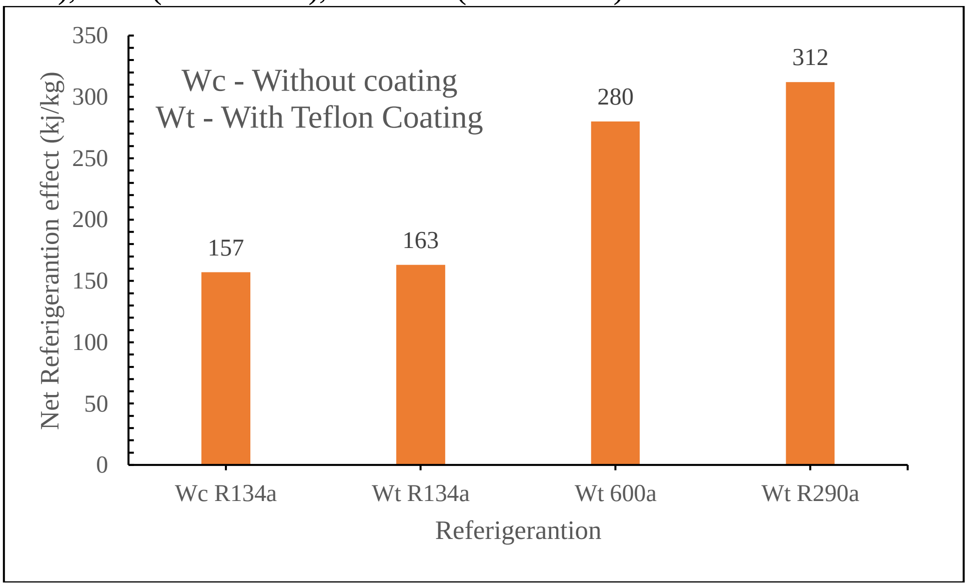

Fig.8: Refrigeration vs Net refrigeration effect

From the above figure,8 shows the comparison of without Teflon coating R-134a, with Teflon coating R-134a, R-600a, and R-290a refrigerants. The refrigerant R290aa without Teflon coating refrigerant shows that high net refrigeration effect with other refrigerants. The cycle's heat absorption and rejection rates increase. As a result, the system's net refrigeration impact is increased.

CONCLUSION:

In an experiment, the performance of a household refrigerator (210L) with and without Teflon coating on evaporator R-134a, R-600a, and R-290a refrigerant is evaluated. In this experiment, three refrigerators with and without Teflon coating were compared for their coefficient of performance, net refrigerants, frost formation, and work done. The conclusions reached are as follows:

It has been experimentally established that with the coated evaporator, the frost formation decreases by nearly 36% (Wc R-134a), 37% (Wc R-600a), and 50% (Wc R-290a) compared to the non-coated evaporator when the cooling time changes from both 12 hours and 24 hours. Also, it has been experimentally established that with the coated evaporator, the decrease in the coefficient of performance increases the R-290a refrigerant (0.6%, 0.4%, or 0.3%) among all refrigerants.

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REFERENCES:

1) James. Calm, the next generation of refrigerants historical review, considerations and outlook, int. J. refrig.31 (2008)1123-1133.
2) J. Corberian, Review of standard for the use of hydrocarbon refrigerant in A/C, heat pump, and refrigerant equipment.
3) Himanshu Sharma, the experimental and the performance study of Nano Refrigerant (R290+CEO) in VCRS (June 2019) int J. of Research.Vol.6.
4) T.O.Babarinde, Enhancing the energy efficiency of VCRS using R600a with graphene nano lubricant (Sept-2019) int conf on Power and E.S.Engine (CPESE-2019)
5) M.E.Haque, M.M.Noor, Performance of a domestic Refrigerator using POE oil as a base lubricant with Al_2O_3 and TiO_2 as Nano Particle. (2016), int. J. Mech Eng Science. 1778-1791.
6) Nithyanandhadhass Kamaraj, Experimental analysis of VCRs using Refrigerant with Nano Particles, (2016) int. J. Mech Eng 16-25.
7) R.Reji Kumar, Heat Transfer enhancement in the domestic refrigerator using R600a/MO-Al_2O_3 as the working fluid. Int. J. of computational Engg Research/Vol-3
8) B.Pitchia Krishnan, Experimental analysis of VCRs by using Nano Refrigerant (R290/R600a/ Al_2O_3) int. conf. on Material, Manufacturing, and Machining (2019).
9) M.S.Bandgar, R.N.Kare, VCRS using R600a/POE/MO/Nano-SiO_2 as working fluid (ICRTESM) int. conf. on Recent Trends in Engg Science and Management. Fluid (Dec-2016).
10) M.S.Bandger, Dr.K.P.Kolhe, An experimental investigation of VCRS using R134a/POE/MO/SiO_2 as working fluid (July-2016), J. of energy technologies and innovative Research. Vol-3.
11) 11. Niraj. N. Raja, Experimental investigation on the performance of VCRS using Nano-Refrigerant (R134a+Al_2O_3) with the evaporative condenser. (June-2020) Asian Review of Mech Eng.