EFFECT OF CERAMIC COATING ON EVAPORATOR AND COMPARISON OF COP UNDER VARYING COATING THICKNESS ON R-134A

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Abstract:
R134a is widely used and considered an environmentally safe refrigerant and a more suitable refrigerant for domestic refrigerators. It is safer than the ozone layer, but it has GWP. Most of the researchers find that the refrigerant is a heat-carrying medium used in the refrigeration system. It absorbs heat from the low-temperature system and discards the heat for a higher-temperature system. Energy has become a basic need for all human beings because it not only drives the economy of a country but also leads to technological development. The improvement in the standard of living has raised the demand for refrigeration and air conditioning. But the use of refrigeration and air conditioning has led to greenhouse gas emissions and thermal pollution. A well-designed refrigerator consumes less energy for a given storage volume, and improving the evaporator's 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 in the evaporator itself. Here we focus on two methods: one without ceramic coating and one with ceramic coating. The coating that sustains the low temperatures and is non-wettable is chosen so that the formation of corrosion on the evaporator is reduced. A domestic refrigerator of 210 liters capacity working with refrigerant without ceramic coating, R-134a, and with coating R-134a of ceramic coating thickness (0.5, 1, 1.5) mm has formed the experimentation. The results are obtained and compared for both the coating and the non-coating of ceramic. From the experiments, it was observed that corrosion formation is drastically decreased when the coating is used and that power is saved when the evaporator is coated.

Keywords: R134a, Ceramic Coating, Evaporator, Corrosion

1. Introduction:

In order to chill a product or place to the desired temperature, refrigeration can be described as the act of obtaining and maintaining a temperature below that of the surroundings. Perishable food products are preserved by being kept at low temperatures, which is one of the most significant uses of refrigeration. Using air conditioning, refrigeration systems are also frequently employed to give people thermal comfort. R134a and R12 are typically used as refrigerants in commercial freezers such chest freezers, wine coolers, Visi coolers, show cabinets, water coolers, and walk-in coolers. In India, an estimated 40,000, 27000, and 500 units of commercial walk-in coolers, water coolers, and refrigerated rooms are manufactured annually. According to the Ministry of Environment and Forestry (2005), small and medium-sized businesses produce about 80% of these units. R152a and hydrocarbon mixes are a good substitute for R134a in commercial applications. There were around 14,000 milk chilling and cold storage workers in India. The majority of cold storage and milk chilling facilities use ammonia, while a few also use R502. Ammonia's excellent environmental characteristics (zero ODP and GWP) will cause it to rule the industrial refrigeration market. For low-temperature industrial applications, 507 and hydrocarbon mixes are the preferred alternatives to R502. Mechanical refrigeration is a subset of a vapour compression refrigeration system (VCRS). Refrigerant in a vapour compression refrigeration system can cycle between phases constantly with some external force.

Domestic refrigerators, sizable warehouses for chilling and storing food, meats, and refrigerated trucks can all use vapor compression refrigeration systems. The Vapor Compression Refrigeration System operates on the same principle in numerous sectors, such. The heat pump in the refrigerator uses the thermodynamic second law to operate. The second law asserts that an isolated system's total entropy Water undergoes phase shift with a higher latent heat value than ice. Vaporizing liquid refrigerant has greater benefits than utilizing ice to create a cooling effect. Once the system is shut down, only refrigerant should be used.

2. Literature review:

A trans critical cycle using two separate refrigeration systems, R744 and R134a, was subjected to an exergy analysis by Ciro Aprea (2013). The system using R134a as the refrigerant performed better than R744 in the incremental percentage range of 20% to 44%, according to the findings of the general exergy analysis. In order to increase the effectiveness of the R744 system, the exergy study was also carried out to determine the exergy losses in certain system components. In order to display a refrigeration system, Belman-Flores (2017) developed an artificial neural network application. The main objective is to evaluate how well three refrigerants—R134a, R450a, and R513a—use energy. In order to present only three energy parameters—the cooling limit, the power consumption, and the coefficient of performance—as components of the evaporating temperature and the condensing temperature, the artificial neural network was used.

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 Ceramic Coating:

A large group of materials, such as ceramics, have a wide range of properties. Ceramic materials can be defined as compounds of both metallic and non-metallic elements. The properties of ceramic materials include a high melting point, low density, high corrosion resistance, high hardness, and low thermal expansion. Ceramics were used in applications of too-hot metals, such as ovens and heat engines. Sometimes high-grade ceramic coatings are used in refrigeration systems and in evaporators that are not too cold when cooling is low.

- Resistant to high temperatures
- High chemical stability
- High hardness values
- Low densities

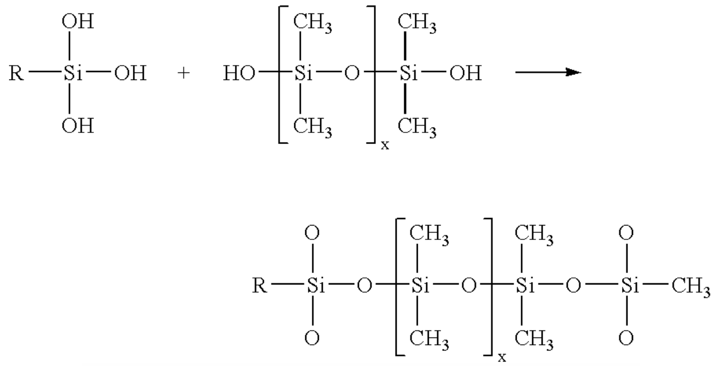

Fig .1: Chemical composition of Ceramic

3. Vapor compression refrigeration system

Most home refrigerators, freezers, and air conditioners use a vapor compression cycle. Refrigerant, a circulating fluid, enters the compressor during this cycle as low-pressure vapor or at a temperature just a little bit higher than the refrigerator's interior. After being compressed, the vapor releases as a high-pressure, superheated vapor. The condenser, which is made up of coils or tubes that are passively cooled by contact with the room's air, is where the superheated vapor passes under pressure. The vapor cools in the condenser, liquefying as a result. A metering or throttling device, also known as an expansion valve (basically a pinhole-sized constriction in the tube), is used to force this liquid refrigerant into a location of significantly lower pressure. A portion of the liquid evaporates in a flash that resembles an explosion as a result of the quick drop in pressure. This "auto-refrigeration" process draws the majority of the latent heat it absorbs from the nearby still-liquid refrigerant. The evaporator unit's coils or tubes continue to pass this cold, partially evaporated refrigerant. Once fully evaporated and slightly warmed, the refrigerant exits the evaporator and travels back to the compressor inlet to complete the cycle.

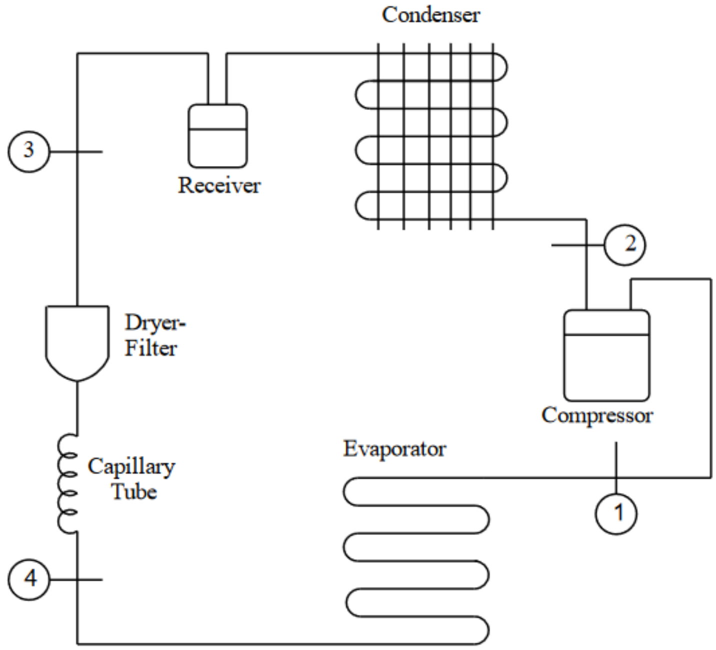

Fig.2: Vapour Compression refrigeration system

4. 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 Ceramic R134a as a refrigerant
- The System with a coating of Ceramic (0.5mm) R134a as a refrigerant
- The System with a coating of Ceramic (1mm) R134a as a refrigerant

- The System with a coating of Ceramic (1.5mm) R134a as a refrigerant

Fig.3: Refrigeration

5. Results and Discussion:

In the present work, a domestic refrigerator operated on a vapor compression refrigeration (VCRS) cycle was used for the experimentations. with ceramic coating R-134a, with a ceramic coating of (0.5,1,1.5 mm) R-134a, 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 Ceramic coating	R134a with ceramic Coating (0.5mm)	R134a with ceramic Coating (1mm)	R134a with ceramic Coating (1.5mm)
1	Net Refrigeration Effect in kJ/kg	161	170	177	182
2	Compressor Work in kJ/kg	44	45	46	47
3	Power Consumption in kW	0.95	0.92	0.904	0.903
5	Coefficient of Performance	3.65	3.8	3.85	3.88

ISSN: 2278-4632
Vol-13, Issue-05, No.04, May : 2023

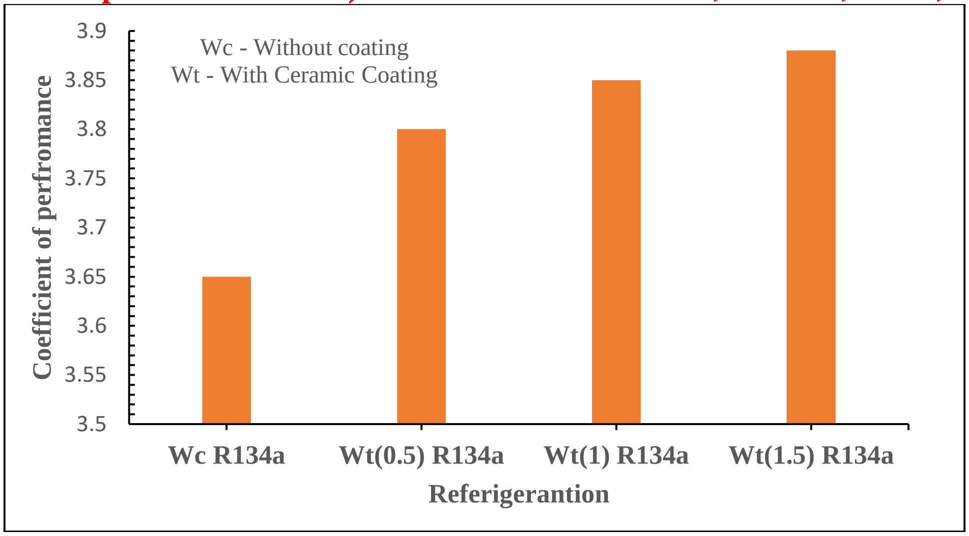

Fig.4: Refrigeration vs Coefficient of performance

From the above figure, 5 shows the comparison of without Ceramic coating R-134a, with ceramic coating (0.5,1,1.5) mm refrigerants. The refrigerant R134a of ceramic coating of 1.5 mm 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.

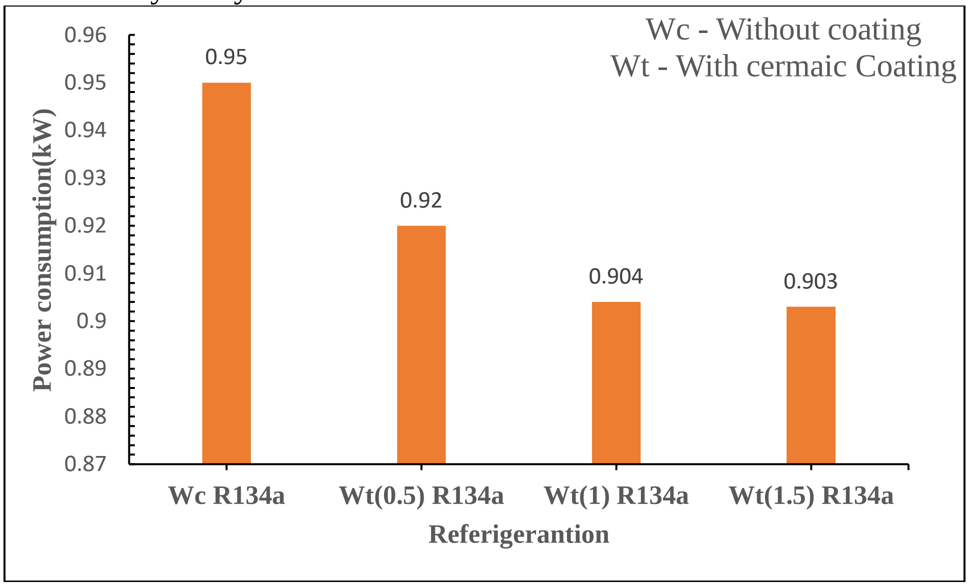

Fig.5: Refrigeration vs power consumption

From the above figure, 6 shows the comparison of without Ceramic coating R-134a, with ceramic coating (0.5,1,1.5) mm refrigerants. The refrigerant R134a without coating refrigerant shows higher power consumption than other refrigerants. The decrease in compressor work results in reducing the power consumption of the system.

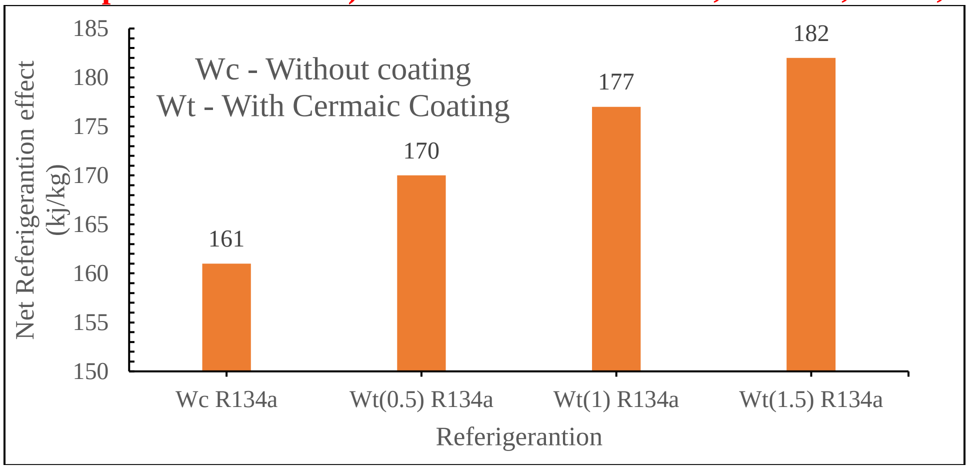

Fig.6: Refrigeration vs Net refrigeration effect

From the above figure,8 shows the comparison of without Ceramic coating R-134a, with ceramic coating (0.5,1,1.5) mm refrigerants The refrigerant R134a (1.5) mm with ceramic 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) without Ceramic coating R-134a, with ceramic coating (0.5,1,1.5) mm refrigerants are evaluated. In this experiment, three refrigerators with and without ceramic 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 corrosive resistance formation decreases by nearly 0.6% 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-134a refrigerant (0.6%, 0.4%, or 0.3%) among all refrigerants.

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