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Performance of the Shape of Ellipse of Evaporator Coil in Vapour Compression System

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Abstract: To learn about the factors that can improve the overall performance of a simple vapour compression refrigeration system, it's important to examine the device responsible for the system's expansion. An investigation into how capillary tube geometry impacts cooling efficiency is crucial. The literature review centres on the relationship between geometrical parameters and system performance metrics such pressure drop, COP, and mass flow rate. These factors include capillary tube length, bore diameter, coil pitch, number of twists, and twisted angle. Improve the efficiency of the cooling system by tweaking the aforementioned settings. In this study, we examine how changing the tube diameter, tube length, coil pitch, and inlet condition affects the mass flow rate of the refrigerant through the helical coil capillary tube, as well as how the coiling effect of the capillary tube affects the system's COP. In order to meet the modern trend toward smaller refrigeration systems, helical capillary tubes are increasingly being used.

Key words: Capillary tubes, capillary tube geometry, and the coefficient of performance, vapour compression cycle.

1. INTRODUCTION

The VCR is a modern advancement of the air refrigeration system.[1] This technique is predicated on the fact that certain liquids may soak up vast amounts of heat when they evaporate. The efficiency of a refrigeration system is measured by its coefficient of performance, which is proportional to the ratio of the system's refrigerating effect to its compression work. [2] These days, people employ vapour compression refrigeration systems for cooling everything from beverages to meat to vegetables. It has widespread commercial applications, from the smallest home refrigerator to the largest central air conditioning facility.

VCR Parts and Pieces
1).Compressor
2).Condenser
3) an expansion valve, and
4) an evaporator.

The evaporator in a VCR is where the refrigeration effect (output) is created. A domestic refrigerator that is powered by a VCR has limited options for increasing its COP. [3] One of the best ways to boost VCR performance is to increase the refrigeration effect. The efficiency with which a system makes use of the energy it is given is a crucial factor in determining its ultimate performance. The increased use of high-tech appliances such as heaters, chillers, refrigerators, and air conditioning systems has resulted in a worldwide increase in daily energy consumption.[4]

Domestic refrigerators, beverage and food processing companies, cold storages, frozen meat storages, milk chilling plants, ripening chambers, and medical storage applications all contribute to the continually rising demand for energy to power refrigeration systems. When evaluating the effectiveness of a refrigeration system, energy efficiency is a crucial metric to consider. Refrigeration via Vapor Compression Most refrigeration systems employ the vapour-compression refrigeration cycle because of its many benefits, including superior refrigerant thermodynamic properties, a more powerful cooling effect, a greater COP, and so on. [5]

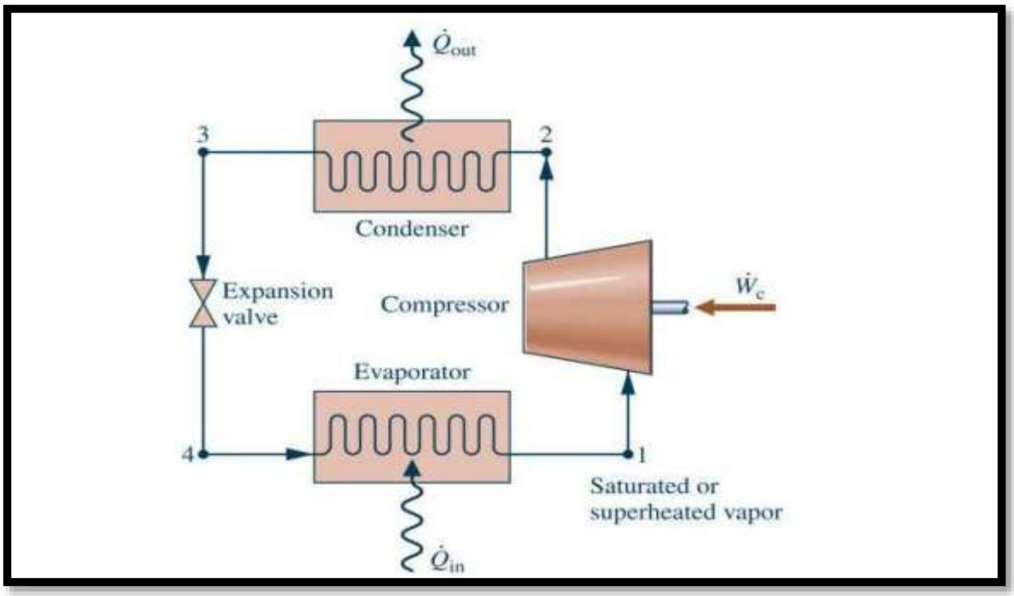

Fig 1: Vapor-compression refrigeration system

This refrigeration cycle has several uses, including in home and commercial refrigerators, food storage facilities, refrigerated trucks, and more. The heat in the cooling area is absorbed by the refrigerant circulating in a VCR system and then rejected to a high-temperature source (the atmosphere).The compressor, condenser, expansion device, and evaporator are the four main components. After absorbing heat from the evaporator (low pressure, low temperature vapour), the refrigerant travels to the compressor, where it is compressed by an external work input.[6] Heat is rejected to the environment from the high-pressure, high-temperature vapour refrigerant due to the constant-pressure condensation process in the condenser. By allowing the high-pressure liquid refrigerant to be expanded into the low-pressure, low-temperature liquid refrigerant, the throttling process guarantees heat absorption in the evaporator. This refrigerant continuously prepares itself for the cycle by taking on the heat load from the evaporator.

Capillary tubes are often used as expansion devices in small refrigeration and air conditioning systems for regulating refrigerant flow. It's only a simple tube with a small diameter, often between 0.5 and 2 millimetres. Despite the fact that the device has no mechanical or electrical active feature to actively react to any abrupt change in the load conditions, it is nonetheless widely used because of its ease of use, inexpensive price, and low starting torque requirement for the compressor. [7] The system size has the greatest impact on the capillary tube length needed. The refrigerant begins the vapor-compression refrigeration cycle as a saturated vapour and condenses to a saturated liquid at the end of the cycle. As it absorbs heat from the chilled area, it is allowed to build up to the evaporator's pressure and vaporise.

Alterations to Steam Compressors

Vapor compression devices incur much more thermodynamic losses than the ideal reverse Carnot cycle. These are the thermodynamic costs of compressing and isentropically expanding a gas.[8] High refrigerant temperatures at the condenser's or gas cooler's outlet, along with increased compression work and heat rejection, are the result of the first loss. A considerable amount of throttling loss and insufficient refrigeration capacity are the results of a second loss. To reduce thermodynamic losses, several researchers have proposed modifying subcritical and transcritical vapour compression systems by adding performance-improving devices such as heat exchangers, desuperheaters, intercoolers, ejectors, vortex tubes, and ejector-expanders.Several examples of subcooling systems (heat exchanger, mechanical subcooled, and thermoelectric subcooled), expansion loss recovery systems (expander, ejector, and vortex tube), and multi-stage systems that make use of these performance-improving devices can be found in the literature (desuperheater, intercooler). In most cases, the use of such devices can improve the COP and energetic efficiency of subcritical and transcritical vapour compression systems [9].The current study replaces the throttle valve in a transcritical VCR system with a vortex tube in order to lessen the throttling losses. It is important to note that the transcritical systems under consideration make use of other performance-improving devices, such as desuperheaters and intercoolers, at suitable locations. [10]

Spiral tube of vortices

The vortex tube (VT) is a straightforward heating appliance that requires no moving parts. It can split a compressed gas flow at the intake into two distinct gas flows. One of the two streams is hot, while the other is cold relative to the inlet. The energy (or temperature) separation effect describes how the incoming gas is split into low- and high-temperature components. [11]

Heat is rejected at the condenser in a vapour compression refrigeration system as the refrigerant changes phases from liquid to vapour and back to liquid in a closed cycle. A measure of how efficiently a refrigeration system transfers heat from the evaporator to the compressor is called the coefficient of performance (cop). Either decreasing compressor work or boosting the refrigeration effect will lead to a higher performance coefficient. The literature describes a number of attempts to improve the effectiveness of the vapour compression refrigeration system.

2. MATERIALS AND METHOD

The following are known to have an effect on VCR performance:
a. Working fluid characteristics
b The system pressure and the total amount of charge

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c The size of the capillary walls
d. Water temperature at the intake
In this study, we examine how changing the width of a spiral-coiled capillary tube affects the efficiency of a refrigeration system's vapor-compression cycle and the mass flow rate of the refrigerant. The study's goal was to evaluate the efficiency of various capillary tube sizes under various loads. In place of an opening, a narrow tube can be used to increase the flow rate of a fluidics the efficiency of a refrigeration system's vapor-compression cycle and the mass flow rate of the refrigerant. The study's goal was to evaluate the efficiency of various capillary tube sizes under various loads. In place of an opening, a narrow tube can be used to increase the flow rate of a fluid. A capillary tube expansion device uses a narrow tube to achieve the same result as a wide aperture. This "hairlike" structure is called a capillary tube. The small bore diameter is what gives rise to the term. A capillary tube with an inner diameter of 0.50 to 2.30 millimetres is commonly used for cooling. The pressure drop a capillary tube can cause in the flow of refrigerant increases with its length and/or with a decrease in its interior diameter. Simply put, a larger pressure differential between the high pressure and low pressure sides is required to achieve a certain refrigerant flow rate.

Configuration of the Experiment
A home refrigerator of the appropriate capacity serves as the main piece of equipment, with its suction ports, evaporator outlet, capillary tube, and evaporator inlet having been changed to facilitate the connection of the tested capillary tube to the vapour compression cycle.

3. RESULTS

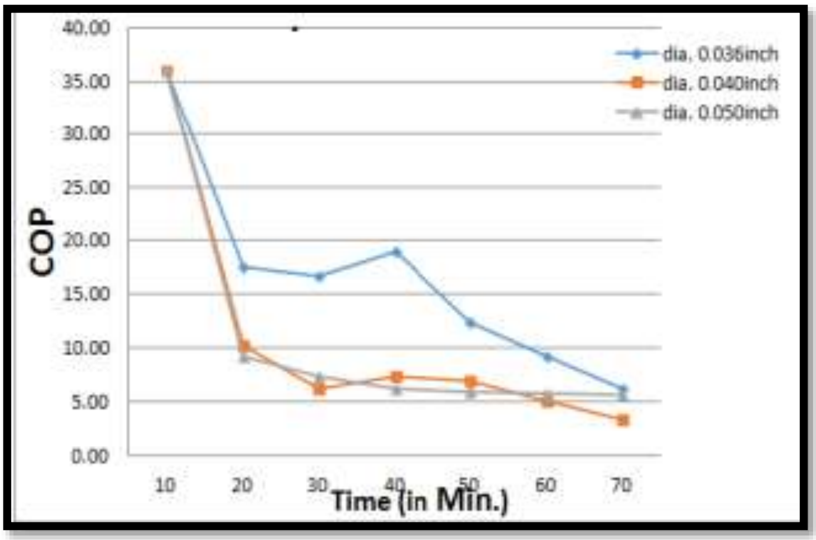

Fig 1. COP Vs TIME for 6 litres /load

Figure 1 depicts the performance coefficient versus time for a 6-liter load. When the diameter of a capillary tube is decreased, the mass flow rate of the refrigerant increases, causing the water temperature to rise.

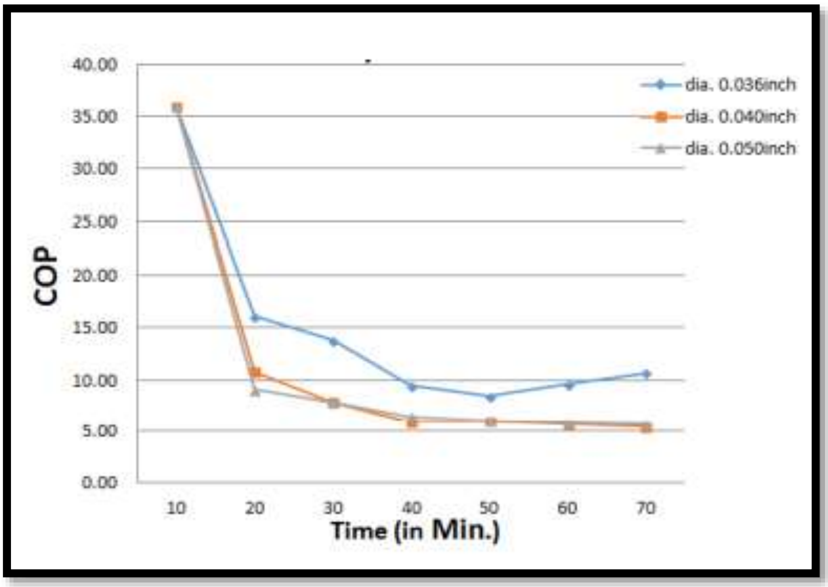

Fig. 2. COP vs. time for 4.0 L/Load

Figure 2 depicts the performance coefficient versus time for a 4.0 L load. the evaporator, where it takes in less heat from the water or substance being cooled

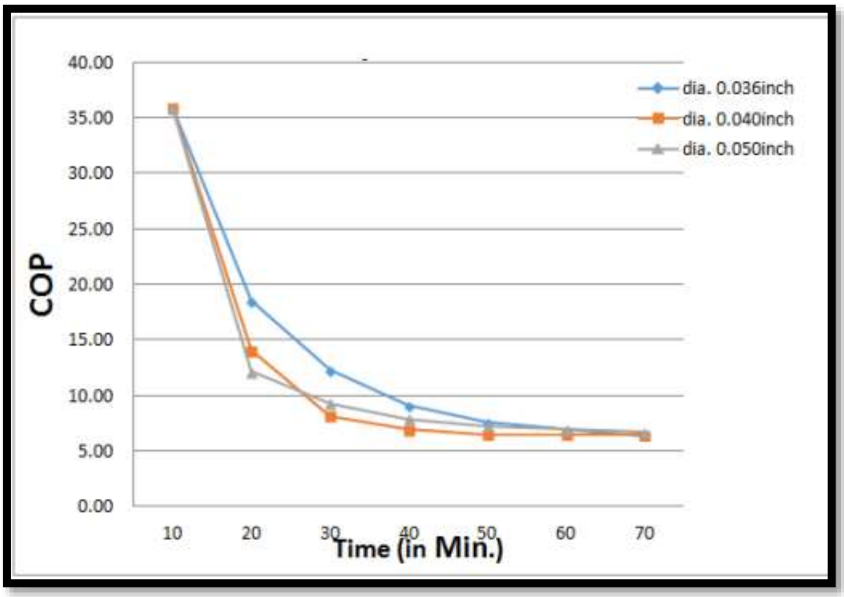

Fig 3: COP vs. time for 2.0 L/Load

In Fig. 3, we see the performance coefficient versus time for a 2.0-liter load. When a capillary tube with the lowest possible inside diameter is employed in a vapour compression system, the system's performance coefficient increases rapidly as a function of time.

4. DISCUSSIONS

For the purposes of this study, we employed 0.036", 0.040," and 0.050" diameter capillary tubes for our experiments. [12] Each trial segment was exactly 1 metre long. There are at least five measurements in each set, all of which measure the same variables under varying loads. The steady-flow energy equation and pressure-enthalpy relationships are used in this section to analyse the performance of a vapor-compression refrigeration system. [13] COP, power of the compressor, enthalpy of each point, and mass flow rate of the refrigerant are the four most important factors to consider when analysing the R-143a diagram. Consequently, various variables were recorded, including the refrigerant temperatures at the inlet and outlet of the compressor (T1 and T2), the outlet of the condenser (T3), the input and outlet of the evaporator (T1 and T4), and the evaporator cabinet (T4). It also monitored the compressor's electrical voltage and current consumption as well as the high and low pressures of the vapour compression cycle. [14] As can be seen from the graphs above, the smallest diameter capillary tube (0.036") yields the highest coefficient of performance of the vapour compression system with regard to time for varying loads of 6 litres, 4 litres, and 2 litres. Since the pressure drop is known to be proportional to the length of the tube and inversely proportional to the bore diameter, it follows that the longer the tube, the greater the pressure drop. The large amount of frictional resistance produced by a narrow tube is responsible for the necessary pressure drop (the pressure difference between the condenser and the evaporator). [15]

5. CONCLUSIONS

Understanding how capillary tube shape affects refrigeration performance is crucial. Based on the data collected for this study, it was determined that single capillary tubes with a smaller inner diameter are better suited for freezing applications, while those with a larger inner diameter are better suited for cold storage or air conditioning. Considering that the pressure drop is proportional to the tube's length and inversely related to its bore diameter, using capillary tubes with a smaller diameter increases the system's COP under varying loads. The necessary pressure drop (pressure difference between condenser and evaporator pressure) is created by the high frictional resistance provided by a small diameter tube.

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