THE PERFORMANCE EVALUATION OF VAPOUR COMPRESSION REFRIGERATION SYSTEM BY THROTTLING VARIATION

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ABSTRACT

This project looked into and reported on the impact of throttling variation on the operation of a vapour compression refrigeration system employing R134a refrigerant as the working fluid. Under conditions of room temperature of 29 to 32°C, the experiment was conducted using a refrigeration test rig with a capillary line acting as a throttling device that was divided into three capillary lines of equal length. The test rig has instruments fitted at the condensing and evaporating units' intake and outlet to measure the pressure and temperature of the working fluid. The pressure temperature data were taken during experimental tests when one, two, and all three capillary lines were used for the throttling procedure**.**

Based on the experimental data, the performance of the refrigeration system was examined. The temperature differential between the evaporating unit's input and outlet increased, refrigerating impact increased, and compressor work decreased as the number of capillary lines used increased from one to three, according to the results. If only one or two capillary lines were used, respectively, for the throttling process, it was discovered that the system's coefficient of performance increased more than its COP. enhancing the system's efficiency.

A Description of The Refrigeration System :

The science of refrigeration can be summed up as the practise of lowering and keeping a substance or space's temperature below that of its surroundings.This is accomplished by continuously removing heat from the enclosed area to keep the temperature below the ambient temperature. The substance that dissipates this heat is referred to as a refrigerant, also known as a working fluid. By evaporating at low temperatures and low pressure and condensing at high temperatures and high pressure, this working fluid absorbs heat from the area to be cooled. Among the many uses for refrigeration are the preservation of domestic perishable food and beverages, industrial cooling, cryogenics, and air conditioning.

According to how they operate, refrigeration systems can be divided into three (3) basic categories: gas cycle, vapour compression, and vapour absorption systems. Although there are different types of refrigeration systems, the vapour compression refrigeration system (VCRS) is the most often used. Its main parts are the compressor, condenser, expansion valve, sometimes known as a throttling mechanism, and the evaporator.

NEED FOR THE PROJECT:

• The vapour compression refrigeration system, which uses more energy than other thermal systems, is a crucial one.

• The vapour compression refrigeration system (VCRS) uses more energy each year as a result of its heavy usage.

• The vapour compression refrigeration system faces significant hurdles in terms of reducing energy usage and ensuring good performance.

OBJECTIVE:

To investigate the effect of throttling on the performance of the Vapour Compression Refrigeration System

WORKING THEORY:

Vapor compression refrigeration systems are commonly used in industrial facilities to create environments conducive to the perseveration and safe storage of products. In this guide, we will go over how a compression refrigeration system works, and the four main components used to create the refrigeration cycle.

The compression refrigeration cycle consists of circulating a liquid refrigerant through four stages of a closed system. As the refrigerant circulates through the system, it is alternately compressed and expanded, changing its state from a liquid to a vapor. As the refrigerant changes state, heat is absorbed and expelled by the system, lowering the temperature of the conditioned space.

Diagram of the Vapor Compression Refrigeration Cycle

Initially, compression

In the first phase of the refrigeration cycle, low-pressure vaporised refrigerant enters a compressor. The refrigerant is superheated as the compressor compresses it into a high-

COMPRESSOR

pressure vapour. After being heated and compressed, the refrigerant exits the compressor and moves on to the following phase of the cycle.

TIP: Different types of compressors, such as reciprocating, centrifugal, scroll, or screw compressors, can be utilised in the refrigeration cycle.

Condensation in Stage 2

The hot vapour refrigerant moves on to the condensation phase of the cycle after exiting the compressor. The refrigerant enters a condenser and travels through a network of S-shaped tubes during the condensation step. Cool air is pumped across the tubes as the hot vapour passes through the condenser.

Measurement of expansion in Stage 3

The high-pressure liquid refrigerant enters a metering device or expansion valve in the third stage of compression refrigeration systems' operation. The metering device operates to expand the liquid refrigerant and lower pressure on the outflow side while maintaining high pressure on the entrance side. The liquid refrigerant's temperature decreases together with the expansion process.

Expantion valve

Fourth stage: evaporation

The refrigerant is now prepared to reach the evaporation stage, where the heat is eventually expelled from the space being conditioned, in a cool, low-pressure liquid form.

The cool liquid refrigerant exits the metering equipment and enters coiled tubes in an evaporator during the evaporation step. Then warm air is blown via fans.

FABRICATION PROCESS:

Generally speaking, a vapour compression refrigeration system has two heat exchangers. One involves absorbing heat, which is accomplished by the evaporator, and the other involves removing heat from the refrigerant in the evaporator and the heat supplied during compression in the compressor before condensing it back into liquid, which is accomplished by the condenser.

The goal of this project is to improve heat rejection in the condenser, which can only be done by adding a fan or extending the surfaces. Fins are the extended surfaces. The quantity of offins attached to the condenser affects how quickly heat is rejected there. Copper materials are employed in residential refrigerator fins today.

Temperature and pressure gauges are put at each entry and exit of the component in order to determine the vapour compression refrigeration system's operating parameters. Condensers with fins are used in the experiments.As well as using snips to trim the fins to the necessary diameters, tube cutters to cut the tubes, and tube benders to bend the copper tube to the necessary angle.

Finally the domestic refrigerator is fabricated as for the requirement of the project.

EXPERIMENTAL SETUP:

As seen in Fig., the main loop of the system under study consisted of five fundamental components: a compressor, an evaporator, a condenser, capillary tubes, and liquid line filter-drier.A system with a three-phase, 220 V, reciprocating compressor that was first created for R134a refrigerant was utilised. The compressor's input power inside the system ranged from 230 to 300 W. Mineral oils were a key component of the compressor lubrication. To take care of the moisture, a silica gel drier filter was used. Compact forced air cooled type condenser were employed because of their effective heat transfer capabilities.Capillary tubes of differentint diameters were used tofind the optimum operating points of the system.

The evaporator cabinet was properly insulated with foam and thermocaol to reduce heat loss. R134a was the refrigerant in use. An electrical switch, a valve for regulating the mass flow rate of the refrigerant, a bourdon tube type pressure gauge, and a compound pressure gauge were some other measuring and controlling elements employed in the system.

OBSERVATIONS AND CALCULATIONS:

The performance measures considered in the experimentation are
Coefficient of Performance
Refrigerating Effect
Degree of Sub-cooling
Condensing Temperature
Evaporating Temperature
Condensing Pressure

S.No	Condenser Temperature				Evaporator Temperature			
	Inlet		Outlet		Inlet		Outlet	
	P2(bar)	T2(°C)	P3(bar)	T3(°C)	P4(bar)	T4(°C)	P1(bar)	T1(°C)
1	11.40	44.33	9.66	38.11	6.62	24.83	3.14	1.94
2	11.04	43.11	10.01	39.42	6.97	26.56	3.11	1.67
3	11.73	45.43	10.01	39.42	7.11	27.24	3.14	1.94
4	10.76	42.13	10.07	39.64	6.97	26.56	2.97	0.39
5	11.59	44.97	10.01	39.42	6.90	26.22	3.17	2.21
Average	11.30	43.99	9.95	39.20	6.91	26.28	3.11	1.63
Standard Error	0.18	0.61	0.07	0.28	0.08	0.40	0.04	0.32

S.No	Temp 1	Temp 2	Temp 3	Enthalpy 1 (kJ/kg)	Enthalpy 2 (kJ/kg)	h3 = h4 (kJ/kg)	Ref effect (kJ/kg)	Work (kJ/kg)	COP
1	194	44.33	38.11	309.73	421.25	253.6	146.13	21.52	6.12
2	167	43.11	39.42	399.57	420.75	255.54	144.03	21.18	6.23
3	194	45.43	39.42	399.73	421.69	255.54	144.19	21.96	6.31
4	0.39	42.13	39.64	399.83	420.34	254.38	144.45	21.51	6.18
5	2.21	44.97	39.42	399.89	421.51	255.54	144.35	21.62	6.51
Average	1.63	43.99	39.20	399.55	421.11	254.92	144.63	21.56	6.65

RESULTS AND DISCUSSION:

The following outcomes were attained by varying the throttle during the operation of the vapour compression refrigeration system.

1. Temperature and pressure readings at the condenser and evaporator's input and outlet when one capillary line was opened 39.31 bar Condenser Pressure at Outlet

Temperature at evaporator exit: -4.00

Values of compressor work, COP, and refrigerating impact with three capillary lines 144.63 kj/kg of enthalpy

COP on average: 6.71

According to the data, changing the throttle flow increases both the quantity of work done and the cooling impact.

Additionally, the condenser's pressure drop is maximised.

CONCLUSION:

The performance of vapour compression refrigeration system (VCRS) has been successfully investigated with the following deductions:

1.When one, two, and three capillary lines, respectively, were engaged for the throttling process, it was discovered that the temperature differential between the inlet and exit of the evaporating unit increased in the range of 8.66°C, 20.16°C, and 24.65°C. This shows that as the number of capillary coil lines utilised for throttling increased, so did the rate of heat transfer and the refrigerating effect.

2. The refrigerating effect was seen to increase from 141.2 kJ/kg to 144.6 kJ/kg when the number of capillary lines used for the throttling process increased from one to three, while the work performed by the system compressor reduced from 24.8 kJ/kg to 21.6 kJ/kg.

3.When one, two, and three capillary lines were used for the throttling process, the system's COP was found to rise in the range of 5.690.04, 6.240.04, and 6.710.04, respectively. The COP of 6.710.04 was 17.9% and 7.5% higher than the system's COP if only one and two capillary lines were used, respectively.

4.An earlier transition of the working fluid from the saturated liquid state to a two-phase flow mixture at the outlet of the expansion valve has been attributed to the behaviour of the VCRS with changes made to the throttling process. Additionally, as the number of capillary lines increases, the flow velocity decreases, reducing the friction and momentum of the refrigerant before it enters the evaporating unit.

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