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Performance Analysis of Vapour Compression Refrigeration System with Serpentine and Spiral Condensers by Using R600a

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ABSTRACT

The present work is to analyse the performance of VCRS system with two condensers i.e., Serpentine and Spiral tube using Isobutane (R600a) refrigerant. These two condensers are kept in parallel with other components of refrigerating unit while construction. The performance of refrigeration system is checked for each condenser at various cooling loads. The performance of the condenser is measured for whole refrigeration unit in terms of C.O.P, compressor work, Efficiency of the system, Heat Rejection Ratio, and Heat Rejected from Condenser. The result will show that for both condensers for refrigerant R600a, coefficient of performance increases with increase in heating load, increase in refrigerating effect and decrease in compressor work. From the analysis of two condensers, coefficient of performance of refrigeration system using serpentine and spiral condenser VCRS is more compared to conventional VCRS. Also, R600a gives better cooling effect than tetrafluroethane (R134a). The substitution of R134a by R600a is useful in order to generate a good thermo-economic output, zero ODP (Ozone Depletion Potential) and very low GWP (Global Warming Potential).
Keywords : VCRS, Serpentine condenser, Spiral condenser, Coefficient of performance (COP). ODP, GWP

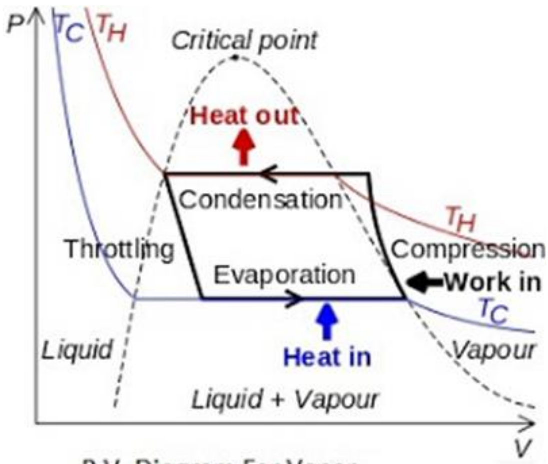
I. INTRODUCTION

Vapor-compression refrigeration, in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles and is the most widely used method for air-conditioning of buildings and automobiles. It is also used in domestic and commercial refrigerators, large-scale warehouses for chilled or frozen storage of foods and meats, refrigerated trucks and railroad cars, and a host of other commercial and industrial services. Oil refineries, petrochemical and chemical processing plants, and natural gas processing plants are among the many types of industrial plants that often utilize large vapor-compression refrigeration systems.

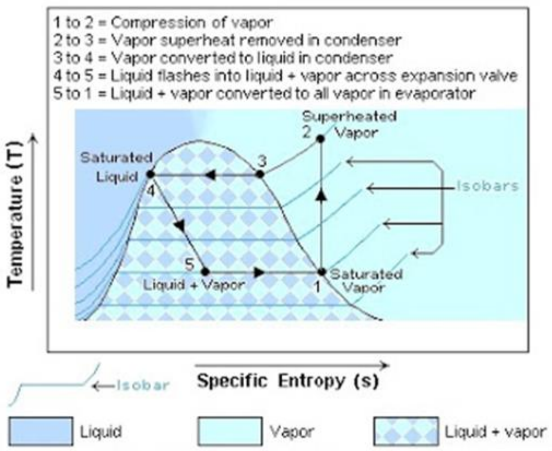
Vapor Compression Refrigeration System:

As shown in the figure the basic system consists of an evaporator, compressor, condenser and an expansion valve. The refrigeration effect is obtained in the cold region as heat is extracted by the vaporization of refrigerant in the evaporator. The refrigerant vapour from the evaporator is compressed in the compressor to a high pressure at which its saturation temperature is greater than the ambient or any other heat sink. Hence when the high pressure, high temperature refrigerant flows through the condenser, condensation of the vapour into liquid takes place by heat rejection to the heat sink. To complete the cycle, the high pressure liquid is made to flow through an expansion valve. In the expansion valve the pressure and temperature of the refrigerant decrease. This low pressure and low temperature refrigerant vapour evaporates in the evaporator taking heat from the cold region. It should be observed that the system operates on a closed cycle. The system requires input in the form of mechanical work. It extracts heat from a cold space and rejects heat to a high temperature heat sink.

A refrigeration system can also be used as a heat pump, in which the useful output is the high temperature heat rejected at the condenser. Alternatively, a refrigeration system can be used for providing cooling in summer and heating in winter. Such systems have been built and are available now



P V Diagram For Vapor Compression system



TS Diagram for VCR System

Working of vapour compression refrigeration system

Most of the modern refrigerators work on this cycle, in Its simplest form there are four fundamental operations required to complete one cycle.

1)Compression

The low pressure Vapour in dry state is drawn from the evaporator during the Suction stroke of the compressor. During compression Stroke the pressure and temperature increase until vapour temperature is greater than the temperature of condenser cooling medium (air or water).

At **point 1** in the diagram, the circulating refrigerant enters the compressor as a saturated vapor. From **point 1** to **point 2**, the vapor is isentropically compressed (i.e., compressed at constant entropy) and exits the compressor as a superheated vapor.

2) Condensation

When the high pressure refrigerant vapour enters the condenser heat flows from condenser to cooling medium thus allowing the vaporized refrigerant to return to liquid State.

From **point 2** to **point 3,** the vapor travels through part of the condenser which removes the superheat by cooling the vapor. Between **point 3** and **point 4**, the vapor travels through the remainder of the condenser and is condensed into a saturated liquid.

3) Expansion

After condenser the liquid refrigerant is stored in the liquid receiver until needed. From the receiver it passes through an expansion valve where the pressure is reduced sufficiently to allow the vaporization of liquid at a low temperature of about -10°C.

Between **points 4 and 5**, the saturated liquid refrigerant passes through the expansion valve and undergoes an abrupt decrease of pressure. That process results in the adiabatic flash evaporation and auto-refrigeration of a portion of the liquid (typically, less than half of the liquid flashes).

d) Vaporization

The low-pressure refrigerant vapour after expansion in the expansion valve enters the evaporator or refrigerated space where a considerable amount of heat IS absorbed by it and refrigeration is furnished.

II. METHODS AND MATERIAL

Experimental Apparatus and Procedure

The refrigerator system has an aggregate volume of 165L.The detailed technical specifications of the refrigerator shows that the serpentine condenser, spiral condenser, and the compressor were located inside the base of the refrigerator. Both the air inlet and outlet grilles were set in the back panel and separated from the serpentine condenser. Hence, some heat exchange will get around the liquid suction line due to a smaller pressure will be increased in the conventional situation. Consequently, this heat rarely contacted with the serpentine condenser and exchanged less heat with in the refrigerant, thus increase the serpentine condenser performance.

Fig 1. Serpentine Condenser

Fig 2. Spiral Condenser

Test Procedures

The serpentine and spiral condenser is used to improve the performance of the refrigerator. By implementing the serpentine condenser effective cooling takes place in the refrigerator, so that it reduces the compressor work by used liquid suction heat exchanger. The refrigeration system experimentation was carried out with

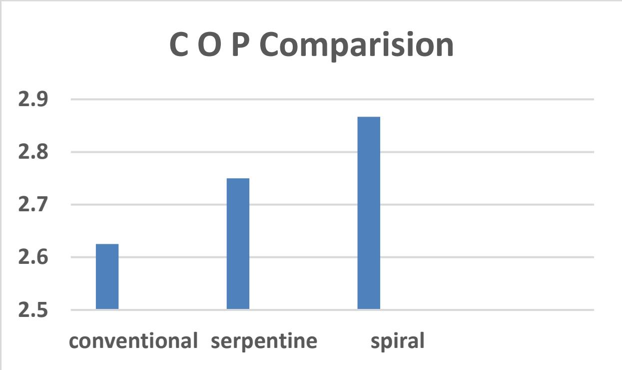
1. Conventional VCR system with R600a as refrigerant.
2. VCR System with R600a as refrigerant with serpentine condenser.
3. VCR system with R600a as refrigerant with spiral condenser.

Experiments are tired all cases and also the values of pressures and temperatures are tabulated and calculations are done.

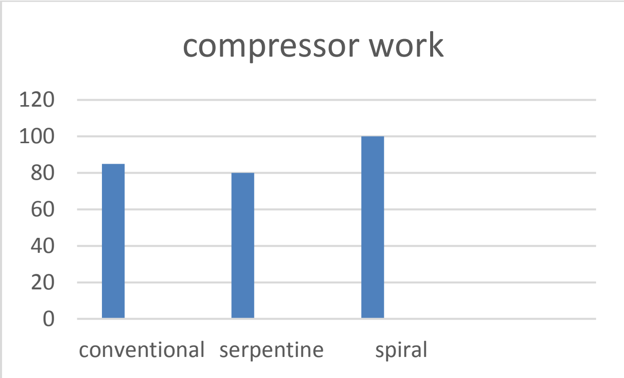
III. RESULTS AND DISCUSSION

The coefficient of performance (COP), refrigerating effect is obtained numerically for the vcrs with serpentine and spiral condensers using R600a refrigerant.

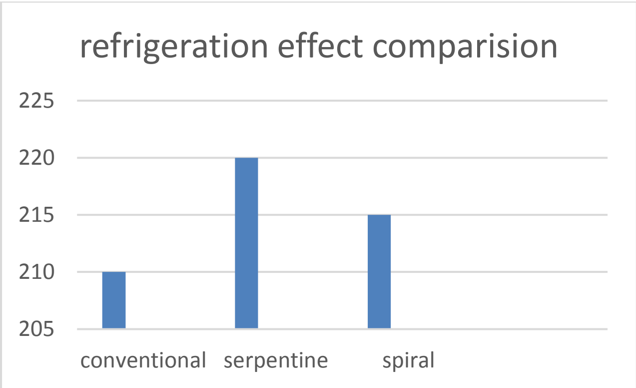
3.1 Comparision of C.O.P for the serpentine and spiral condensers



3.2 Comparision of compressor work for serpentine and spiral condenser



3.3 Comparision of refrigeration effect for Serpentine and Spiral condenser VCRS



IV.CONCLUSION

This study provides the performance of VCRS using serpentine and spiral condensers for R600a under various pressure ratios. It presents a contribution to the following of methodology making it possible to predict condenser impact on COP. It was found that the COP increases with the increase in refrigerating effect and with decrease in compressor work. R600a presents greater COP improvement compared to R134a. Therefore, the substitution of R134a by R600a is useful in order to generate a good thermo-economic output, zero ODP (Ozone Depletion Potential) and very low GWP (Global Warming Potential).

The performance of the refrigeration system is increased by reducing the space of high thermal conductivity material fins. High heat rejection through the spiral and serpentine condenser helped to increase COP of the modified VCRS. In the modified system, due to the combined effect of fins spaced condenser, COP is increased for both serpentine condensed VCRS.

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