COMPARATIVE STUDY OF PERFORMANCE OF ICE CANDY PLANT USING CAPILLARY TUBES OF DIFFERENT DIAMETERS

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***Abstract* – The effect of using capillary tubes of different diameters is studied on Ice Candy Plant showing the concept of Indirect Cooling using R-134a as refrigerant. The capillary tubes used to check the Coefficient of Performance of the plant are of same length and having different diameters of 0.036 and 0.044 inch. The comparative analysis is done on the basis of various factors and the result obtained shows that the Coefficient of Performance of the 0.044 inch diameter capillary is more than the 0.036 inch diameter capillary.**

***Keywords* – Ice Candy Plant, Vapour Compression Cycle, Indirect Cooling, Capillary Tubes, R-134a, Coefficient of Performance.**

I. INTRODUCTION

The term Refrigeration refers to the extraction of heat from cold body and transferring it to a hot body at the expense of some external work, thus producing the cooling effect. The refrigerant produces this effect through expansion followed by condensation.

The Vapour Compression Refrigeration Cycle basically consists of 4 major components which are Compressor, Condenser, Expansion device and Evaporator. The Compressor isentropically compresses the low pressure and temperature refrigerant to the high pressure and temperature according to the compression ratio, this refrigerant then passes through Condenser and ideally at constant pressure the temperature of refrigerant decreases, the low temperature and high pressure refrigerant then passes through expansion device where isenthalpic expansion takes place and last it passes through evaporator where ideally at constant pressure the temperature increases which then passes to compressor and thus the cycle completes as shown in figure 1.

A. ICE CANDY PLANT

The Ice Candy Plant works on the principle of VCR Cycle. It shows the concept of indirect cooling in which the brine solution is cooled first with the help of refrigerant and then this cold brine solution cools the specimen. We have used two capillary tubes of same length and different diameter to check the performance of the plant. We are using R-134a as refrigerant as it is eco-friendly, easily available.

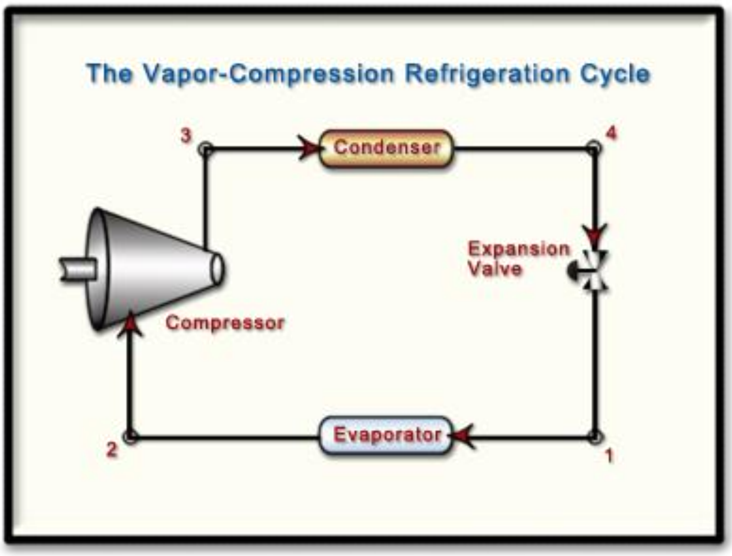

Fig. 1 Schematic diagram of vapour compression refrigeration cycle[1]

II. EXPERIMENTAL SETUP AND PROCEDURE

The experimental setup of the ice candy plant is shown in the figure 2. The refrigerant (R-134a) is compressed in a reciprocating compressor (THK1352YCF) and passes through the condenser () where the temperature drops, then refrigerant passes through filter (silicon gel) where all the foreign particles are filtered. Now this filtered refrigerant splits into 2 parts using a T section, one moves to the capillary tube of diameter 0.036 inch and other to capillary tube of diameter 0.044 inch, both the capillary tubes are of same length. 2 Hand operated Control valves (knob type) are used so that we can operate plant through a single capillary at a time. The refrigerant then expands in the capillary tube and passes through the evaporator coils (copper tubes, 5/16 inch, 33 feet). The copper coils are kept in Brine solution tank (24x21x21) inch which is of Thermocol thus having proper insulation. Inside the thermocol box a Tarpaulin is used so that there is no direct contact between brine and thermocol. The container kept in brine solution is used as specimen. A motor is kept in brine solution tank as an agitator such that the NaCl in brine solution doesn't settle down. The suction line of compressor is covered with sleeve for insulation purpose. Dial Pressure gauges (model LX4008B) are used at suction and discharge of compressor for measuring the pressure. Digital Temperature sensors (TPM-10) are used at 4 points (compressor's inlet and outlet, condenser's outlet and brine solution tank).

Fig. 2 Complete assembly of Ice Candy Plant

III. SAMPLE CALCULATION

The COP is calculated for both capillary tubes of same length and different diameter by assuming that the vapour is dry and saturated at the inlet of compressor, the compression process is isentropic and the expansion process is isenthalpic.

TABLE I
READINGS OF CAPILLARY TUBE HAVING DIAMETER OF 0.036 INCH

Suction Pressure	Discharge Pressure
1.58 bar	11.37 bar

A. RESULTS

Refrigeration Effect – 126.73 kJ/kg
Work done by compressor – 41.18 kJ/kg
Coefficient of performance – 3.07

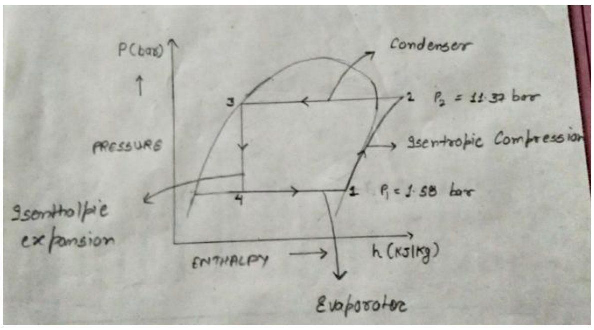

Fig. 3 P-h Chart of plant using capillary tube of diameter 0.036 inch

TABLE II
READINGS OF CAPILLARY TUBE HAVING DIAMETER OF 0.044 INCH

Suction Pressure	Discharge Pressure
2 bar	9.65 bar

B. RESULTS

Refrigeration Effect – 139.98 kJ/kg
Work done by compressor – 32.68 kJ/kg
Coefficient of performance – 4.26

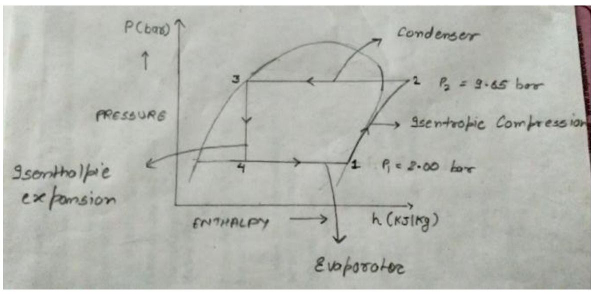

Fig. 4 P-h chart of plant using capillary tube of diameter 0.044 inch

We finally obtained that the COP of 0.044 inch diameter capillary is 4.26 which is more than the COP of 0.036 inch diameter capillary that is 3.07.

IV. CONCLUSION

We conclude that the larger diameter capillary tube is having more COP than small diameter capillary tube because of mainly 2 reasons, first that due to small diameter the friction is more which increases load on compressor and second that in tube of large diameter we are having additional expansion such that increased Refrigeration effect.

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