ISSN 2348 – 7968

Improvement inCOPof Refrigeration Tutor By Using Single Embossed Plate Coil Evaporator Over A Bonded Coil Evaporator

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Abstract

In this paper, coefficient of performance of conventional cooling system and different passage that is six passage and eight passage of single embossed plate coil evaporator for small water cooler are reviewed. Normally coil type evaporator is used. Bonded coil assembly have front area of coil coming in contact with tank after brazing is small compared with the total surface area of the coil and also there is indirect contact between water to be cooled and the evaporator coils. Due to this type of assembly most of the portion of the evaporator coil remains ineffectual. Plate coil exchanger has straight surface area connect between two fluids. The whole heat exchanger surface is dipped in one of the fluid so effective area of contact is total surface area.

Keywords:Bonded coil Evaporator, plate coil evaporator (PHE), Single embossed plate evaporator.

1. Introduction

Water cooler is a common example of refrigeration system observed in day to day life. The purpose of water cooler is to make water available at a constant temperature irrespective of ambient temperature. They are meant to produce cold water at about 7°C to 13°C. It has the primary function of cooling potable water and dispensing it to integral and/or remote areas, by means of a complete mechanical refrigeration system There are three types of water cooler such as storage type, bottler type and instantaneous type water cooler. Out of which storage type water cooler is most popular among all other types. Refrigeration system of water cooler consists of different components as followsHermetic compressors are commonly used for both 50 Hz AC applications. Compressors are similar to those used in household refrigerators. Forced air-cooled condensers are most commonly used. Capillary tubes are used almost exclusively for refrigerant flow control in hermetically sealed systems. This water cooler has the evaporator formed by refrigerant tubing bonded to the outside of a storage tank; such evaporator is called bonded coil evaporator. This bonded coil construction has very small effective surface area of evaporator. As coils used are of circular cross section, there is line contact or small area contact between coils and storage tank. Remaining area of the evaporator coils is covered with insulation and remains ineffectual, so effective surface area is very less compared with total surface area of the coil. This limitation of bonded coil evaporator can be overcome by replacing it with plate coil heat exchanger as an evaporator.Plate coil heat exchangers are relatively inexpensive and can be made into desired shapes and thicknesses for heat sinks and heat sources under varied operating conditions. Hence, they have been used in many industrial applications, such as cryogenics, chemicals, fibers, food, paints, pharmaceuticals, and solar absorbers The most commonly used materials for plate coils are carbon steel, stainless steel, titanium, nickel and its alloys, and Monel. The plate coil sheet metal gauges range between 1.5 and 3.0 mm (0.06 to 0.12 in.) depending on the materials used and whether or not the panels are single or double embossed.[1] Embossing pattern used for plate coil heat exchanger is of following types.[1]

2. Design Procedure

The design procedure followed in the tutor may follow for temperature difference (Temperature required) to be maintained in the evaporator or for water and flow rate of water. Refrigerant to be generally R 134a used Then capacity of small water cooler plant is calculated then capacity of compressor ,capacity of condenser and and capacity of evaporator is calculated. After deciding the capacities of all equipments, all the equipments are either designed at home industries or import from other industries . After assembling the machine, the machine is tested for performance check

3. Equipment Selection

A water cooler available in market consists of hermetically sealed compressor, air cooled condenser and capillary as expansion device. Thermostat is provided to control temperature of water. Separate inlet and outlet water connections are provided to storage tank. Water level is maintained with the help of float valve.

The hermetic compressor and air cooled condenser are mounted on the base plate of fabricated stand. The storage tank is insulated with heatlon sheet in order to reduce the heat transfer. All components such as compressor, condenser, evaporator and capillary are connected by copper tube. Copper tubes are joined by brazing. Then refrigerant is charged into the system. Outlet water tap and drain is provided on the front and back of the water cooler.

Thermocouples are provided at various points in order to measure temperature. Pressure gauges are used to measure the pressure on both sides of compressor. A separate control panel is provided for measurement of temperature, pressure and compressor power (with the help of energy meter). With the help of this facility calculation of COP can be performed.

TESTING SETUP

1 Digital temp Sensor of range -50 TO 99

2 Digital thermometer of range -50º c to 99 º c

3 pressure range :

Suction range 0-250psi

Discharge range 300-350psi

4. Experimental Testing

i. Water level in tank is at 40 liter is ensured.
ii. Hand operated valve for water supply is open is ensured.
iii. Hand operated valves H2 and H4 kept at open position and H1 and H3 at closed position for operating system with bonded coil evaporator.
iv. Power supply switched “ON”.
v. Initial reading of temperatures noted down.
vi. Set up run for about 1 hr till temperature drop for 17°C is observed.
vii. Faucet opened and flow of water adjusted to maintain temperature drop of 17°C.
viii. Set up is allowed to run for about 1 hr till temperature drop observed is stable.
ix. Temperatures at all points noted down.
x. Time required for 10 flashes in energy meter noted down.
xi. Time required for flow of 1 liter of water noted down.
xii. Condenser and evaporator pressure in pressure gauges noted down.

Procedure was repeated by operating system for dimpled evaporator. Hand operated valves H1 and H3 kept at open position and H2 and H4 at closed position for that purpose.

5. Performance Calculation: performance calculation of 40 li based small water cooler is shown. Work done and COP calculation for every configuration is shown with the result table and charts, and are shown below for all the configurations.

Calculations Procedure:

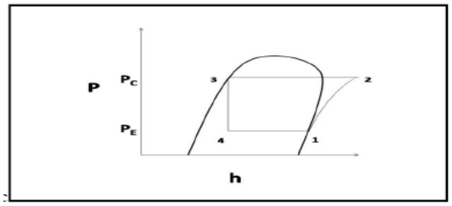
A). Carnot COP = $\frac{T_L}{(T_H - T_L)}$

Where TL= Lowest Temperature in cycle i.e. saturation Temperature Corresponds to evaporator pressure (°K),

TH= Highest Temperature in cycle i.e. saturation Temperature Corresponds to condenser pressure (°K)

B). Theoretical COP = $\frac{\text{TheoreticalRefrigeratingEffect}}{\text{TheoreticalCompressorWork}}$

Enthalpy values according to P-h Chart of refrigerant R134a Corresponding to pressure and temperature conditions of evaporator and condenser inlet and outlet.



p-h chart

$h_1 =$ kJ/kg,

$h_2 =$ kJ/kg,

$h_3 =$ kJ/kg,

$h_4 =$ kJ/kg,

Theoretical refrigerating effect = $(h_1 - h_4)$ kJ/kg

Theoretical Compressor Work = $(h_2 - h_1)$ kJ/kg

C). Actual COP = $\frac{\text{ActualRefrigeratingEffect}}{\text{ActualCompressorWork}}$

Actual Refrigerating Effect = mw × Cpw × (T5-T6) kW

$m_w = \frac{1}{t_w}\frac{kg}{s}$

Actual Compressor work = Energy supplied / Time

Actual Compressor work = $\frac{10}{N} \times \frac{3600}{t_{10}}$ kW

Where, N=Energy meter constant in rev/kW-hr.

N=3200 rev/kW-hr

ISSN 2348 – 7968

D). Relative COP = $\frac{\text{Actual COP}}{\text{Theoretical COP}}$

6. Result and discussion

Table no.1 Comparison of all result

CONVENTINAL BONDEDCOIL EVAPORATOR					
No. of Reading	Day	(COP) C	(COP) T	(COP)A	(COP)R
1	1 Day	5.3	3.8	1.77	0.466
2	2 Day	4.8	3.21	1.9	0.589
3	3 Day	4.7	3.44	1.78	0.52
4	4 Day	5.2	3.4	1.8	0.53
5	5 Day	4.9	3.75	1.73	0.47
SIX PASSAGE SINGLE EMBOSSED PLATE EVAPORATOR					
No. of Reading	Day	(COP) C	(COP) T	(COP)A	(COP)R
1	1 Day	5.36	4.8	0.51	0.106
2	2 Day	5.07	3.23	0.521	0.161
3	3 Day	4.9	4.03	0.517	0.128
4	4 Day	5	3.1	0.54	0.174
5	5 Day	5	3.72	0.52	0.139
EIGHT PASSAGE SINGLE EMBOSSED PLATE EVAPORATOR					
No. of Reading	Day	(COP) C	(COP) T	(COP)A	(COP)R
1	1 Day	5.11	3.4	2.181	0.641
2	2 Day	4.9	3.49	2.151	0.616
3	3 Day	4.8	3.2	2.54	0.795
4	4 Day	4.95	3.6	2.44	0.678
5	5 Day	4.84	3.32	2.4	0.725

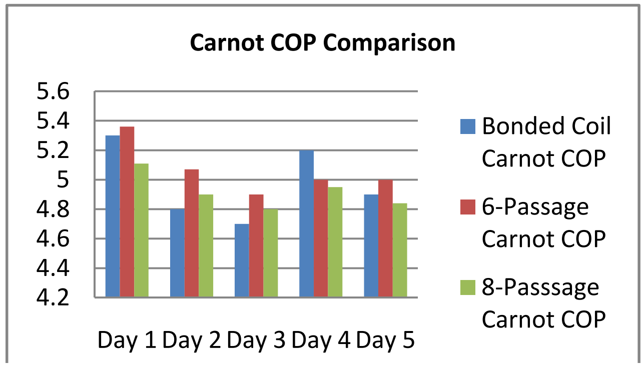


Fig.1Carnot COP Comparison Chart

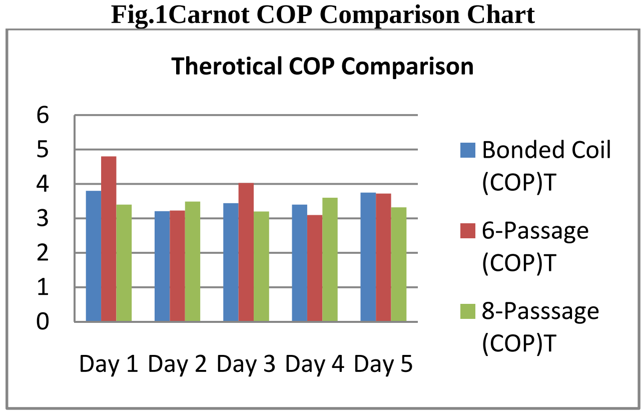


Fig.2 Theoretical COP Comparison Chart

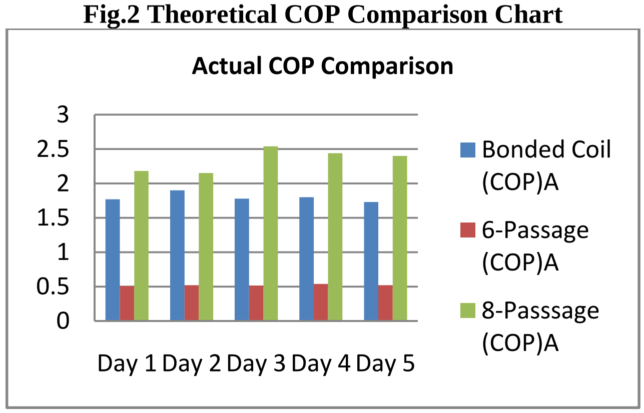


Fig.3 Actual COP Comparison Chart

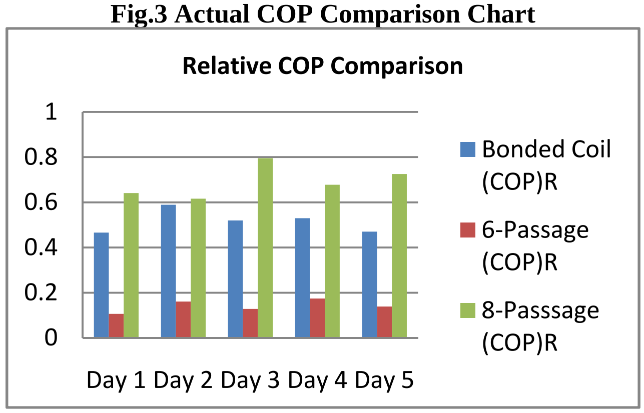


Fig.4 Relative COP Comparison Chart

ISSN 2348 – 7968

From above result as Carnot COP of bonded coil and single embossed six passages plate evaporator is same but as increasing passages like from six to eight passage plate evaporator Carnot COP decreases but in Theoretical COP we seen that COP increases from bonded coil to single embossed six passages evaporator and decrease from six passages dimpled plate evaporator to single embossed eight passages plate evaporator because increase of theoretical compressor work in eight passages plate evaporator. Actual COP of the system observed was very poor. As there is very small rise in temperature of refrigerant leaving the evaporator, refrigerant may not following expected flow path. It may be due to width of the passage formed was large so small portion of refrigerant coming in contact with evaporator surface and refrigerant was leaving evaporator in just dry saturated state. To increase refrigerating effect, it was decided to narrowing the width of the passages. As width of passages going to reduce, number of passages for given width of the plate were going to increase, increasing length of the path followed by the refrigerant.

4. Conclusions

1) System operating with eight passages evaporator outperforms both bonded coil evaporator and six passages evaporator.
2) Evaporator having eight passages was more effective due to increased length of path for the refrigerant. It was causing effective utilization of surface area and increasing time for which refrigerant was in the evaporator.
3) Refrigerating effect was increased by 17.61% for eight passages evaporator with relatively less increase in compressor work (5.8%). It was observed that COP improved from 1.76 to 1.95.

References

[1] R. K. Shah, D. P. Sekulic, “Fundamentals of Heat Exchanger Design,” John Wiley & Sons, Inc. 2003.
[2] Transfer The Heat Transfer People, Texas, brochure
[3] T. Kuppan, “Heat Exchanger Design Handbook,” CRC Press, 2000.
[4] ASHRAE Refrigeration Handbook, 1994, Chapter 49, pp.49.1-5.Plate Coil prime surfaces, Sweden, brochure

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