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Experimental and Theoritical Analysis of Roll Bond Evaporator as Air Conditioner

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Abstract: Aluminium Roll-Bond evaporators provide unique design flexibility for direct cooling refrigeration systems. Roll-Bond evaporators deliver efficient thermal performance in a product that can be shaped to fit most applications. If your product requires a simple flat panel or a multi-shaped evaporator.Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more comfortable conditions, typically with the aim of distributing the conditioned air to an occupied space to improve thermal comfort and indoor air quality. Roll Bond Evaporator if used as the internal unit of Air Conditioning System can economise the unit to a High Extent, as the cost of the system would decrease to more than 50% of the present cost. Initially when the system incorporated the CAPILLARY tube as the expansion device there was a sudden pressure drop, which led the system trip off as it was unable create the pressure build up. Followed by which, a automatically operated Expansion Valve was brazed to the unit for the same and could improvise the problem to an extent. But the Area of condensation over the length being unspecific did not show appropriate cooling over the surface. Freezing effect being seen on the surface which decreased the efficiency of the unit.The Execution was modified by replacing the Expansion valve with the Manually Operated NEEDLE VALVE. The appropriate pressure build up over the condensation length could be a certain temperature over the length of Evaporator tubes. The suction pressure being 9.5 Kg/sqcm and the discharge pressure being 11.75 kg/sqcm, the freezing effect was being seen over the evaporator length, which was the desired effect by the unit. The effect of the Air conditioning unit was observed by a virtual enclosure made by thermocol and the Air condition being run, the cooling effect could be directly felt. The readings seen and measured by the thermocouple did show a variation of about 4-5 Degrees centigrade.

Keywords: Roll-Bond evaporators, Caplillary, Needlevalve, cooling effect, freezing effect.,R-22,

I. INTRODUCTION

The basic concept behind air conditioning is said to have been applied in ancient Egypt,where reeds were hung in windows and were moistened with trickling water. The evaporation of water cooled the air blowing through the window. This process also made the air more humid, which can be beneficial in a dry desert climate. In Ancient Rome, water from aqueducts was circulated through the walls of certain houses to cool them. Other techniques in medieval Persia involved the use of cisterns and wind towers to cool buildings during the hot season. Modern air conditioning emerged from advances in chemistry during the 19th century, and the first large-scale electrical air conditioning was invented and used in 1902by American inventor Willis Carrier. The introduction of residential air conditioning in the 1920s helped enable the great migration to the Sun Belt in the United States. The 2nd-century Chinese inventor Ding Huan (fl 180) of the Han Dynasty invented a rotary fan for air conditioning, with sevenwheels 3 m (9.8 ft) in diameter and manually powered. In 747, Emperor Xuanzong (r. 712–762) of the Tang Dynasty (618–907) had the Cool Hall (Liang Tian) built in the imperial palace, which the Tang Yulin describes as having water-powered fan wheels for air conditioning as well as rising jet streams of water from fountains. During the subsequent Song Dynasty (960–1279), written sources mentioned the air conditioning rotary fan as even more widely used In 1758, Benjamin Franklin and John Hadley, a chemistry professor at Cambridge University, conducted an experiment to explore the principle of evaporation as a means to rapidly cool an object. Franklin and Hadley confirmed that evaporation of highly volatile liquids (such as alcohol and ether) could be used to drive down the temperature of an object past the freezing point of water. They conducted their experiment with the bulb of a mercury thermometer as their object and with a bellows used to speed-up the evaporation. They lowered the temperature of the thermometer bulb down to −14 °C (7 °F) while the ambient temperature was 18 °C (64 °F). Franklin noted that, soon after they passed the freezing point of water 0 °C (32 °F), a thin film of ice formed on the surface of the thermometer's bulb and that the ice mass was about a quarter-inch thick when they stopped the experiment upon reaching −14 °C (7 °F). Franklin concluded: "From this experiment one may see the possibility of freezing a man to death on a warm summer's day"

II. ROLL BOND EVAPORATOR

Aluminium Roll-Bond evaporators provide unique design flexibility for direct cooling refrigeration systems. Roll-Bond evaporators deliver efficient thermal performance in a product that can be shaped to fit most applications. Whether your product requires a simple flat panel or a multi-shaped evaporator.

Manufacturing Process

Process for roll-bond evaporator:

- preparing materials
- Plates inputting
- Washing & cleaning
- Brushing
- Plates Overlapping-
- annealing
- inflating/blowing up
- Shearing/pressing/punching
- folding and sharpening
- adding the capillary
- assemble welding
- leakage testing
- cleaning and drying coating
- inspection

Preparing materials:

Surface treatment for roll-bond evaporator: No treatment or Powder coating;White or Black; Oxidizing. The roll-bond evaporator can be with Copper- Aluminium tube, can be with capillary, or can be without tube.Structure: Double side roll-bond evaporator, Single side evaporator; Part single side roll bond evaporator. The buyer need to tell us the dimension, thickness, with/without tube or capillary, surface treatment, purchased quantity, and then we`ll offer you the best competitive price and quality roll bond evaporator.

Material for Roll-bond Evaporator:

The brand code of Aluminium material we used to make roll bond evaporator is Aluminium / Aluminium 1060 alloy. In this article, you can know about Aluminium / Aluminium 1060 alloy, which we are using.Aluminium / Aluminium alloys are known for their strong corrosion resistance characteristics. These alloys are sensitive to high temperatures and experience an increase in strength at subzero temperatures. Aluminium / Aluminium alloys are good low-temperature alloys.Aluminium / Aluminium 1060 alloy is a low strength and pure Aluminium / Aluminium alloy with good corrosion resistance characteristic. The following datasheet provides an overview of Aluminium / Aluminium 1060 alloy.

III. FABRICATION AND HEAT TREATMENT HARDENING

Aluminium / Aluminium 1060 alloy can be hardened only from cold working. Tempers H18, H16, H14 and H12 are determined based on the amount of cold working imparted to this alloy.

Annealing

Aluminium / Aluminium 1060 alloy can be annealed at 343°C (650°F) and then cooled in air.

Cold Working

Aluminium / Aluminium 1060 has excellent cold working characteristics and conventional methods are used to readily cold work this alloy.

Welding

Standard commercial methods can be used for Aluminium / Aluminium 1060 alloy. The filter rod used in this welding process whenever needed should be of AL 1060. Good results can be obtained from the resistance welding process performed on this alloy through trial and error experimentation.

Forging

Aluminium / Aluminium 1060 alloy can be forged between 510 to 371°C (950 to 700°F).

Forming

Aluminium / Aluminium 1060 alloy can be formed in an excellent manner by hot or cold working with commercial techniques.

Machinability

Aluminium / Aluminium 1060 alloy is rated with fair to poor machinability, especially in the soft temper conditions. The machinability is much improved in the harder (cold worked) tempers. Usage of lubricants and either high-speed steel tooling or carbide are recommended for this alloy. Some of the cutting for this alloy can also be done dry.

Heat Treatment

Aluminium / Aluminium 1060 alloy does not harden by heat treatment and it can be annealed after the cold working process.

Hot Working

Aluminium / Aluminium 1060 alloy can be hot worked between 482 and 260°C (900 and 500°F).

Cooling Refrigerants

Refrigerants are what make air conditioning possible. Contained within the coils of an air conditioner, these liquid agents cool and dehumidify indoor air. For years, the most common refrigerant used in air-conditioning systems was R-22 (Freon).

Today, in response to growing environmental concerns, production of systems using R-22 refrigerant is being phased out. Meanwhile, Lennox is leading the industry in introducing systems that use an environmentally friendly alternative to R-22.

R-22.The old standard.

Acting in accordance with an international treaty called the Montreal Protocol, the U.S. Environmental Protection Agency (EPA) has mandated the phaseout of R-22 through the Clean Air Act. As of 2010, the manufacture of systems using R-22 refrigerant will be prohibited, and by 2020 the production of R-22 itself must cease.The main reason for this regulatory action is that R-22 is a hydrochlorofluorocarbon (HCFC) compound, which contains ozone-depleting chlorine.

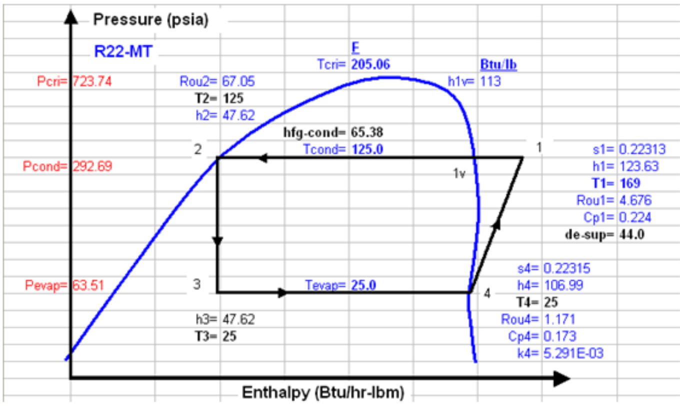

Fig.1 :Psycrometric chart

IV. COMPONENTS

COMPRESSOR

Compresses the refrigerant from a low temperature, low pressure gas to a high temperature, high-pressure gas.

CONDENSER

Is actually a radiator in which the refrigerant condenses from a gas to a liquid form as it is cooled.

ORIFICE TUBE / EXPANSION VALVE

Regulates the liquid refrigerant going into the bottom of the evaporator. Actually acts as a restrictor to the flow of the liquid refrigerant.

EVAPORATOR

This is where the refrigerant evaporates from a liquid form back into a gaseous form. As the refrigerant evaporates it gets very cold and allows the cars interior to be cooled off.

ACCUMULATOR / DRIER

A storage tank and filter for the R22. Its main purpose is to remove moisture from the refrigerant.

REFRIGERANT

More commonly known as R22 is the liquid or gas which passes through all the other components in the A/C System.

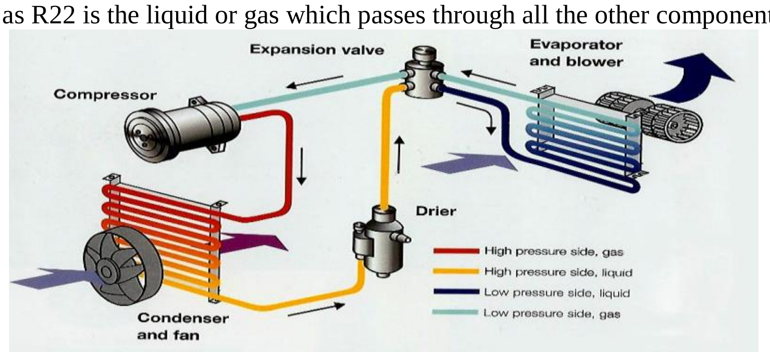

Fig.2: Block diagram for airconditioning

Observation Values:

Suction Pressure: 1 kg/sqcm to 1.5 kg/sqcm

Discharge Pressure: 9.5 kg/sqcm to 11 kg/sqcm

Table-I: Observation made with the THERMAL EXPANSION VALVE used as the Expansion device, at the time intervals of one hour.

	T1	T2	T3
Receiver Gas	23.1	21.4	22.6
Discharge Gas	69.4	114.0	127.0
Liquid Line	26.3	27.0	27.6
Shell Top	66.7	95.9	118.2

Shell Bottom	70.6	90.3	88.0
Evaporator Entry	17.4	13.6	12.2
Evaporator Exit	22	18.6	21.6
Plate	20.5	16.1	17.4
Ambient	23.8	22.3	23.8
Ambient	25.9	25.7	26.1
Ambient	26.8	27.8	28.2

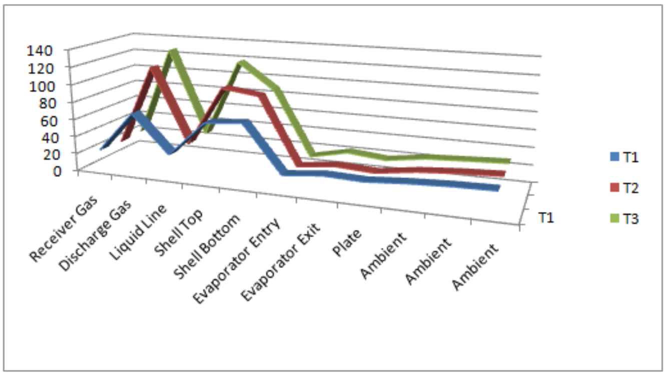

Fig.3: Graphical representation of temperature at different point of evaporator

SPECIFICATION:

AMBIENT TEMPERATURE: 32°C i.e 273+32 = 305 K

COOLANT USED : R22

CRITICAL TEMPERATURE : 98°C

EVAPORATOR USED : FLAT SURFACE EVAPORATOR

HEAT FLOW

- AMBIENT TEMPERATURE (Ta) : 305 K
- HEAT TRANFER (Q) : hA(Tf –Ta)
- $Tf= \frac{Tw+Ta}{2}$
- Tw=wall temperature
- Tw=10°C
- $Tf=\frac{10+32}{2}$

Tf=21°C

$hconvection = \frac{2k}{\delta x}$

Heat Flow through Condutction (QConduction) :

$Q = \frac{\Delta T}{R}$; $R = \frac{L}{KA}$

$$\delta x = 3.93 x Pr^{-0.5} (0.952 + 1\,Pr)^{0.25} Gr^{-0.25}$$

- Gr = Grashaff's Number
- $Gr = \frac{g.\beta.x^3.\Delta T}{v^2}$
- g= Gravitational Constant
- x=1mm.
- ΔT=32-10 = 22°C i.e. 295 K
- $\beta=\frac{1}{Tf}$

Properties:

- Density (ρ) =2707 kg/m^3.
- Thermal Diffusivity (α) = $\frac{k}{\rho c}$ =$84.18 * 10^{-6}$ m^2/sec
- Specific Heat (c) =896j/kgk.
- Thermal Conductivity (k) =204.2W/mk.

For Convection Fluid is Air.

Properties of air:-

- Density (ρ) =1.1576kg/m^3.

- Abolute Viscosity (μ) $=18.728 * 10^{-6}\ \mathrm{Ns/m^2}$
- Kinetic Vescosity (ν) $=16.192 * 10^{-6}\ \mathrm{m^2/sec.}$
- Thermal Diffusivity (α) $=23.15 * 10^{6}\ \mathrm{m^2/sec.}$
- Prandtl Number = 0.7006.
- Specific Heat (c) $= 1005\ \mathrm{j/kgk.}$
- Thermal Conductivity (k) $=0.02691\mathrm{W/mk.}$

$\beta=\frac{1}{Tf}=\frac{1}{(21+273)}=3.4 * 10^{-3}\mathrm{k}^{-1}$

- ν $= 16.192 * 10^{-6}\ \mathrm{m^2/sec.}$
- x =1mm.
- ΔT =295 K.
- g $= 9.810\ \mathrm{m/sec^2}.$

$Gr = \frac{g.\beta.x^3.\Delta T}{\nu^2} = \frac{9.81*3.4*10^{-3}*(0.001)*295}{(16.192*10^{-6})^2}$

$=\frac{0.00983943}{262.1808*10^{-12}}$

- Gr= $3.7529 * 10^{7}$
- Pr= 0.700
- $\delta x=3.93 * (0.1)(0.7006^{-0.5})(0.952 + \mathrm{Pr})^{0.25}\mathrm{Gr}^{-0.25}$
  $=0.469521 * 101338 * (3.7529 * 10^{7})^{-0.25}$
  $= 0.5323 * 0.01277$

δx=0.0068008m.

- hconvection $=\frac{2k}{\delta x}=\frac{2*0.02691}{0.0068008}$
- hconvection = $7.91377\ \mathrm{w/m^2\ k}$
- Q = hA(Tf-Ta) ;A = 100*2
  ; = $2000\boldsymbol{cm^2}$
- Q= 449.502 w.

Heat Transfer through convection:
Q= 449.502 w.
Number of Plates Used = 4.

- Q = 4 * 449.5 = 1798 w

Heat Transfer through conduction:

$Q =\frac{\Delta T}{R}$; $R = \frac{L}{KA}$

$R = \frac{33000}{\left(0.5+\frac{\pi}{4}\right)*204.2}$

R= $125.72\ \mathrm{w/m^2k}$

$Q = \frac{\Delta T}{125.72}$

$Q = \frac{295}{125.72} * 4$ plates

Q = 9.385 W

Therefore TOTAL HEAT FLOW is

- Qconvection + Qconduction
- Q = 9.385 + 1798
- Qtotal = 1807.385 W

V. CONCLUSION

- Strong air-circulation makes rapid heat-transfer from heater to Aluminium coil, providing fast heating.
- The thermal analysis in air conditioner completely based on specification of the room and it also depend upon on appliances like light, fan, thermal equipments, no of persons in the room. And we also did the analysis of filtration.
- First we employed capillary tube and observed for 5 to 6 hours, the return gas which is coming to the compressor is not properly functioned.
- Now the capillary tube is replaced by thermal expansion valve and we noticed no change and the return gas is not going to the compressor again
- Now we employed manually operated expansion valve , and noticed that the return gas is moving to compressor in return at suction pressure 1.75kg/sqcm and discharge pressure at 11.5kg/sqcm.
- Thus the practical results are not upto the mark when compared to the theoretical results.
- On considering the practical results, the convection heat transfer is determined on the plates using ANSYS.
- The heat flow is also determined using ANSYS for the obtained results
- The directional heat flow is also determined.

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