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# Design Methodologies of air-conditioner cum water dispenser

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## Abstract

*Design of Air-conditioner cum water dispenser utilized as a Novel Air-conditioning system Now a days. Today market conditions demands utility of air-conditioner. This paper delivered the design contributions for evaporator, condenser and capillary tube. Based on conventional methodologies the design calculation were done. Further the paper discusses the designed methods which are suitable for combined conventional air-conditioning and dispenser.*

**Keywords:** Dispenser ,evaporator, condenser, capillary tube .

## Introduction

Refrigeration systems are also for providing cooling and dehumidification in summer for air conditioning. The working principle and basic features air conditioning along with water dispensers (heater and cooler) systems are introduced in this paper. The air conditioner along with water dispenser system can operate in various modes [1]. Water heating, water cooling, space cooling, space, heating, etc. The first air conditioning were used for industrial comfort air conditioning

In this paper we have designed the three main parts i.e. condenser, evaporator and throttle valve. In early 1980s,large size of heat pump and air conditioner are created . But they are of heavy size and not easy to transport. So technologist concentrate to create a model which is portable and easy to move and compact size. Over 10000 units of this air to water heat pumps for homes were sold every year in US [2].Air conditioning units with an integral hot storage tank and immersed condenser using ambient air as a heat source. [3]According to the Air-Conditioning and Refrigeration Institute (ARI), 81% of all new homes constructed were equipped with central air-conditioning in 1996 [5] These early models were suffered from high purchase prices, high maintenance costs, noisy, poor, longevity a limited installation options. To overcome all these problems we offer an air conditioner coupled with heat pump water heater system which can act as air conditioner and water heater with the main components such as heat exchanger, compressor, and valves. The air to water heat pumps water heater offers an energy saving alternatives. Heat pump water heater can provide hot water two to three times more energy efficient than electric resistance heater. So the primary cost will be reduced and it can realize multifunction easily. Here we can demonstrate an air conditioning water heater (ACWH) and the performance analysis

## 1.1 Description of vapor compression cycle for air-conditioner cum dispenser

The following is a list of parameters that are to be measured or determined during the testing process which will be used to verify the operation of the prototype and validate the original base design. The parameters are based on the system diagram shown in Figure 1.

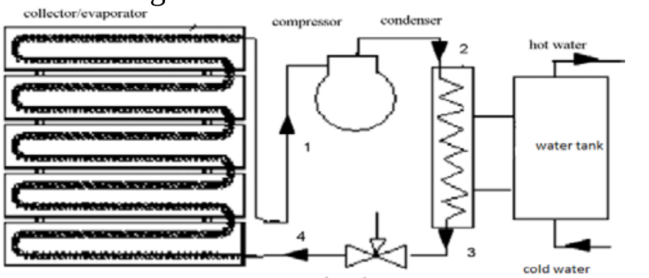


Fig 1.1 -Schematic diagram of vapor compression system

Various mode are operated for air conditioner cum dispenser. While different parameters were considered before the design calculations. The parameters water temperature entering and exit of the condenser. Another includes evaporator temperature at entry and exit of refrigerant. The refrigerant condition of evaporator, condenser and compressor were calculated to understand the requirement of air conditioner cum dispenser.

## 2. Design calculation for condenser & evaporator

### 2.1 Design steps for Condenser

1. The heat transfer rate for condenser is obtained from

$$\dot{Q}_h = \dot{m}(h_2 - h'_4)$$

[2.1.1]

2. $\Delta T$ rise of condensing temperature the increase power is found to be

$$\delta P = TR.\delta p'\Delta T/\eta$$

[2.1.2]

Let the temperature rise of water is $\Delta T_w$ and $\dot{Q}$ is the heat transfer from condenser per ton-h of refrigeration. Then, for $\dot{m}_w$ water flow rate we get

$$\dot{m}_w = TR\dot{Q}/(\Delta T_w C_p)$$

[2.1.3]

Where $\Delta T_w = T_e - T_1$ is the temperature rise of cooling water

Further, it is assumed that $\Delta T_a$ is the temperature approach and $T_h$ is the condencing temperature of the simple refrigeration cycle. The temperature of water leaving the condenser is given to be:

$$T_e = T_h - \Delta T_a$$

[2.1.4]

Differentiation of equation with respect to T for given parameters and simplification

$$\Delta T_0 = \left(\frac{\dot{Q}.Cw}{c}\frac{\eta}{Cp\ \delta\ P1000}\right)^{1/2} + \Delta T_a$$

[2.1.5]

$$= 0.01545[(\dot{Q}/\delta P).(Cw/C)\eta]1/2 + \Delta T$$

And the optimum condensing temperature is then:

$$T_{ho} = T_1 + \Delta T_0 = T_1 + 0.01545\left(\frac{\dot{Q}.C_w.\eta}{\delta P.c}\right)^{\frac{1}{2}} + \Delta T_a$$

[2.1.6]

Where,

$C_1$ = Electric charge Rs/kwh

$C_w$ =water charge Rs/m$^3$

$r$ =compression ratio

$T_h$ =condensing temperature (k)

$T_i$ =water temperature at inlet (k)

The economical water velocity is another important aspect in the design of condenser.The heat transfer coefficient can be express as:

$$h = C'C_v^{\ m}$$

[2.1.7]

Where $C'$ is a constant for a given configuration and fluid.The head loss as a result of fluid flow in a pipe is given by:

$$h_f = \frac{fL_pC_v^{\ 2}}{2d} = C''C_v^{\ 2-n}$$

[2.1.8]

Laminar pipe flow $C''$=64.0, n=1 and

Turbulent pipe flow $C''$=0.316, n=0.25

If $C_1$ is the saving in Rs. [rupees] per unit heat transfer coefficient and $C_2$the amount spent per unit head loss, the net saving can be found from:

$$C = C_1C'C_v^{\ m} - C2C''C_v^{\ 2-n}$$

[2.1.9]

The differtiationof [12.17] with respect toCv and equating the resulting quantity to zero yields

$$C_v = \left[\left(\frac{C_1}{C_2}\right)\left(\frac{C'}{C''}\right)\left(\frac{m}{2-n}\right)\right]^{\frac{1}{2-n-m}}$$

[2.1.10]

In particular for turbulent flow the heat transfer coefficient for straight pipe is given by

$$h = 0.023(k/d)(\rho d/\mu)^{0.8}P_r^{\ 0.4}C_v^{\ 0.8}$$

[2.1.11]

Where$P_r$, is the prandtlnumber

$$H_f = \frac{0.316\mu^{0.25}\rho^{0.75}LC_v^{\ 1.75}}{(2d^{1.25})}\ W$$

[2.1.12]

### 2.2 Design steps of Evaporator

An evaporator should transfer enough heat from as small size as possible the liquid should not leave the evaporator in order to prevent the wet compression the liquid supply to evaporator should be easy the size arrangement of the pipe should be so adjusted as to cause easy oil return to the compressor crank case the corrosion and fouling of the inside and outside surface should be minimum .it should be light compact, safe and durable. The loss should be as low as possible.

There are many types of evaporators employed in the refrigerator and air conditioning system in these case we use the design procedure of fin and tube-evaporator.

Enthalpy of the refrigerant can be obtained from the saturated table. The refrigerant flow rate through the system is found from:

$$\dot{m} = \frac{\dot{Q}_D}{q_c} = \frac{\dot{Q}_D}{(h_1 - h'_4)} \quad [2.2.1]$$

The diameter of tube can calculate by:

$$t = pd/(2f) \quad [2.2.2]$$

Where $p, d, f$ are maximum pressure, diameter of pipe and hoop stress respectively

Therefore to compare wall thickness of the tube, we can use Lame's Equation:

$$t = 0.5d[(f+p)/(f-p)]^{0.5} - 0.5d \quad [2.2.3]$$

The evaporator is tested under pressure for leak and strength. Pipes must withstand the recommended pressure. Some allowances are made for corrosion, threading, mechanical and other defects and thus empirical equation can be used to determine the minimum pipe thickness:

$$t_m = \frac{pd}{2f + 0.8p} + c \quad [2.2.4]$$

In case of threaded steel, wrought iron or nonferrous pipe one can take about 1.5mm up to 9mm diameter pipe. And in case of nonferrous pipe with plain end zero allowance is made.

Surface area of the evaporator is obtained from

$$A = \dot{Q}_D/\Delta T(U) \quad [2.2.5]$$

Here$\Delta T$, the logs mean temperature difference

Magnitude of $T_1$and $T_2$ can be decided from the amount of fluid flowing over the coil i.e.

$$Q_D = \dot{m_f}\, C_p\, \Delta T \quad [2.2.6]$$

Where $\dot{m}_f$ is the mass of fluid flowing over the coil and $C_p$ the specific heat. It is evident that for a given $Q_D$ the higher the mass flow rate, the lower would be the temperature difference. For a larger mass flow rate, a big blower or pumping mechanism is needed. As such $\Delta T = T_1 - T_2$ should be selected in order to have minimum overall cost

Length of pipe:

$$L_p = A/(\pi d) \quad [2.2.8]$$

If length of each pipe of the evaporator is assumed to be$l_p$ the number of tube is found to be:

$$n_p = \frac{L_p}{l_p} \quad [2.2.9]$$

**2.3 Design calculation of evaporator-**

Enthalpy of the refrigerant can be obtained from the saturated table. The refrigerant flow rate through the system is found from:

$$\dot{m} = \frac{\dot{Q}_D}{q_c} = \frac{\dot{Q}_D}{(h_1 - h'_4)} \quad [2.3.1]$$

$$= \frac{81.5}{250 - 87} = 0.5$$

The wall thickness tube can calculate by:

$$t = pd/(2f) \quad [2.3.2]$$

$$= \frac{250 \times 0.0689 \times 9.525 \times 10^{-3}}{2 \times 57.42}$$

$$t = 2 \times 10^{-3} m = 2mm$$

Where $p, d, f$ are maximum pressure, diameter of pipe and hoop stress respectively

Therefore to compare wall thickness of the tube, we can use Lame's Equation:

$$t = 0.5d[(f+p)/(f-p)]^{0.5} - 0.5d \quad [2.3.3]$$

$$= 0.5 \times 9.525 \times 10^{-3} \left(\frac{57.42 + 250 \times 0.0689}{57.42 - 250 \times 0.0689}\right)^{0.5} - 0.5 \times 9.525 \times 10^{-3}$$

$$t = 1.728 \times 10^{-3} m$$

Therefore our design is safe

The evaporator is tested under pressure for leak and strength. Pipes must withstand the recommended pressure. Some allowances are made for corrosion, threading, mechanical and other defects and thus empirical equation can be used to determine the minimum pipe thickness:

$$t_m = \frac{pd}{2f + 0.8p} + c \quad [2.3.4]$$

$$= \frac{250 \times 0.0689 \times 9.525 \times 10^{-3}}{2 \times 57.42 + 0.8 \times 250 \times 0.0689} + 2.25 \times 10^{-4}$$

$$t_m = 1.5 \times 10^{-3} m$$

In case of threaded steel, wrought iron or nonferrous pipe one can take about 1.5mm up to

9mm diameter pipe. And in case of nonferrous pipe with plain end zero allowance is made.

$$Q_D = \dot{m}_f \; C_p \; \Delta T \qquad [2.3.5]$$

$$81.5 = 0.5 \times 0.057 \times 1000 \times \Delta T$$

$$\Delta T = 2.86^0 C$$

Where $\dot{m}_f$ is the mass of fluid flowing over the coil and $C_p$ the specific heat of refrigerant. It is evident that for a given $Q_D$ the higher the mass flow rate, the lower would be the temperature difference. For a larger mass flow rate, a big blower or pumping mechanism is needed. As such $\Delta T = T_1 - T_2$ should be selected.

### 2.4 Design steps of Capillary tube

It is a copper tube of small internal diameter and of varying length depending upon the application .The inside diameter of the tube used in refrigeration work is generally about 0.5mm to 2.25mm and the length varies from 0.5 m to 5 m.

As F = L/D

As frictional resistance is directly proportional to length and inversely proportional to diameter .Therefore longer the capillary tube and smaller its inside diameter and greater pressure difference between condenser and evaporator.

Fig 2.1-capillary tube design

Some design specification which is applicable for design calculation are given in following table.

## 3.Design Specification of air-conditioner cum water dispenser

| Sr.No | Name of component | Design specification |
|---|---|---|
| 1 | Compressor | Capacity-1.5 tones Mass flow rate-0.5 kg/min |
| 2 | Condenser | Coil length-96 feet, Pipe size-3/8 inch. Number of turns-48 |
| 3 | Evaporator | Coil length-54 feet Number of turns-27 |
| 4 | Double pole main power switch | Capacity-240 Volt, 32 Ampere |
| 5 | Fan motor | RPM-920, 230 volt Capacitor-3MFD |
| 6 | Capillary tube | Diameter-0.055 inch Length-22 inch |
| 7 | Pressure gauges | Range-0-500 PSI |
| 8 | Ammeter & Voltmeter | 0-30 Ampere & 0-300 Volt |

## 4. Conclusion

In this way the design calculation were performed to obtained novel air-conditioner cum dispenser system. The overall compression with an air conditioning system alone nearly same efforts were required to obtained the combination of dispenser. This work also suggest put efforts to understand material and size of condenser. Additionally the temperature difference between the condensing medium & vapor refrigerant. Finally evaporator, condenser and capillary tube were designed so as to run on both cycle that water and air.

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