JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

PERFORMANCE CALCULATIONS OF THREE IN ONE AIR CONDITIONER

[1]K C Mahendra,[2] Channaveera Swamy J M,[3]Javeed S,[4]Pavan Kumar B K, [5]Prince Kumar Singh, [6]Raghavendra M

[1]Assistant Professor, [2]Technical Staff, [3-5]UG Students
[1]Department of Mechanical Engineering,
[1]RYM Engineering College, Ballari, Karnataka, India

Abstract: In the realm of mechanical engineering, the driving force is encapsulated by the term "CHANGE." This concept is at the core of our new project, a pioneering foray into the domain of air temperature regulation, closely intertwined with human comfort. In the pursuit of accommodating both technological breakthroughs and the evolving needs of individuals, our project has emerged as a response. Our venture is centered on the fusion of air temperature management and human comfort, addressing the dichotomy between extreme heat and cold. The crux of our innovation lies in the manipulation of water cooler output to effectively modulate the ambient air's temperature. By amalgamating a cooling system within a singular unit, we propose a revolutionary solution that promises to usher in economic practicality while offering comfort-enhancing conditions universally. This project reflects our dedication to transforming the conventional paradigms of temperature control and advancing the synergy between technology and human well-being.

***Index Terms* – Piston, Reciprocating Compressor, Design, Specification, Performance characteristics.**

I. INTRODUCTION

The pursuit of "Faster, mightier & smaller" continues to underscore every innovation and advancement. In our daily lives, our focus remains on optimizing efficiency and compactness in products. In alignment with this ethos, we have conceptualized and manufactured an affordable and dependable creation called the "Water Cum Room Cooler." As the axiom goes, "Human comfort finds expression in the thermal environment of the mind." In our project, we've harnessed the competing attributes of chilled water and cool air. This integrated system is engineered for continuous usage. The innovation we've devised negates the necessity for separate air conditioners, air coolers, and water coolers. By consolidating these functionalities within a single unit, we've significantly mitigated costs. The Imperative for Air Conditioning Human bodies emit approximately 100 kcal of heat per person per hour. Analogous to an engine, our bodies consume sustenance, perform tasks, and radiate heat. The energy we expend generates heat, which in turn is released into the environment.

Consequently, human activity generates substantial heat within enclosed spaces, leading to temperature elevation and the creation of discomfort. This buildup of heat, sourced from various outlets, escalates indoor temperatures and spawns an inhospitable atmosphere. Elevated temperatures, coupled with potentially high relative humidity, culminate in a distressing indoor environment. Hence, our undertaking endeavors to alleviate these challenges and improve the comfort and well-being of occupants by seamlessly integrating the roles of temperature and humidity control within a singular, user-friendly framework.

II. LITERATURE SURVEY

J R Sand et al. [1997]: This abstract discusses the environmental impact of hydro fluorocarbons (HFCs) and their alternatives in refrigeration and insulation. It introduces the Total Equivalent Warming Impact (TEWI) assessment, which considers both direct and indirect effects on global warming. The goal of TEWI is to evaluate the overall impact of gases released into the atmosphere, including CO_2 emissions from energy use. Various alternative chemicals and technologies are proposed, such as hydrocarbon (HC) refrigerants, CO_2, ammonia (NH3) systems, absorption cycles, and evacuated panel insulations, all aiming to reduce environmental harm. The paper summarizes key findings from the TEWI-III study.

Raut A S et al. [2011]: In this paper, we examine the retrofitting of refrigeration appliances through the utilization of capillary tubes. Altering the refrigerant in an established system has a direct impact on its COP (Coefficient of Performance). To address this, it becomes imperative to make adjustments and retrofit the existing system. Modifying the design of the compressor can be a complex and costly endeavor. Therefore, we advocate for modifications in the dimensions of the capillary tube as a more practical solution to restore and optimize system performance.

Raman Kumar Singh et al. [2015]: The field of mechanical engineering, driven by technological advancements and people's needs, inspired our maiden project in air temperature control and human comfort. We've innovated by creating a cost-effective "Water Cum Room Cooler," combining cooling systems for versatility. Our focus: "Faster, mightier & smaller" solutions for compact and efficient products. This three-in-one air conditioner ensures comfort by addressing hot and cold environments, recognizing that human comfort is deeply tied to the thermalenvironment.

Akintunde et al. [2007]: This study investigated the impact of capillary tube geometries on refrigeration system performance, focusing on coil pitch. While prior research mainly considered coil diameters and lengths, serpentine-coiled capillary tubes hadn't been explored. Results indicate that for helical-coiled geometries, pitch doesn't significantly affect performance, but coil diameter does. However, in serpentine geometries, both pitch and height influence performance positively. Correlations were proposed to describe relationships between straight, helical, and serpentine-coiled capillary tubes, showing strong correlations between them.

Bikrant Rauniyar et al. [2018]: This paper introduces the principles and features of air conditioning systems. The rising standard of living has led to widespread adoption of air conditioning. The growing demand for comfort has increased the need for trained personnel in practical, technical, and sales roles in modern air conditioning. The technical information in this work covers fundamental concepts and principles in the field. Air conditioning has become a permanent fixture in universities in the country.

Xin Zhou et al. [2016]: This study examines centralized air conditioning (AC) systems in residential communities. It focuses on three engineering projects and discusses their applicability. The research investigates the factors affecting energy consumption and efficiency differences between centralized and decentralized AC systems in residential buildings. Findings highlight potential issues at the intersection of centralized and user load, impacting energy consumption and efficiency in residential settings.

III. Construction and Working

3.1 Water cooler

Water cooler is a device which is used to cool the water. It consists of four components. They are as follows,

- Compressor
- Condenser
- Expansion Valve
- Evaporator

The water cooler works under vapour compression cycle. The vapour compression cycle is explained below.

In this system the same old principle “the liquid evaporates when absorbs heat” is employed. The only specialty of this method is that same refrigerant is used again and again in a cycle. The refrigerant continues changing from liquid to vapour state, when absorbing heat and from vapour to liquid state, when giving out heat.

The refrigerant picks up heat from the space to be cooled and takes it to a distant point and rejects it there. In other words in this care heat is transferred from a lower temperature to a higher temperature. According to second law of thermodynamics this can only be accomplished by the expenditure of energy from some external source. Vapour compression refrigeration system was refrigeration sealed in an airtight and leak proof mechanism. The refrigerant is circulated through the system and it undergoes a number of changes in its state while passing through various components of the system.

Each such change in the state of vapour is called a process. The system repeats over and over again this process. The process of repetition of a similar order of operation is called cycle.

The compression cycle is given this name because it is the compression of the refrigerant by the compressor which permits transfer of heat energy. The refrigerant absorbs heat from one place and releases it to another place. In other words the compressor is used to put the heat latent refrigerant vapour in such a condition that it may dissipate the heat it absorbed at low pressure from the refrigerated space, to an easily available cooling medium.

Table 3.1: Thermal conductivity of material

Aluminum	754 KJ/m-hr-k
Cast iron	214 KJ/m-hr-k
Steel	251 KJ/m-hr-k
Copper	386KJ/m-hr-k

3.2 Fan

It continuously moves the mass of air at a desired velocity by the action of its rotor.

3.3 Compressor

The vapour compression machine consists of the compressor, condenser, expansion device, and evaporator. Out of all these components of the system the compressor is the only moving part in the system and its functions is to raise the pressure of the vapor refrigerant coming form the evaporator, high enough so that the temperature of the leaving gas is higher than that of the condensing medium. Hence, the same refrigerant can be liquefied back and expanded to the evaporator suction conditions in a cycle.

The compressors are classified as follows:

1. According to method of operation

Reciprocating compressor

Rotary compressor

Centrifugal compressor

Screw compressor

2. According to drive employed

Open type (belt drive)

Semi-hermetic or Semi-sealed (direct drive, motor and compressor in separate housings)

Hermetic or Sealed compressor (direct drive, motor and compressor in same housings)

Reciprocating compressor

The reciprocating compressor sucks the low pressure and low temperature refrigerant during its suction stroke and delivers it as high pressure and high temperature. The reciprocating compressors are built in sizes ranging from a fraction horse power to several hundred horse power. These are used of refrigerant plant ranging in sizes from 0.25 ton to 1000 tons capacity per unit. The reciprocating compressors are satisfactorily used with the refrigerant as Dichlorodifluro methane (CCl2F2) and most of the freons. This is preferable for high compression ration and low specific volume refrigerant.

Low capacity compressors are cooled just by providing the fins on the cylinder head. This type of cooling is more effective and sufficient for low capacity compressor when F-12 is used as refrigerant because of the low temperature of gas at high pressure.

Figure 3.1: Trunk Type Piston

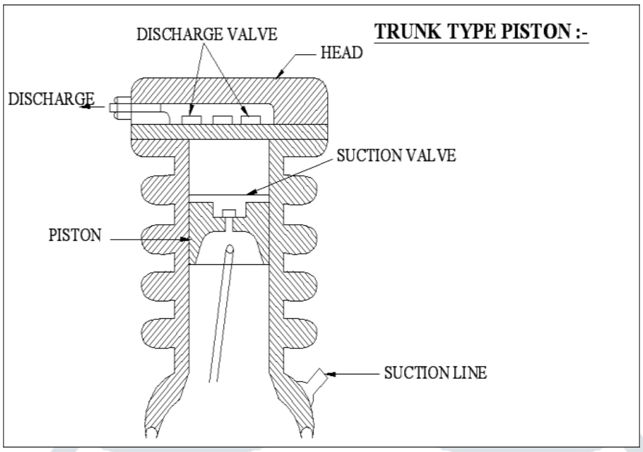


Figure 3.2: Single Acting Reciprocating Compressor

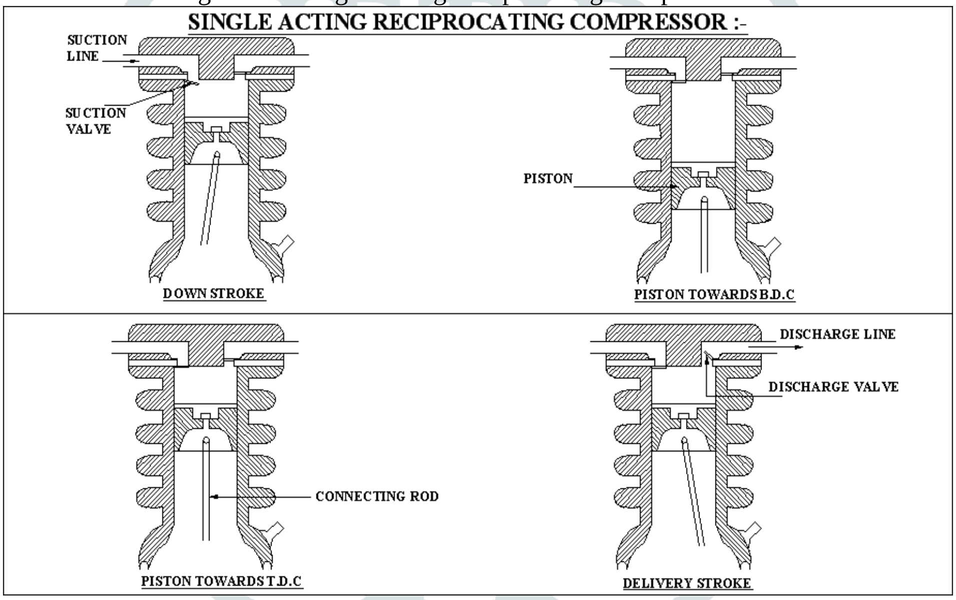


Table 3.2: Single Acting Reciprocating Compressor

Number of cylinders	One
Working position	Vertical
Method of compression	Single acting
Number of times of compression of gas	Single stage
Cooling system	Air
Cooled Capacity	0.5 ton
Motor used	Single phase
Speed of the motor	1400 rpm

Power of the compressor

During the compression process, heat is transferred very quickly form the refrigerant vapour to the walls of the cylinder initially but as the compression process is very short and mean effective temperature is almost constant. It can be safely assumed that the process takes place polytropically with an exponent of 1.30.

Compressor drive

Since we have chosen a twin cylinder single acting reciprocating compressor for the work, it is usually driven by an electric motor which rotates at a speed of 1420 rpm.

Lubrication

Lubrication system ranges from the simplest “splash system” to the most elaborate “forced feed system” with filters, vents and equalizers. The type of lubrication required depends largely on bearings. It is conventional to use splash lubrication in reciprocating compressor in order to get a good performance and excellent service. The splash system in turn consists of special dippers or slingers fastened to the crank to tank.

The suction pressure on the compressor is 25 - 35 psi. The delivery pressure on the compressor is 150 – 180psi.

3.4 Condenser

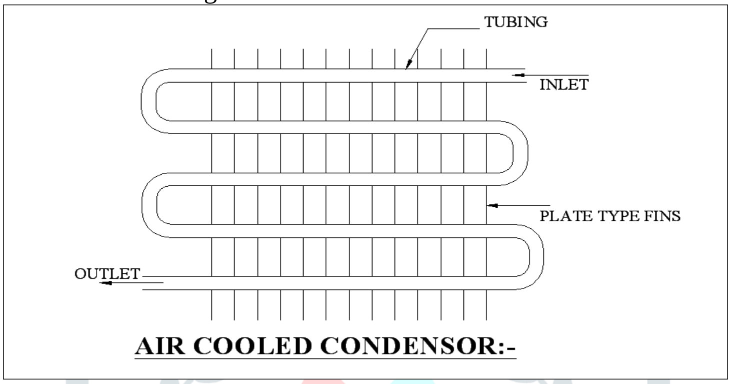
The condenser is an important device, used in the high pressure side of a refrigeration system. Its function is to remove heat of the vapour refrigerant discharged form the compressor. The hot vapour refrigerant consists of the heat absorbed by the evaporator and the heat of compression added by the mechanical energy of the compressor motor. The heat form the hot vapour refrigerant in a condenser is removed first by transferring it to walls of the condenser tubes and then form the tubes to the condensing or cooling medium.

Classifications of condensers

The common forms of condensers may be broadly classified on the basis of the cooling medium as:

- Water cooled condenser
- Air cooled condenser
- Evaporative (air and water cooled)condenser
- In the work Fin and Tube condenser (air cooled) issued.

Figure 3.3: Air Cooled Condenser



Fin and tube condenser

The fin and tube condenser is one in which the removal of heat is done by air. It consists of steel or copper tubing through which the refrigerant flows. The size of tube usually ranges from 6mm to 18mm outside diameter, depending upon of the size of the condenser. Generally copper tubes are used because of its excellent heat transfer ability. The tubes are usually provided with plate type fins to increase the surface area for heat transfer. The fins are usually made from aluminum because of its lightweight.

The condensers with the single row of tubing provide the most efficient heat transfer. This is because the air temperature rises as it passes through each row of tubing. The temperature difference between the air and the vapour refrigerant decreases in each row of tubing and therefore each row becomes low effective. However single row condensers required more space than multi row condensers.

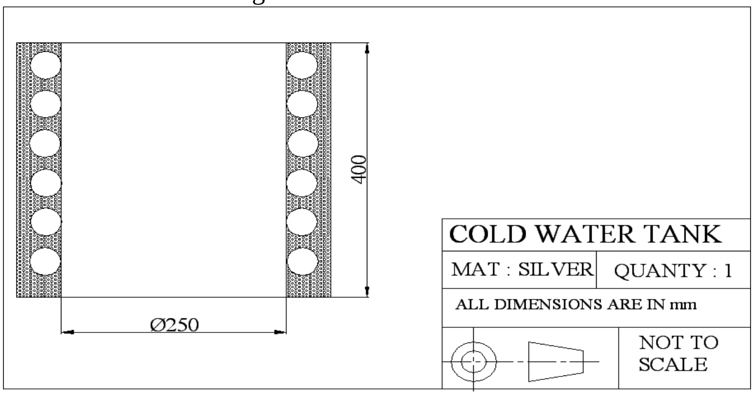
3.5 Evaporator

The evaporator is an important device used in the low pressure side of a refrigeration system. The liquid refrigerant from the expansion vale enters into evaporator where it boils and changes into vapour. The function of and evaporator is to absorb heat from the surrounding location or medium which is to be cooled, by means of the refrigerant. The temperature of the boiling refrigerant in the evaporator must always be less than that of the surrounding medium so that heat flows to the refrigerant. The evaporator becomes cold and remains cold due to the following reasons:

The temperature of the evaporator coil is low due to low temperature of the refrigerant inside the coil.

The low temperature of the refrigerant remains unchanged because any heat it absorbs is converted to latent heat as boiling proceeds.

Figure 3.4: Cold water tank



Shell and coil evaporator (cold tank)

The shell and coil evaporators are generally dry expansion evaporators to chill water. The cooling coil is continuous tube that can be in the form of a single or double spiral. The shell may be sealed or open. The sealed shells are usually found in shell and coil evaporators used to cool drinking water. The evaporators having flanged shells are often used to chilled water in secondary systems.

The capacity of the cold tank used in the work is 15 liters. The dimensions of the tank are of 300 mm diameter and 450mm height. The tank, whose diameter is 3/8 , through which the refrigerant flows. The cold tank is placed between the expansion valve and the drier which is placed nearer the compressor.

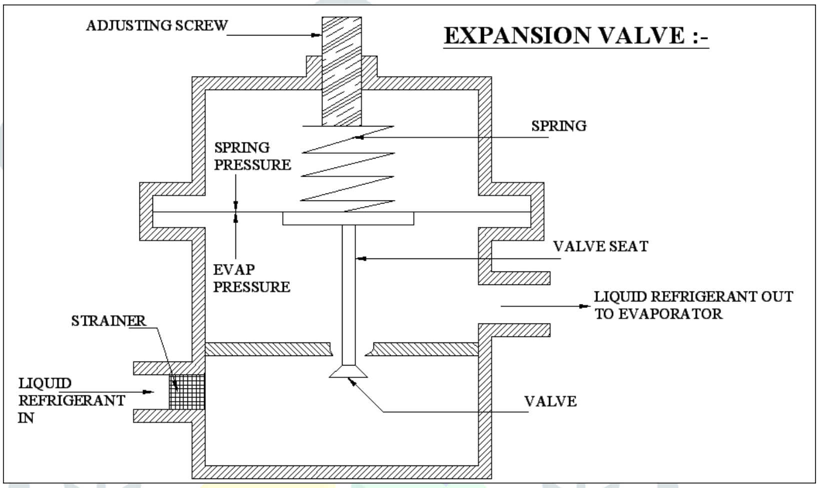
The cold water temperature obtained in the work is 180C.

3.6 Expansion device

The expansion device is an important device that divides the high pressure side and low pressure side of a refrigerating system. It is connected between the receiver and the evaporator. The following are the functions of the expansion device:

- It reduces the high pressure liquid refrigerant ot low pressure liquid refrigerant before being fed to theevaporator.
- It maintains the desired pressure difference between the high and low pressure sides of the system, so that the liquid refrigerant vaporizes at the designed pressure in the evaporator.
- It controls the flow of refrigerant according to the load on the evaporator.

Figure 3.5: Expansion Value



The automatic expansion valve is used in the work.

Automatic expansion valve

It is valve whose operation is controlled by the low pressure side of the system. Its generally employed in the liquid line just before the cooling coil for controlling the flow of liquid refrigerant. Its operation depends upon the suction pressure of the system dropping below the valve. Setting on the running part of the system and raising above the valve setting when the system drops.

Working of three in one air conditioner

The low pressure, low temperature liquid refrigerant enters the evaporator, the refrigerant present inside the evaporator coil absorbs the heat from the water and then refrigerant temperature increases due to this liquid refrigerant is converted to vapour refrigerant, and therefore heat is removed from water it gets cooled. At the same time the air made to pass through the evaporator, therefore the temperature of air reduces and that of refrigerant increases. The low pressure, high temperature vapour refrigerant coming out from the evaporator coil enters the compressor, the pressure and temperature of refrigerant increases.

The high temperature and high pressure vapour refrigerant coming out of the compressor enters the condenser, where heat from the refrigerant is absorbed by the water and therefore water temperature increases and water get sheeted, as heat from refrigerant is dissipated, the refrigerant changes its state from vapour to liquid. This low temperature, high pressure liquid refrigerant from the condenser enters the expansion valve, the pressure of the refrigerant decreases and therefore it gets converted to low pressure, low temperature refrigerant. And this refrigerant is passed to evaporator and cycle is repeated.

Figure 3.6: Working of three in one air conditioner

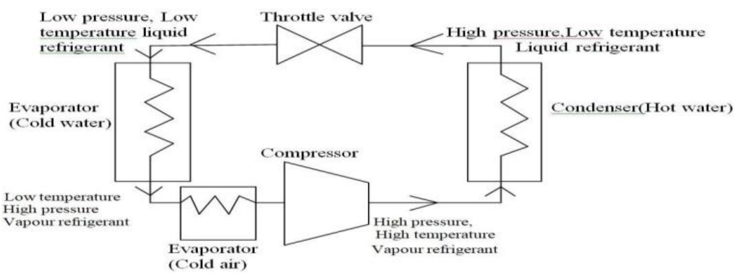
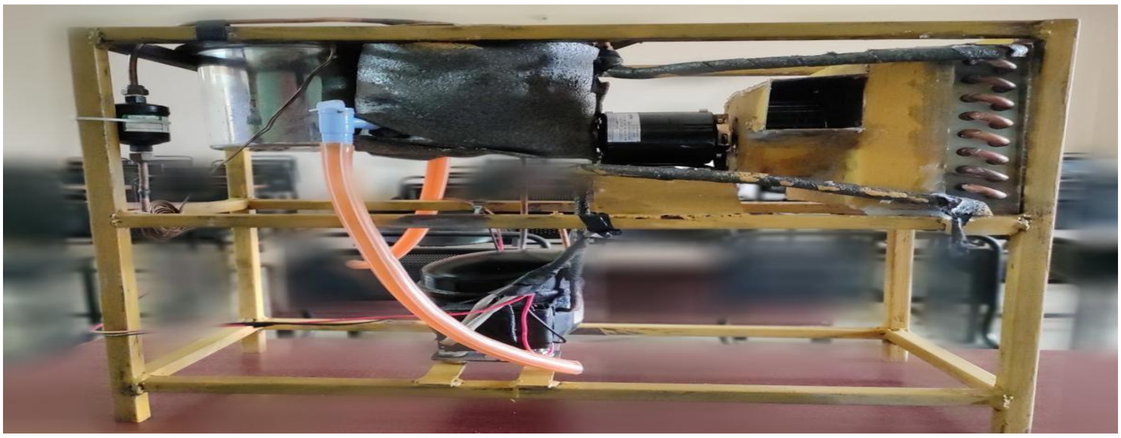
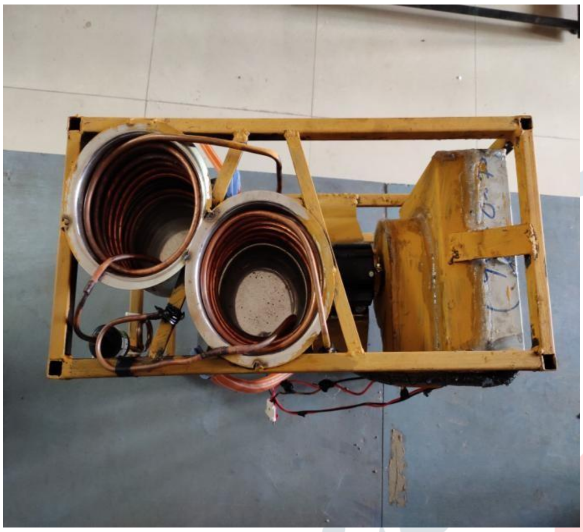
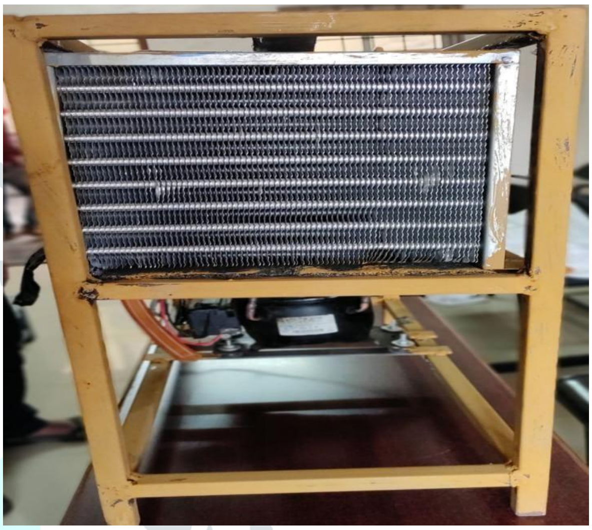


Figure 3.7: Three in one air conditioner







IV. SELECTION OF REFRIGERANT

Any substances capable of absorbing heat from other required substances can be used as refrigerant. Example:-ice, water, air, etc. A mechanical refrigerant which will absorb the heat form the source (which is at low temperature) and dissipate the same to the sink (which is at higher temperature than source). Either in the form of sensible heat (as the case of air refrigerant) or in the form of latent heat (as the case of vapour refrigerant).

The thermodynamic, physical as well as safe working properties should be taken in to account before selecting a refrigerant for a particular purpose. There is no single best refrigerant which can be used for all refrigeration purposes.

- The following properties must be taken in to account before selecting the refrigerant,
- Working pressure range and pressure ratio
- Corrosiveness and flammability
- Space limitation

Temperature required in the evaporator. The refrigerant used in the work isR-134a.

Table 4.1: Single Acting Reciprocating Compressor

Explosive tendency	Non-stable
Toxic nature	Non-toxic
Flammable	Non-flammable
Odor	No objectionable
Corrosive	Non-Corrosive
Oil solubility	completely miscible
Chemical stability to working temperature	Good
Electrical insulation	Excellent
Co-efficient of performance	4.61
Critical temperature	101.06 0 C
Critical pressure (bar)	40.56
Boling point at atmospheric pressure	26.15 0 C

Charging through the Suction valve

A small installation, which needs a few kilograms of refrigerant, is usually charged through suction service valve gauge port. The system is fully evacuated and charged as follows:

- The suction valve B is back-seated and valve A is discharged.
- Charging line is connected to the suction valve gauge port. Attach a gauge to the discharge valve and open half turn.

- The other end of the charging line is connected to a refrigerant cylinder, which should be standingupright.
- The Cylinder valve is opened slightly and the flare out is loosened at the compressor end. This operation removes air from the line. When the sound of escaping gas is heard, the nut istightened.
- Suction valve is turned into close the suction line, thus drawing the gas directly form the cylinder by thecompressor.
- Compressor is started drawing the requisite quantity of refrigerant. The suction pressure should not be allowed to exceed 2 bar gauge.
- The cylinder valve is closed and the compressor is allowed to run sufficient time in the charging line to 0 bargauge.
- Compressor is stopped and the suction valve is back-seated. The charging line is detached and compound gauge is attached. The valve is turned in one half turn. The system is thus ready for testing and normaloperation.
- The charging through the suction valve gauge port is applied.

V. DESIGN OF EQUIPMENTS AND CALCULATIONS

5.1 Specification

WATER COOLER

Name	: VOLTASTUSAR
Compressor	: DAN FOSS 1/6HP
Condenser	: 9” * 9” Size
Capacity	: 15liters
Cooling	: Fan Cooling Type
Volts	: 220 V, 50cycles
Amps	: 1.7 A
Evaporator	: Plate Type
Evaporator Temperature	: 45 Degree F
Power Consumption	: 1 ½ unit per hour

RADIATOR

Core	: Aluminum
Tube	: Aluminum
Header	: Plastic
Tube Length	: 320 mm
Fin Length	: 350 mm
Fin Thickness	: 0.4 mm
Gap between two fins	: 1 mm
Total No. of tubes	49
Capacity	: 1.25litres

FAN

Name	: AUE
Type	: Shaded pole
HP	: 1/80
RPM	: 1360
Output power	: 9 watt
AMPS	: 0.3 A
Volts	: 230 V
Frequency	: 50 Hz

5.2 Design Calculations

Duration of test		= 20 min
Height of the container	H	= 17.5Cm = 0.175m
Diameter of the container	D	= 20Cm = 0.2m
Volume of water	V	= (πD2H)/4 = (π*0.22*0.175)/4 = 5.5ltr=0.0055m3
Mass of the water	M	= ρ * V = 1000 * 0.0055 =5.5Kg
Mass flow rate of water	m	= mass/time =5.5/20 = 0.275 kg / min.
Work done by compressor	w	= (¼)HP = 746/4= 186.5watts=0.186Kw = 11.16 KJ/min.
Ambient temperature	t1	= 280C

Quantity of heat absorbed by Q 1 = m*cp*ΔT water
Outlet temperature of water at condenser t2 =360C
Therefore, Q1 =0.275*4.187*(36-28)
= 9.21Kg/min.
Co-efficient of performance COP = desired effect/work input
= 9.21/11.16 = 0.830

Quantity heat rejected by water Q2 = m*cp*ΔT Outlet temperature of water at evaporator t3 =140C
Therefore, Q2 =0.275*4.187*(28-14)
= 16.11KJ/min.
Co-efficient Of Performance COP = desired effect/work input
= 16.11/11.16 = 1.44

Quantity of heat rejected by air Q3= m(h1-h2) Outlet temperature of air at blower t4= 240C From psychometric chart,
Enthalpy h1=72KJ/Kg
Enthalpy h2=63KJ/Kg
Mass of air m = ρ *A*v
Velocity v = (π*D*N)/60
v = (π*0.21*1360)/60 =14.95m/sec
Area A=(π*D2)/4
A = (π*0.212)/4 =0.034m2

Therefore, m = 1.21*0.034*14.95 =0.61 KJ/Kg

Therefore, Q3=0.61(72-63)=5.49KJ/sec

VI. FABRICATION

Body of the unit

- Machine and tools required are
- Drilling machine.
- Jig –Saw.

- Chisel.
- Nails.
- Aluminum Sheets.
- Thermo Cole.
- Wood.

The duct is the main body of our project which is fabricated by the use of wood, Aluminum Sheet, Thermo Cole, Plywood.

First the wooden block is made by the use of cutting operation and it is reassembling as per the diagram shown.

In the back part of the radiator is placed by merging it with the wooden block. The merging operation is done up and down to place the radiator. The holes in the wooden block to place radiator is done by the drilling machine.

Next the fan is place just in front of the radiator by the use of reaper and this reaper is cut by the use of Jig – Saw which is in curved path as shown in figure. This reaper is placed on the centre of the wooden block by the use of bolt and nuts with drilling machine operation. With the help of lath machine the nylon shaft is made according to the dimensions. The bottom head of the radiator is connected to the suction pipe of the pump. The outlet of the pump is again fed into the water cooler.

The one end of the machined nylon shaft is connected to the impeller of the pump and the other end is connected to a pulley. In order to eliminate the vibration of the shaft a bearing is connected. The machined nylon shaft of the pump with its pulley is connected to the motor shaft pulley by means of rope. The aluminum sheet is covered over the duct with the help of nail and according to the dimensions. Over this aluminum sheet the thermo Cole is pasted with the help of fevicol. At lastly whole block is covered with the plywood and it is made to be fixed with the help of nails and fevicol.

VII. Results and Discussions

- In this unit we get three outputs simultaneously i.e. hot water, cold water and cool air.
- The temperature of hot water obtained is 360C.
- The temperature of cold water obtained is 140C.
- The temperature of cool air obtained is 240C.
- The total COP obtained for the system is2.27.
- The air conditioning effect can be increased by reducing the load on the evaporator.

VIII. Conclusion

In this changing modern world every day there is a new discovery in all fields of science and technology, benefiting the mankind. In this work the design of water cooler is slightly modified with an addition air cooler. If one utilizes energy which goes as waste even more useful things can be made.

References

[1] J R Sand, S K Fischer and V D Baxter,1997 Energy and global warming impacts of HFC refrigerants and emerging technologies sponsored by the alternative fluorocarbons environmental study and the U S department of energy, Oak Ridge.

[2] Raut, A S, and U S Wankhede,2011 selection of capillary tubes for retrofitting in refrigeration appliances, International journal of engineering science and technology ISSN/EISSN:09755462year.

[3] Raman Kumar Singh design and fabrication of three in one air conditioning, 2015 International journal of research in computer applications and roboticsISSN:2320-7345.

[4] Akintunde, M A, PhD, Effect of coiled capillary tube pitch on vapour compression refrigeration system performance. The Pacific journal of science and technology, 9(2):284-294.

[5] Schaefer, L A, and S V Shelton,1998 heat exchanger mean temperature differences for refrigerant mixtures, proceedings of the ASME advanced energy system divisions, vol. 38 H.Metghalchi etal;pages,pp:383-389.

[6] Bikrant Rauniyar and Harsimran Singh Sodhi,2018 Research on the Air Conditioning System, Volume 8, Issue 12, 2018.

[7] Xin Zhou, Da Yan, and Xing Shi,2016, Comparative research on different air conditioning systems for residential buildings, Frontiers of Architectural Research (2016).