CSMSS
Chhatrapati Shahu Maharaj Shikshan Sanstha's
CHH. SHAHU COLLEGE OF ENGINEERING
Kanchanwadi, Paithan Road, Aurangabad, 431 011
Ph. No. : (0240) 2646373, 9922668199, 2646350 Fax: (0240) 2646222
Website: www.csmssengg.org

Approved by AICTE New Delhi, DTE (Govt. of Maharashtra) and affiliated to Dr. BATU, Lonere (Raigad). **DTE Code: 2533**

Refrigeration and Air Conditioning

Lab Manual

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Vision and Mission of the Institute

Vision:

To be an institution of repute through multidisciplinary educational approach to develop the next generation competent technocrats for industry and society.

Mission:

M1:	Developing student centric educational practices for curriculum delivery and assessment.
M2:	Imparting entrepreneurial and employability skills among students through value-based and skill-based training in collaboration with industry and academia.
M3:	Inculcating social and professional values among students through awareness and outreach activities.
M4:	Providing an environment for innovation and research through various interdisciplinary activities.

CSMSS CHH. SHAHU COLLEGE OF ENGINEERING * AURANGABAD * DTE CODE 2533

PRINCIPAL

Principal
C.S.M.S.S. Chh. Shahu College of Engineering
Kanchanwadi, Aurangabad.

CSMSS

CHHATRAPATI SHAHU MAHARAJ SHIKSHAN SANSTHA's

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Department of Mechanical Engineering

Vision and Mission of the Department

Vision

To Be a Centre of Repute for Preparing Engineering Students as Professionals in the Services, Domain Leadership, Research, and Good Citizens.

Mission

M1: Developing the continuous improvement process for academic practices to strengthen the academic base of students.

M2: Developing the research culture through various efforts that can inspire students for research.

M3: Developing the students for social skills like team building, leadership and social values.

M4: Upgrading the above activities through communication with internal and external stakeholders (Students, Parents, Alumni, Employers, Experts, Society people, etc.).

Dr. R. H. Shinde,
HOD,
Mechanical Engg. Department

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Department of Mechanical Engineering

Program Outcomes

PO	PROGRAM OUTCOMES (POs)
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Department of Mechanical Engineering

Program Specific Outcomes (PSOs)

PSO 1: Interpret, analyze, and provide solutions to real-life mechanical engineering and interdisciplinary problems for realistic outcomes.

PSO 2: Respond to the demands of society by engaging in a lifelong learning approach.

PSO 3: Apply the knowledge of ethical and management principles required to work in a team as well as to lead a team.

Program Educational Objectives (PEOs)

PEO 1: Graduates will achieve professional skills by applying their mechanical engineering expertise and communication in the field of industries or their own start-ups.

PEO 2: Graduates will achieve higher qualifications/skills through further studies.

PEO 3: Graduates will become responsible citizens by contributing significant roles among society.

Dr. R. H. Shinde,
HOD,
Mechanical Engg. Department

DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

Refrigeration and Air Conditioning Lab
(CSMSS/ENGG/MECH/RACLAB/RAC/ BTMEL610)

CSMSS
CHH. SHAHU COLLEGE OF ENGINEERING
KANCHANWADI, CHHATRAPATI SAMBHAJINAGAR - 431011

Course Name: REFRIGERATION AND AIR CONDITIONING

Lab Course Code: BTMEL610

Examination Scheme:

1. **Internal Assessment (CA:TW):** 30 Marks
2. **External Assessment (ESE:PR):** 20 Marks

Course Outcomes:

After successfully completion the course, the students will be able to:		**Blooms Level**
CO1	Examine the test on Refrigeration and air conditioning test units to evaluate their performance.	Apply
CO2	Analyze various components of refrigeration and air conditioning systems.	Analyze
CO3	Sketch performance Cycles/Curves of these machines/systems on Psychrometric Chart	Apply
CO4	Analyze the results obtained from the tests.	Analyze
CO5	Write the conclusions based on the results of the experiments	Apply

MASTER LIST OF EXPERIMENT

PREPARED BY :	CHECKED BY :	VERIFIED BY :	APPROVED BY :
Prof. R. S. Surase Course Teacher	Prof. R. S. Surase Lab In-charge	Department Review Committee	Dr. R. H. Shinde HOD

	CSMSS CHH. SHAHU COLLEGE OF ENGINEERING, KANCHANWADI, PAITHAN ROAD, AURANGABAD	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: STUDY OF VARIOUS TOOLS USED IN REFRIGERATION AIR CONDITIONING PRACTICE	

DEPARTMENT: **MECHANICAL ENGINEERING**	LABORATORY: **CSMSS/ENGG/MECH/RAC LAB**
LABORATORY MANUAL NO.: **CSMSS/ENGG/MECH/RAC-01**	YEAR:**2024-25**

CLASS: **THIRD/ FINAL YEAR**	PART: **VI/ VIII**	SUBJECT: **REFRIGERATION AND AIR CONDITIONING**	PAGE: 01/83

Aim: To Understand Various Tools Used for Refrigeration Tubing and To Perform Various Operations Like Flaring, Swaging, Bending, Brazing etc.

Objective:

1. To study various tools used for refrigeration.
2. To perform various operations like flaring, swaging, bending, brazing etc.

Theory:

(1) Tube/ Pipe Cutter

This instrument resembles wrench. It has a cutting wheel and two sliding wheels. The distance between the cutting wheel and sliding wheel can be altered by means of mechanism on the handle itself. The pipe is fixed in between the wheels and the instrument is given one rotation around the pipe. Then the distance between the wheels is decreased by rotation. Thus, repeating the procedure, the pipe can be cut into two pieces.

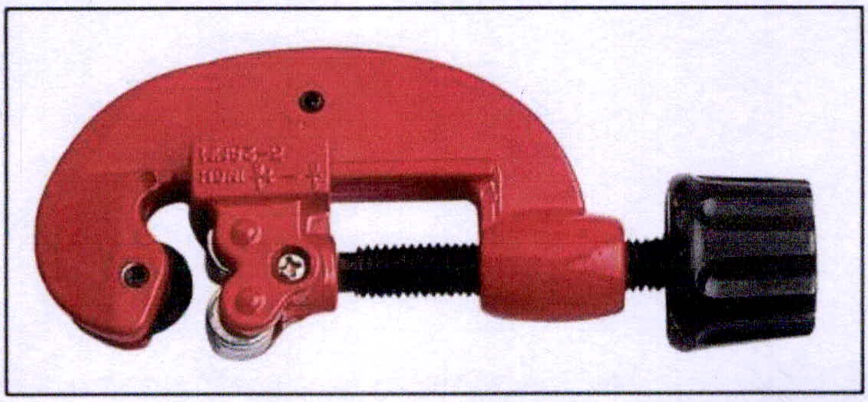


Figure 1.1 Tube/ Pipe Cutter

It is a refrigeration tool use to cut copper tubing from sizes 1/8” to 1/2” outside diameter. A larger tube cutter is also available for large tube diameters. Tubes are mark first before cutting. Slight pressure is applied to the copper tube during cutting. The burr inside the tube is cleaned with blade reamer.

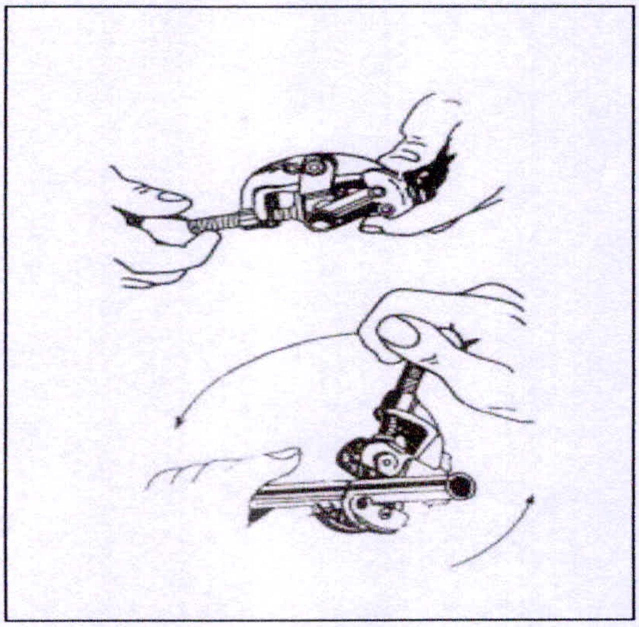


Figure 1.2 Use of Tube/ Pipe Cutter

2. Wrench:

This is commonly used to tight the bolt. It is also used for holding the parts tightly. These are available in different sizes depending upon the diameter of pipe. It is also available in adjustable form. By turning screw, we get desire length between two ends.

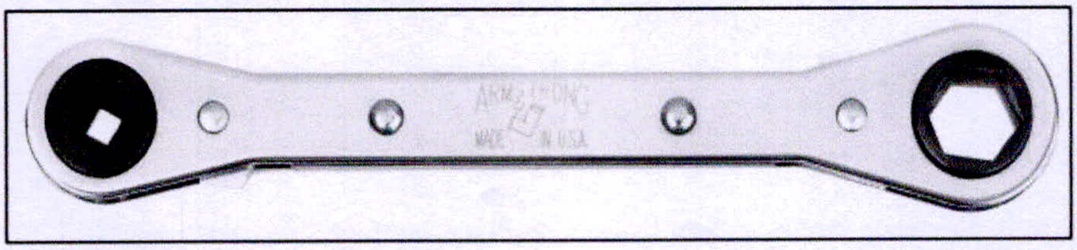


Figure 1.3 Wrench

3. Flaring Tool: This Tool is a simple instrument of two pieces joined by means of two bolts operated by two wing nuts. When joined together, they form holes of different sizes in which different sizes of pipes are held tightly for flaring. The pipes do not slip because grips are provided in the inner side of the holes.

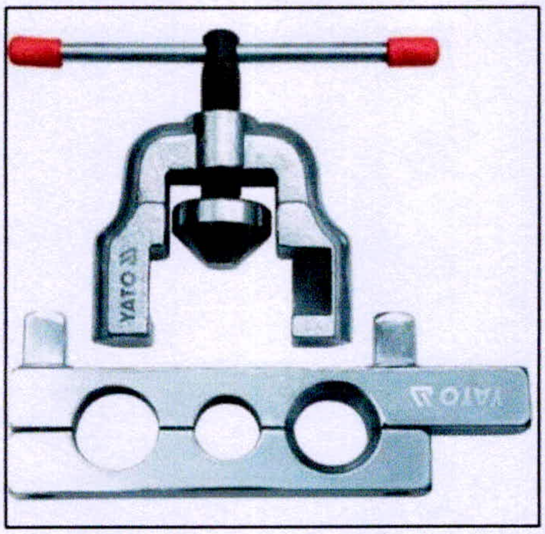


Figure 1.4 Flaring Tool

It is a refrigeration tool use to spread the copper end outward until a flare is formed. File and ream the copper tube before flaring. The copper tube is inserted into the flaring block with 30% of its diameter protruding. Turn the flaring yoke slowly until the flare is completed. Remove copper tube and inspect for defects.

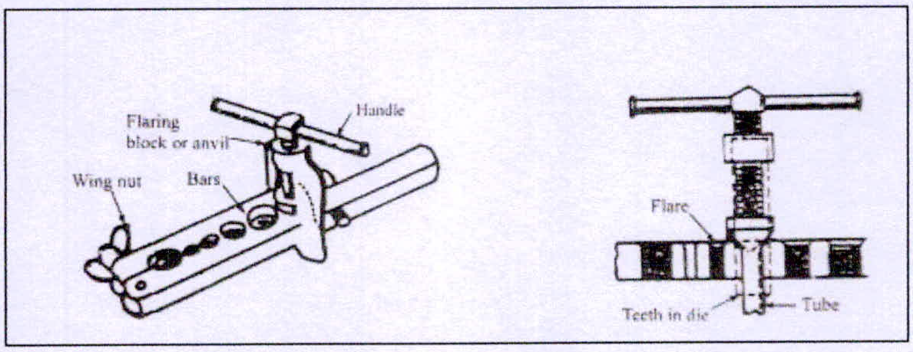


Figure 1.5 Flaring anvil and Flare

4. Pinch Off Tool: The pinch off tool has a similar constructional feature as a flare. It consists of two parts assembled by two bolts as both ends. This is used for holding the pipes while working. Another use is that it pinches off the pipe line before the spot of leakage and helps the workman to work with damaged part.

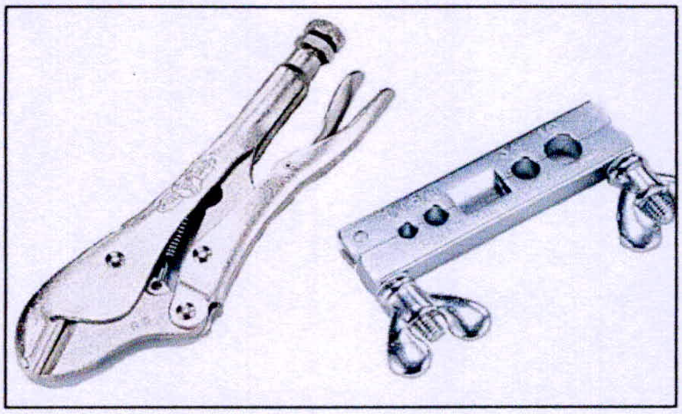


Figure 1.6 Pinch Off Tool

5. Swaging Tool: This tool has a similar construction as the pinch off tool. One end of the tool is pointed which help in swaging the pipe held firmly with a pinch tool. Swaging means increasing the diameter of the pipe. This is done because bolt is not coming out. So after bolt is screwed, swaging operation is done.

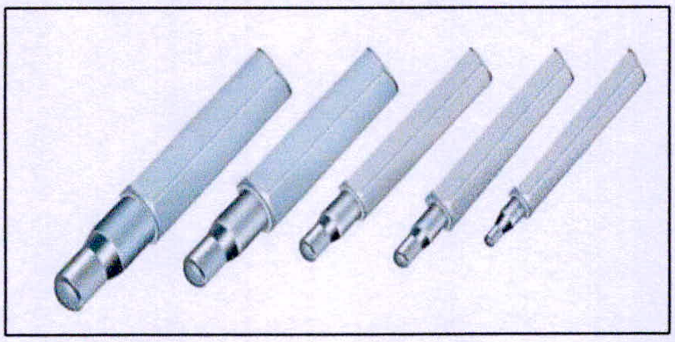


Figure 1.7 Swaging Tool

It is a refrigeration tool use to expand the inside diameter of a copper tube so that the resulting diameter is the same as the outside diameter. It is used to join two copper tubes of the same diameter. Clamp the copper tube by the flaring block so that an 'equal to the outside diameter' of the copper tube length is to be swigged.

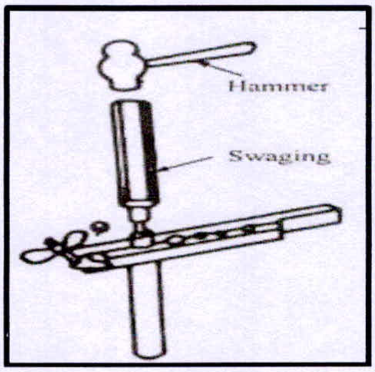


Figure 1.8 Hammer and Swaging Tool

6. Brazing Torch: It is a refrigeration tool use in soldering the joints of two copper tubes together. 800 degrees Fahrenheit is required to solder copper tubing. Map gas is generally used in this application, although oxygen-acetylene is also popular except they are bulky and heavy. It can reach a temperature of 3600 degrees Fahrenheit. When brazing copper tube joints, do it in a well-ventilated area. Prolong inhalation can cause cancer.

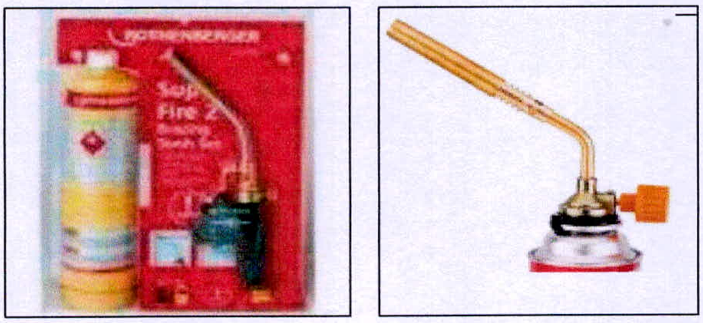


Figure 1.9 Brazing Torch

7. Tube Bender: This is nothing but a spring given a special construction from general spring. One end of the spring is made wider to make it easy to push the pipe inside it, then it is bended thereby giving the shape to the pipe, then it is bended. Then the spring is removed. There are different sizes of bender tubes available. It is a copper tube bending refrigeration tool. It has a three-size moulded half-round wheels. The most common sizes are from 1/4 of an inch diameter, to 5/16, then 3/8. Copper tubes are bent beautifully using this professional bending tool.

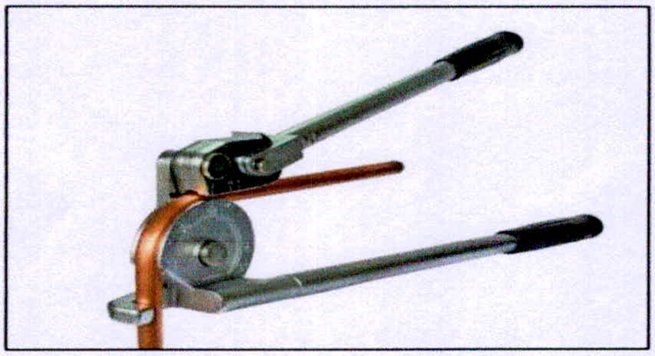


Figure 1.10 Tube Bender

8. Gauge Manifold: refrigeration tool pressure gauges. Whenever you are reprocessing a refrigerator, or replacing a new compressor for a freezer, or charging refrigerant to your automotive air conditioner, you need a gauge manifold to tell you if you are doing it right.

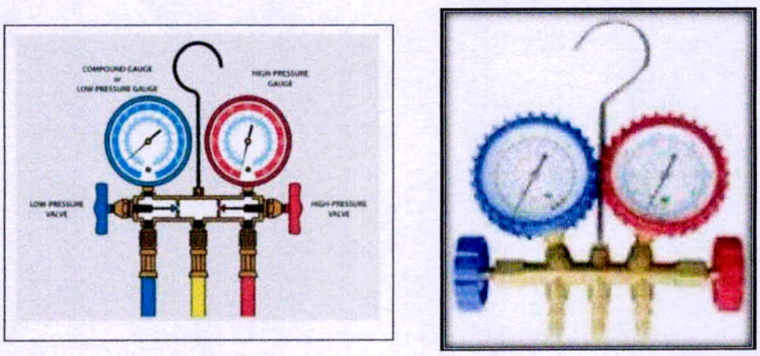


Figure 1.11 Gauge Manifold

9. Vacuum Pump: This pump is used to make vacuum into the system. The pipe is connected to suction line. Then start motor so all refrigerant will be sucked from the system. We can see the reading dial.

Figure 1.12 Leak Detection and Refrigerant Charging unit along with Vacuum Pump

Conclusion: Thus, we have studied various tools used in refrigeration and Air-conditioning.

Reference: https://www.air-conditioning-and-refrigeration.com/Refrigeration-tools.html

Aim: To Study the Charging, Testing, Evacuating, Pumping Down and Leak Detection Techniques in A Refrigeration System.

Objective:

1. To study the charging, testing, evacuating, and pumping down in a refrigeration System.
2. To study leak detection techniques in a refrigeration plant.

Theory:

Charging and Evacuating Techniques:

Charging and evacuating techniques are the method of charging the plant with refrigeration. The detailed procedure of charging the plant is as under:

Initially there may be air entrapped in the piping circuit of the plant. Thus, before charging the plant with the refrigerant, it is essential to remove entrapped air. For removing this air and thereby to create a vacuum, a vacuum pump is used, which sucks the air.

A vacuum pump fitted with a compound gauge is connected to the suction line. As the air is sucked the pointer on the compound gauge keeps on falling steady and vacuum is created. The pump is run for a while till the compound gauge reads. The system is left as it is for some hours at a stretch and the compound gauge reading is observed. If the pointer starts climbing towards zero there, it would be ascertained that there is a leakage and if there is no change in the reading, then we can conclude that the piping is leak proof.

If there is any leakage i.e. if the compound gauge reading slowly rises to higher values, then this leakage has to be detected and plugged properly. For this the plant is pressurized with the air at high pressure, so that the leakage may be removed. This completes the evacuating process.

Now the vacuum pump is disconnected and the suction line is connected to the cylinder containing the refrigerant. There is a valve, provided at the suction line, which is closed before disconnecting the vacuum pump. After connecting the cylinder to the suction line of the compressor, the cylinder valve is opened and the nut joining the pipe to the suction is kept slightly loose. So that when the valve is opened the refrigerant rushes out and forces the air entrapped in the pipe to the atmosphere. Now the suction line is opened. There is vacuum inside, it sucks the refrigerant from the refrigerant cylinder very rapidly. At the same time a pressure gauge indicates the pressure developed in the compressors due to a charging of pipe attached to the suction line is disconnected and back pressure is measured. The correct charging pressure is 175 to 200 lb/in2 and the back pressure is about 20-25 Ib/in2. The correct charging pressure is of importance because if the pressure is more i.e. more refrigerant is charged, then the handling of the refrigerant is not proper, thereby affecting the performance of the plant.

Once the charging is over the plant is ready for service.

Testing:

When the refrigerant plant is newly set-up, the pipe joints and other connections of the system have to be tested for leakage. For that in beginning CO_2 and N_2 is passed through the system and pressure gauge reading is noted. Then at the joint, some soap solution is applied. If no bubbles are formed at the joint and pressure remains constants then we can conclude that the joints are free from any leakage and if bubbles are formed then the joint has to be tightened more. The second method is used to detect the leakage.

The system is completely evacuated after performing leakage test and this is done with the help of a vacuum pump. Whether the system is completely evacuated or not is determined by the pressure gauge readings. Then the plant will be evacuated and charged with refrigerant.

Pumping Down:

Pumping down means collecting all the refrigerant of the plant into its receiver tank. It is useful when there is some minor repair of the plant is to be done. So refrigerant is not required to be removed of the plant which is otherwise necessitates recharging.

For this the delivery valve of the receiver tank is closed and the plant is run for few minutes. After some time, all the refrigerant will be collected in the receiver tank and after rectifying the fault, by opening the delivery valve of the plant refrigerant is charged in the line. If necessary, extra amount of refrigerant should be added from the refrigerant cylinder.

Leak Detection:

If there is any leakage i.e. if the compound gauge reading slowly rises to higher values, then this leakage has to be detected and plugged properly Leak Test Methods:

Different leak testing methods one employed for different types of refrigerants.

1. Ammonia, R12, R22:

A. Sulphur Test Method:

Burning sulphur stick shows a dense white smoke if ammonia is present. The burning sulphur stick is passed around all the joints and suspected leaky points for the appearance of smoke. This test is applicable for tracing minute leaks only.

B. Soap Bubble Test:

This test may not be very effective to trace very minute ammonia leak as it is soluble in water. Fortunately, ammonia is having plungent odor, a heavy leak can be easily detectable.

C. Litmus Test:

Wet litmus paper (Phenolpthalene paper) which turns red in contact with ammonia can also be used to detect leaks.

2. Halogenated Refrigerants:

Soap solution, Halogen leak detector, Halide torch and electronic leak detectors are the methods used to trace leaks in halogenated refrigerants

A. Halogen Torch:

A halogen torch can detect minute leaks, which are not possible to trace with soap solution. The presence of trace of refrigerant can change the light blue colour of the detector flame to green or deep blue. The end of the explorer tube of the detector is carefully passed over the joints and suspected leakage points. If there is a leak, the refrigerant can be drained in with the suction effect at the end of the explorer tube to the hot copper or brass portion of the burning torch. The refrigerant reacts with the metal to form copper chloride, which produces the color change in the flame. A well-maintained halogen torch is claimed to detect leaks of the order of about 15 gram per year.

B. Electronic Leak Detector:

This is an electrical instrument. In this also an explorer tube is used to suck the refrigerant from the leaky points to an instrument. A vibrator is provided to suck the refrigerant through the explorer tube. A filter is also provided at the tip of the tube to prevent atmospheric dert entering the instrument. A heating element in the tube heats the refrigerant drawn in and the refrigerant creates a variation in the current flow of the instrument. The extent of variation of the current is an indication of the amount of leak. The current variation is read on the dial of the instrument. The change of current actuates a relay which operates an indicating light. These detectors are capable of detecting refrigerant leaks of the order of about 0.3 gm per year. The electronic leak detector is a very sensitive instrument and should be handled and stored carefully.

Apparatus:

Vacuum pump, four-way manifold guage,90 degree shut off valve, process stub Schrader valve, dye-drier with Schrader valve, 134a recovery cylinder, 134a charging cylinder and charging hose.

Refrigerant Charging Procedure:

A: Operation Caution:

- During operation, be sure to wear safety goggles and protective gloves.
- Before charging the refrigerant, evacuate the system to remove small amounts of moisture remaining in the system. The moisture in the system can be completely evacuated only under the minimum vacuum level. The minimum vacuum level affects the temperature in the system.
- The list below shows the vacuum values necessary to boil water in various temperatures. In addition, the vacuum levels indicated on the gauge are approx. 3.3 kPa (25 mmHg, 0.98 in Hg) lower than those measured at 304.8 m (1,000 ft) above sea level.

Table 2.1 Vacuum level required to boil water (at sea level)

Temperature	Vacuum
1.7°C (35°F)	100.9 kPa (757 mmHg, 29.8 inHg)
7.2°C (45°F)	100.5 kPa (754 mmHg, 29.7 inHg)
12.8°C (55°F)	99.8 kPa (749 mmHg, 29.5 inHg)
18.3°C (65°F)	99.2 kPa (744 mmHg, 29.3 inHg)
23.9°C (75°F)	98.5 kPa (739 mmHg, 29.1 inHg)
29.4°C (85°F)	97.2 kPa (729 mmHg, 28.7 inHg)
35°C (95°F)	95.8 kPa (719 mmHg, 28.3 inHg)

1) Close the valves on low-/high-pressure sides of the manifold gauge.

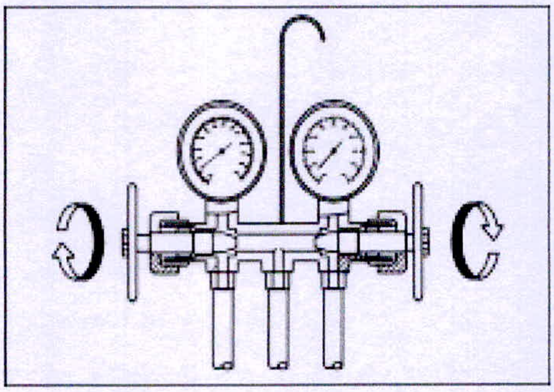


Figure 2.1 Manifold Gauge

A) Low-pressure gauge (Compound pressure gauge)

B) High-pressure gauge

C) Close

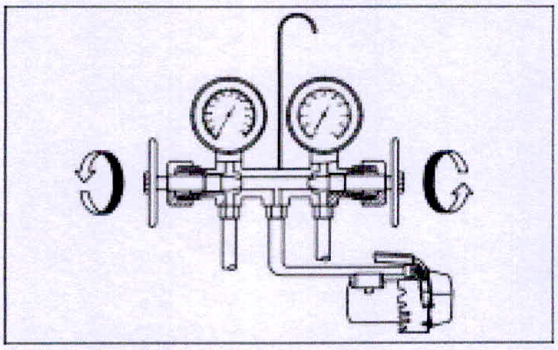


Figure 2.2 Manifold Gauge connected to system

2) Install the low-/high-pressure hoses to the corresponding service ports on the vehicle respectively.

3) Connect the centre hose of the manifold gauge set with the vacuum pump.

4) Carefully open the valves on the low-/high-pressure sides to activate the vacuum pump

(A) Low-pressure gauge (Compound pressure gauge)

(B) High-pressure gauge (C) Slowly open (D) Vacuum pump turn on

5) After the low-pressure gauge reaches 100.0 kPa (750 mmHg, 29.5 inHg) or higher, evacuate the system for approx. 15 minutes (Continue evacuation)

6) After 15 minutes of evacuation, if the reading shows 100.0 kPa (750 mmHg, 29.5 inHg) or higher, close the valves on the both sides to stop the vacuum pump.

(A) Low-pressure gauge (Compound pressure gauge)

(B) High-pressure gauge

(C) Close

(D) Vacuum pump turns off

7) Note the low-pressure gauge reading.

8) Leave it at least 5 minutes, and then check the low-pressure gauge reading for any changes. When a gauge indicator shows near to zero point, this is a sign of leakage.

Check pipe connector points, repair them, and make sure there is no leakage by air bleeding.

9) Following the can tap operation manual instructions, install it to the refrigerant can.

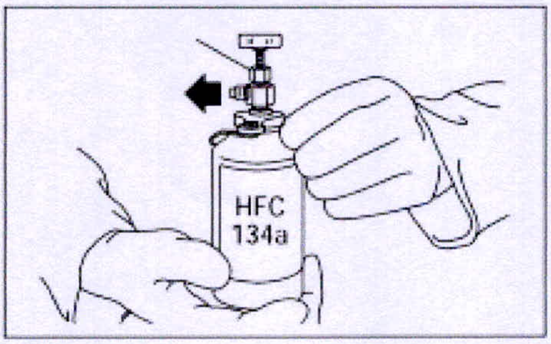


Figure 2.3 can tap operation manual

(A) Tap valve

(B) Centre manifold hose

10) Disconnect the centre manifold hose from the vacuum pump, and connect the hose to the tap valve.

11) When a 13.6 kg (30 lb) refrigerant container is used, measure the refrigerant amount in use using a weighting scale.

12) Confirm that all the 3 hoses are tightly connect-ed to the manifold gauge set.

13) Open the valve on the HFC-134a source.

14) Loosen the centre hose connection on the manifold gauge set (if applicable, press a purge valve on the manifold gauge set) only for a couple of seconds to allow the air in the centre hose to escape by the refrigerant.

15) Carefully open the high-pressure valve with the engine stopping.

CAUTION: Do not open the low-pressure valve.

16) Close the high-pressure valve when the low-pressure gauge reaches 98 kPa (1 kg/cm2, 14 psi).

Using a leak tester, check the system for leaks.

17) If any leakage is found after the refrigerant recovery is completed, repair the applicable area.

18) After confirming that there are no leaks with the leak test, charge the required amount of refrigerant.

19) Close the high-pressure valve when; the readings of low-/high-pressure gauges become almost equal, after the charging speed is reduced, the HFC-134a source becomes empty, or the system is filled with the gas.

20) If the HFC-134a source is empty, close the high-pressure valve, close the valve on the can tap, and replace the HFC-134a source with a new one to restart the operation.

21) Confirm that both the low-/high-pressure valves can be closed. Start the engine with the A/C switch OFF.

21) Quickly repeat ON-OFF cycles a few times to prevent initial compressor damage.

22) Set up the system to on condition.

23) While reading the low-pressure gauge, carefully open the low-pressure valve with the refrigerant source connected and the service hose purged.

24) Adjust the refrigerant flow to maintain the pressure on the low-pressure side at 276 kPa (2.81 kg/ cm2, 40 psi) max.

25) After the system is fully charged, close the low –pressure valve.

26) Close the valve on the refrigerant source.

27) Disconnect the hose from the service port, and install the service port cap.

Conclusion: Hence, we have studied the Charging, Testing, Evacuating, Pumping Down and Leak Detection Techniques in a Refrigeration Plant/ System.

Aim: To study the various controls used in Refrigeration and Air conditioning system.

Objective:

1. To Study of Controls used in Refrigeration & Air conditioning such as expansion devices. Thermostat, HP, LP cut out, OHP, Relays, Solenoid valves. Humidity measurement.

Apparatus used: Schematic diagrams of Refrigeration and Air Conditioning controls, Models.

Theory:

The controls are very essential for satisfactory and economical working of a refrigerant. The electrical connection diagram of a domestic refrigerator is shown in fig. The refrigerant is fitted with following controls.

1. Overload protector:

The basic function is to protect the compressor motor winding from damage due to excessive current, in the event of overloading or due to some fault in the electric circuit. It consists of a bimetallic strip. During the normal working of the compressor, the contacts are closed. Whenever there is any abnormal behaviour, the bimetallic strip gets heated and bands, thereby opening the motor contacts, and de- energizing it. The overload protector is fitted on the body of the compressor and operates due to the combined action of heat produced when current passes through the bimetallic strip and a heater element, and heat transferred from the compressor body. It may be noted that the abnormal behaviour of compressor may be due to low voltage, high voltage, high load, low suction pressure, high suction & discharge pressure.

2. Thermostat:

A thermostat is used to control the temperature in the refrigeration. The bulb of the thermostat is clamped to the evaporator or Freezer. The thermostat bulb is charged with few drops of refrigerant. The thermostat can be set to maintain different temperature at a time. When the desired temperature is obtained, the bulb of the thermostat senses it; the liquid in it compresses and operates the bellows of the thermostat and open compressor motor contacts. The temperature at which motor stops is called cut-out temperature. When the temperature increases, the liquid in the bulb expands thereby closing the bellow contact of the compressor motor. The temperature, at which compressor motor starts, is called cut-in temperature. A thermostat is very crucial in operation of refrigerator as the running time of compressor is reduced considerably thereby cutting the operation cost as well as enhancing the compressor life due to non-continuous working.

3. Flow control devices:

The major devices under this category air the expansion devices. The purpose of the expansion devices is twofold: it must reduce the pressure of the liquid refrigerant, and it must regulate the flow of refrigerant to the Evaporator. An expansion device offers a resistance to flow so that the pressure drops Resulting in a throttling process. Basically, there are two types of expansion devices.

I. Variable restriction type

II. Constant Restriction Type

I. Variable restriction type

In the variable restriction type the extent of opening or area of flow keeps on changing depending on the type of control. There are two common types of such control devices viz,

A. Thermostatic expansion valve.

B. Automatic expansion valve.

A. Thermostatic Expansion value (TEV):

The name may give an impression that it is a temperature control device. It is not a temperature control device and it cannot be adjusted and used to vary evaporator temperature. Actually, TEV is a throttling device which works automatically maintaining proper and correct liquid flow as per the dictates of the load on the evaporator. Because of automatic operation, high efficiency and ability to prevent liquid flood backs this value is extensively used.

P1 = Thermostatic Elements Pressure P2 = Evaporator Pressure

P3 = Pressure Equivalent of the Superheat Spring Force

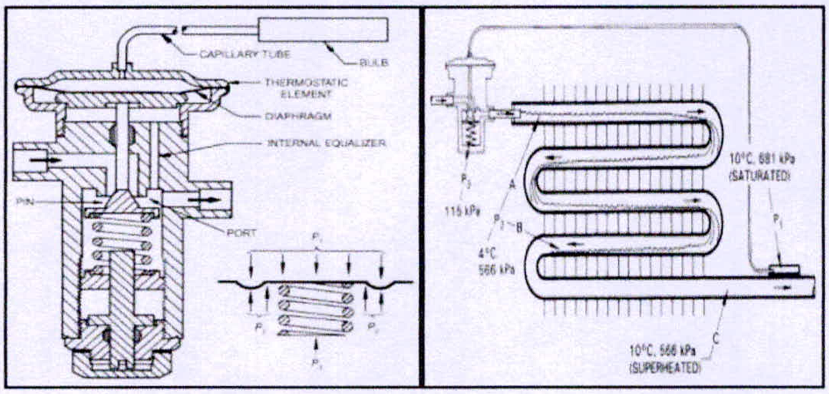


Figure 3.1 Thermostatic Expansion Valve

The functions of thermostatic expansion value are:

1. To reduce the pressure of the liquid from the condenser pressure to evaporator pressure.

2. To keep the evaporator fully active.

3. To modulate the flow of liquid to the evaporator according to the load requirement of the evaporator so as to prevent flood back of liquid refrigerant to the compressor.

4. Pressure P1 in the power element acts to open the valve i.e. to move the value needle away from its seat.

5. The evaporator pressure P2 acts as the bottom side of the diaphragm of the power element tending to close the value.

6. Pressure P3 of the superheat spring also assist in the closing action. Therefore, if the power element pressure P1 is greater than the constrained pressure of P2 and P3, the value will open. It does last two functions by maintaining a constant superheat of the refrigerant at the outlet of the

evaporator it would be more appropriate to call it a "constant superheat valve". The important parts of the valve are power element with feeler bulb, value seat, needle and a superheat adjustment spring. The power element is charged with a refrigerant. The operation of the valve i.e. the closing and opening of the value are controlled by their basic forces. The force balance is shown in figure

B. Automatic Expansion Valve:

AEV is also called as constant pressure expansion value. As name implies it maintains a constant pressure in the evaporator. It works on the same principle as the pressure reducing valves used in compressed air lines, oxyacetylene cylinders etc. A schematic diagram of the constant pressure Expansion. Valve is shown in figure

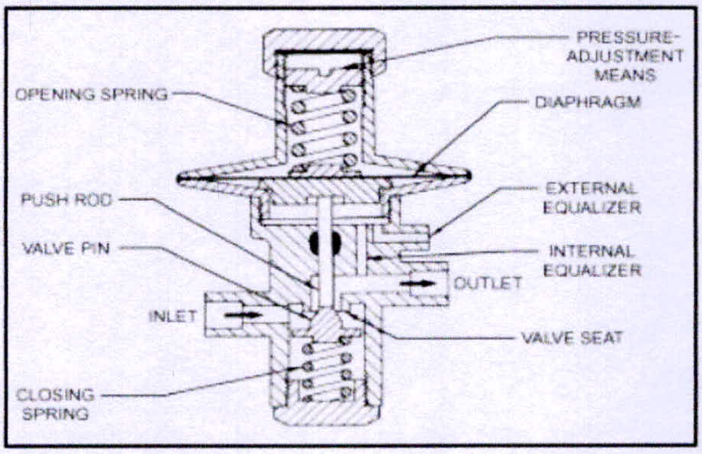


Figure 3.2 Automatic Expansion Valve

The valve consists of seat and needle- which forms the orifice, a metallic diaphragm or bellow, spring and an adjusting screw. The spring pressure and the atmospheric pressure acts on top of the diaphragm, thereby moving the needle away from it seat that is moving the needle valve in the opening direction. The evaporator pressure acts below the diaphragm moving the needle valve towards the closing position. Thus, the evaporator pressure and spring pressure oppose each other and whichever is greater will determine the position of the needle with respect to the seat.

When the plant is running the value maintain an evaporator pressure in equilibrium with the spring pressure plus atmospheric pressure. The tension of the spring can be varied by the spring adjusting screw. The value operates automatically to maintain a constant evaporator pressure as per the setting of the spring pressure. By adjusting the tension of the spring, the evaporator pressure can be varied. Once a setting is made, the valve functions to maintain a constant evaporator pressure. Hence it is called the constant pressure expansion valve". Once the plant stops, the evaporator pressure increases due to the vaporization of the liquid left in the evaporator. This increase in pressure acts on the diaphragm against the spring pressure and closes the valve tightly. It remains closed until the compressor start again and reduces the pressure in the evaporator which is advantageous.

II. Constant Restriction Type

The capillary tube, a long tube with very small bore comes under constant restriction type expansion devices. The capillary tube is a fixed restriction type device. It is a long narrow tube connecting the condenser directly to the evaporator. The pressure drop through the capillary tube is due to the following reasons:

1. Friction due to fluid viscosity, resulting in frictional pressure drop.
2. Acceleration, due to the flashing of the liquid refrigerant into vapour resulting in momentum pressure drop.

The mass flow through the capillary tube will, therefore be adjusted so that the pressure drop through the tube just equals the difference in pressure between the condenser and evaporator. For a given state of the refrigerant, the pressure drop is directly proportioned to the length and inversely proportional to the bore diameter of the tube. A number of combinations of length and bore are possible for a capillary tube to obtain the desired flow and pressure drop. However, once a capillary tube has been selected, it will be suitable only for the designed pressure drop and flow. It cannot satisfy the flow requirements with changing condenser and evaporator pressures. Even then it is most commonly used expansion device in small refrigeration units such as domestic refrigerators, window A/C, water coolers, etc. The advantages of a capillary tube are its quite working, simplicity, low cost and absence of any moving part. Also, it is found most suitable with on-off control because of its unloading characteristics. Thus when compressor stops it allow high and low pressure to equalize, thereby enabling the compressor motor to restart on no load. Accordingly lower starting torque motors can be used.

4. Safety Devices:

a) High pressure and low-pressure cut-out:

Refrigerant compressors are provided with high pressure (HP) and low pressure (LP) cut outs. High pressure cut-out is merely a safety control. When the head pressure increases beyond a set point, the HP cutout cycles off the compressor in order to avoid the possible damage to the compressor. When the head pressure subsequently drops, the circuit is once again closed and the compressor starts. Because of the possibility of scale formation in condenser tubes and the failure of water supply high pressure cutout are essential in the system with water cooled condensers. These cutouts require manual setting. The low-pressure cutout is used both as safety control as well as temperature control. The evaporator governs the suction pressure. A low-pressure cutout is actuated by change in suction pressure and can be indirectly used to control the evaporator temperature.

b) Starting relays:

The relays are generally used in hermetic type units. It allows the flow of electricity through the starting winding of the motor and disconnects the starting winding or starting capacitor from the circuit when the motor reaches 75% of its rated speed. There are two types starting relays.

i. Current relay

ii. Voltage relay.

i. Current Relay: The current relay is used primarily with capacitor start induction motors for disconnecting the starting winding and starting capacitor from the circuit. It is a Magnetic type relay and actuated by the change of current flow in running winding during starting and running periods of motor. It consists of few turns of copper wire in which soft iron plunger is free to more up and down. This soft iron plunger is free to more up and down. This soft iron plunger may be called electronic net. It is connected in series with the running winding and the contact points, which are fitted near the electromagnet, are connected in series with the current relays with the starting winding.

When the motor is energized, the current flow through the relay in the running winding. In the starting, the magnetic field produces around the relay and attracts the plunger to close the contact thus energizing the stating winding. The speed of the motor increases gradually and when it reaches 75% of its rated speed, the motor current and magnetic field of the relay decreases. Permitting the contact points to open. Then motor runs on running winding alone.

ii. Voltage Relay:

The voltage relay is growing in popularity, especially in the larger units. Its operation depends on the increase in voltage as a unit approaches and reaches its rated speed. In construction, the voltage coil made of many turns of wire as compared with current coil which is made of few turns of heavy wire and is connected parallel with starting winding. A set of content points are

Determining dew point

The dew point is the temperature at which water vapor starts to condense out of the air. Once the dry bulb and wet bulb temperatures are known, the dew point can be determined from a chart.

Measuring atmospheric conditions

A sling psychrometer can also measure air temperature, surface temperature, and other atmospheric conditions.

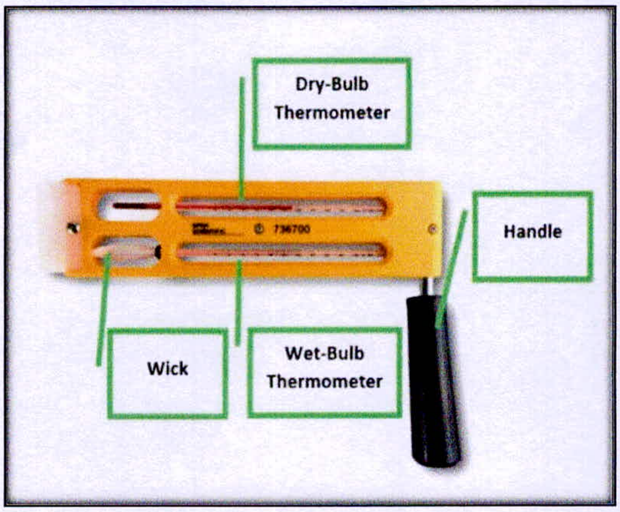


Figure 3.4 Sling Psychrometer

Exercise:

1.	State the name of Different types evaporative devices used in refrigeration system. Explain Automatic expansion valve.
2.	Explain construction, working, advantages and disadvantages of Thermostatic Expansion valve with neat sketch

Conclusion: Hence, we have Studied of Controls used in Refrigeration & Air conditioning Systems.

Aim: To Understand Construction and Working of Reciprocating, Rotary and Centrifugal Compressor Used for Refrigeration & Air Conditioning.

Objective:

1. To study construction and working of reciprocating, rotary and centrifugal compressor

Apparatus used: Schematic diagrams of Refrigeration and Air Conditioning controls, Models.

Theory:

The compressor is the heart of vapour compression system. The compressor is used to reclaim the refrigerant vapour leaving the evaporator. The refrigerant must be compressed to the pressure corresponding to a saturation temperature higher than the temperature of the naturally available air or water. The compressor is also used to circulate the refrigerant through the system. The capacity of compressor determines the capacity of refrigeration system as a whole. The refrigeration compressor and gas or air compressor differs very much because the refrigerating compressor is integral part of the cycle and it is coupled to other components.

Classification:

Classification of refrigeration compressors:

1. Reciprocating compressor.
2. Rotary compressor.
3. Centrifugal and scroll compressor.

1. Reciprocating Compressor:

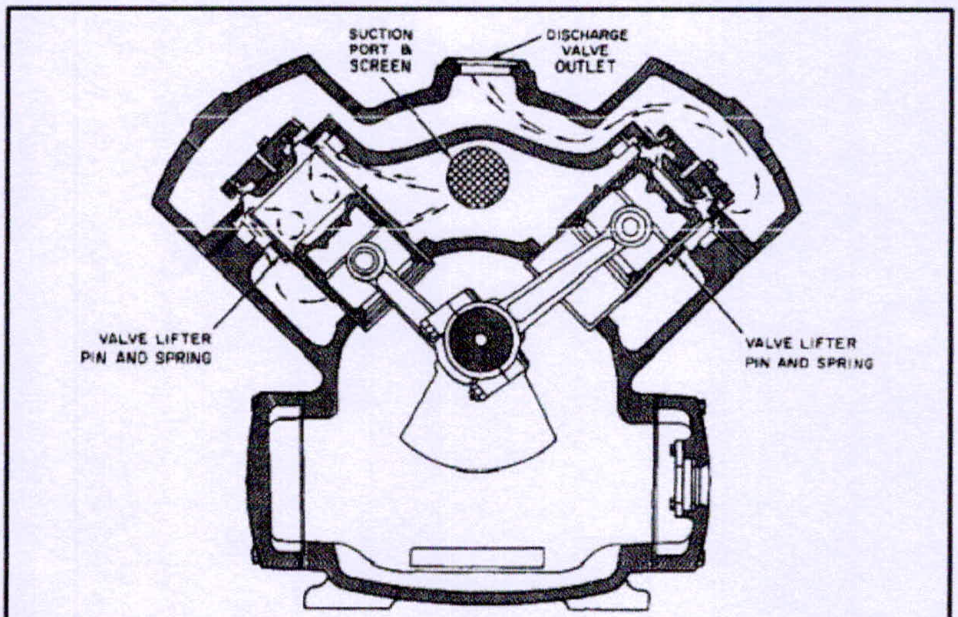
The reciprocating compressors are available in sizes as small as 1/12 hp up to about 150 hp for large capacity installation. The reciprocating compressors are of three types.

a) Open type compressor.

b) Hermetically sealed compressor.

a) Open type of compressor:

A compressor whose crankshaft extends through the compressor housing so that a motor can be externally coupled to the shaft is called open type compressor. These types of compressors adopt a volumetric compression system using pistons and work much like an internal combustion engine. The pistons run up and down inside cylinders, producing suction and compression of the refrigerant gas. Each cylinder has a suction valve for the gas refrigerant and a discharge valve to deliver the gas to the condenser after having been compressed. A disadvantage of the open type of compressor is that the shaft seal is most vulnerable point for leakage of refrigerant.



Reciprocating compressor.

Figure 4.1 Cross-Section of Open Type compressor

b) Hermetically sealed compressor:

In hermetic compressor there is no need for shaft seal. The compressor and motor are mounted on single shaft and whole assembly is fixed in a steel shell, the joint of which are welded. The losses due to drive package and shaft seal friction are also eliminated i.e. the power required per tonne of refrigeration is less than that of the open type.

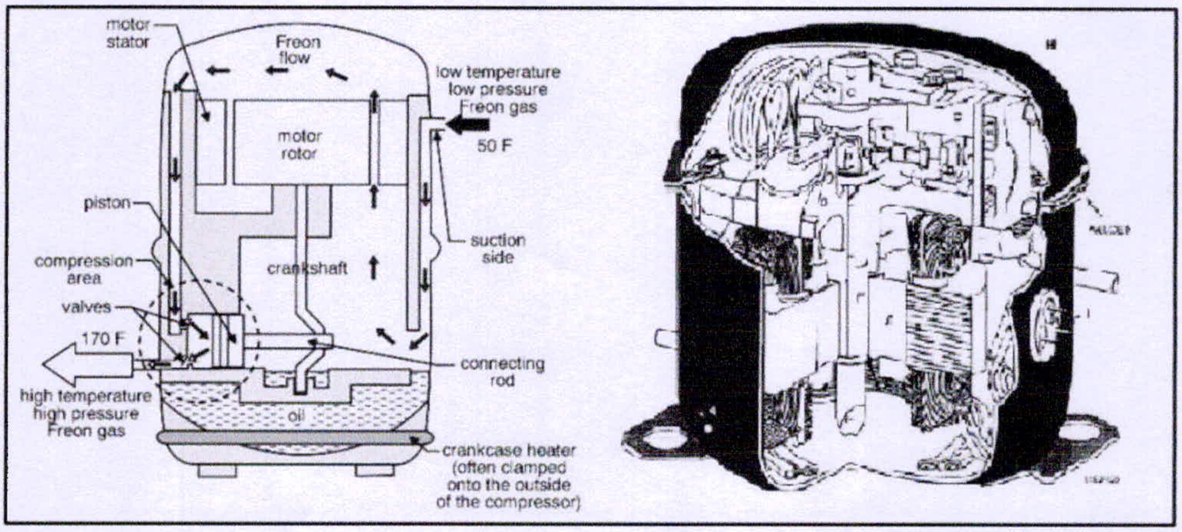


Figure 4.2 Schematic Diagram of Hermetically sealed compressor

In a hermetic reciprocating compressor, as a result of the perfect hermetic sealing of the refrigeration circuit on the compressor body, unlike the two alternative variants – there are no refrigerant leaks possible. They are suitable for air conditioning, cold rooms or low temperature applications, the technology is very reliable, and they come in many different designs for all common refrigerants.

2. Rotary compressor:

As the name implies, the displacement and compression of the refrigerant vapour is achieved due to circular or rotary motion instead of reciprocating motion. These compressors are very efficient because the actions of taking in refrigerant and compressing refrigerant occur simultaneously. They have very few moving parts, low rotational speeds, low initial and maintenance costs, and are forgiving in dirty environments. However, they are limited to smaller volumes of the gas and produce less pressure than other types of compressors. There are two types of rotary compressor.

a) Rolling or Stationary Single Blade type rotary compressor: The main components of rotary compressor are cylinder, roller mounted eccentrically on motor shaft and a spring-loaded shaft.

The roller moves eccentrically on the driver shaft inside a stationary cylinder. The vane moves up and down in the slot. This vane is dividing line between the suction and discharge of compressor

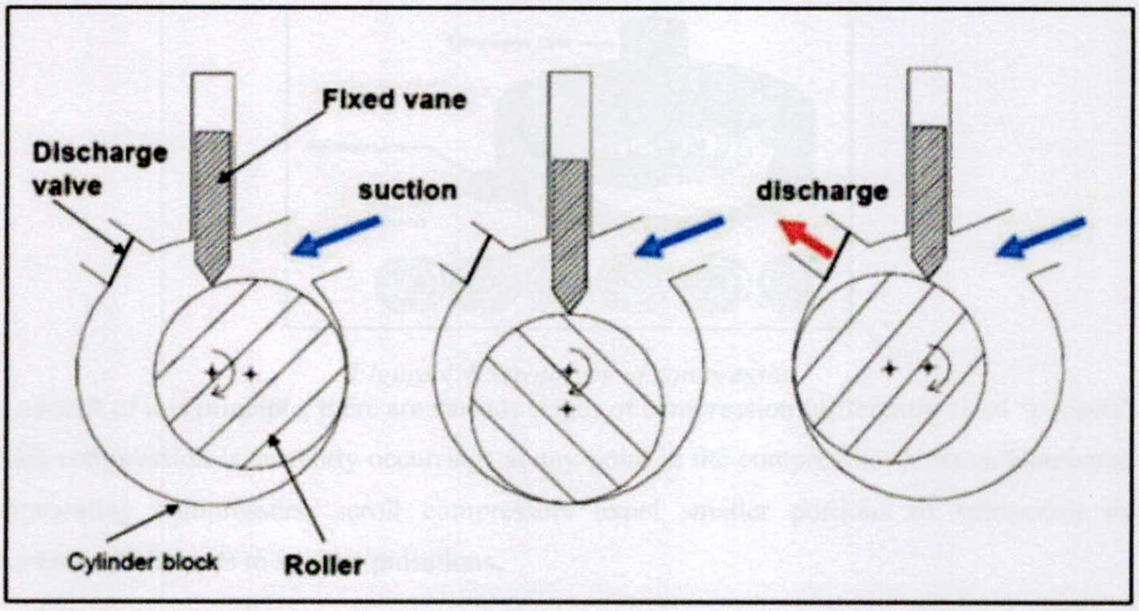


Figure 4.3 Schematic diagram of Rolling type compressor

The suction and discharge ports of the compressor are located on either side of the vane. The suction vapour entering the cylinder gets compressed due to eccentric rotation of the rotor. It progressively reduces the volume of the annular space between cylinder and the rotor. The compressed vapor passes out of the discharge port.

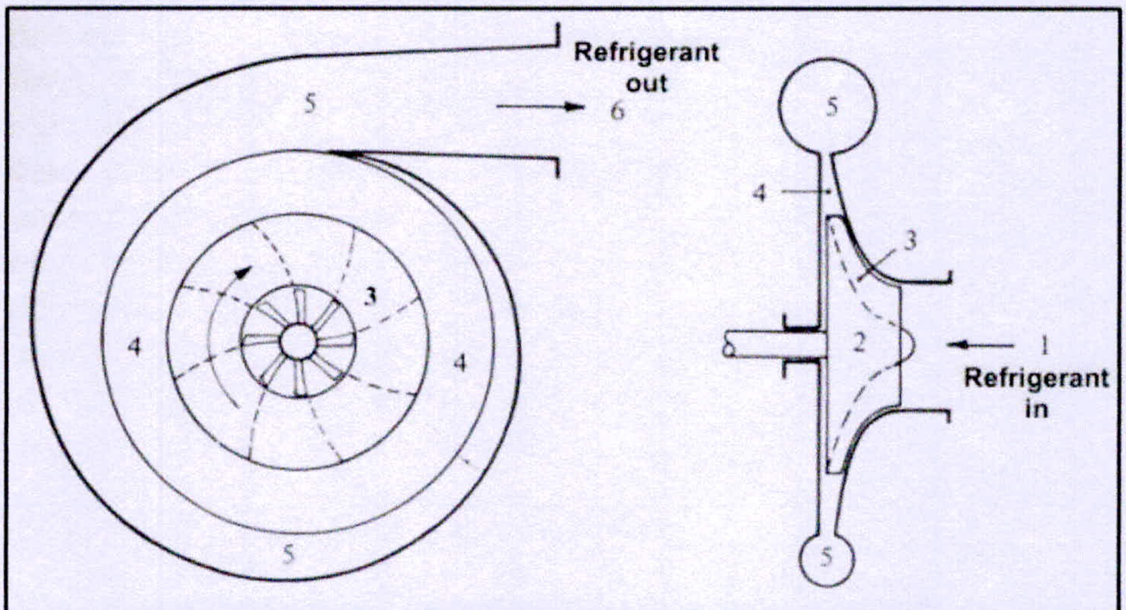
b) Scroll type compressor:

Scroll compressors are in widespread use in air-conditioning systems (their classic application is chiller). In scroll compressors, the crankshaft is arranged vertically. The scroll set is located above it. This scroll set comprises one fixed and one orbiting spiral. These two spirals mesh with one another, compressing the refrigerant through an orbital motion from the outer part of the scroll set towards the middle.

The rotor whose shaft is connected to motor is called as male rotor and other as female. When the male rotor rotates, the female rotor in turn rotates, obviously in opposite direction.

3. centrifugal compressor

Centrifugal compressors are similar in construction to centrifugal pumps, the incoming fluid enters the eye of the spinning impeller and is thrown by centrifugal force to the periphery of the impeller. Thus, the blades of the impeller impart a high velocity to the gas and also build up the pressure. From the impeller the gas goes either into diffuser blades or into a volute casing, where some of the kinetic energy is converted into pressure.



21.1. *Centrifugal Compressor*
1: Refrigerant inlet (eye); 2: Impeller; 3: Refrigerant passages
4: Vaneless diffuser; 5: Volute casing; 6: Refrigerant discharge

Figure 4.6 Centrifugal Compressor

The centrifugal compressors may be manufactured with only one wheel if the pressure ratio is low, although the machines are generally multistage. Centrifugal compressors operate with adiabatic compression efficiency of 70 to 80%.

Different protective devices used on compressors:

Protective devices are designed to protect the compressor against abnormal working conditions.

1. High pressure cutout switch.
2. Internal pressure relief value.
3. Low pressure switch
4. Motor winding thermal protector (Thermostat)
5. Time delay relays

Exercise:

1	Write brief note on Hermetically sealed compressor also give advantages
2	What is a multi-stage compressor? Give its advantages
3	What are the advantages and disadvantages of centrifugal compressor over reciprocating compressors?
4	Explain working of screw type compressor.

Conclusion: Hence, we have Studied Construction and Working of Reciprocating, Rotary and Centrifugal Compressor Used for Refrigeration & Air Conditioning.

Aim: To conduct trial on refrigeration test rig for recognizing Principle of operation and Actual Working of a system and To Calculate COP of System.

Objective:

1. To understand principle of operation and working of vapour compression system.
2. To calculate theoretical, actual and relative C.O.P. of the system

Working:

The refrigeration system works on vapour compression cycle. The refrigeration is the process of (maintaining a closed space temperature below the surrounding temperature) is accomplished continuously circulating, evaporating and condensing a fixed supply of refrigerant in a closed system. Evaporation occurs at a low temperature and low pressure while condensation occurs at a high temperature and pressure. Thus, it is possible to transfer heat from an area of low temperature to an area of high temperature. (the surrounding). The compressor pumps the low-pressure vapour refrigerant from evaporator, increases pressure and discharge high pressure vapour refrigerant to the condenser. In the condenser heat rejected to the surrounding by passing air over it.

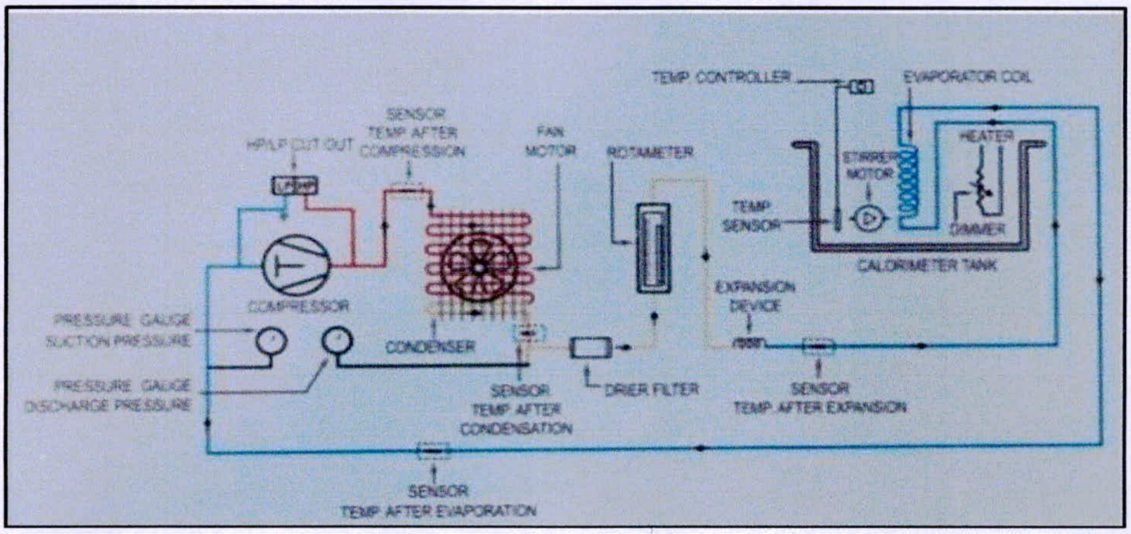


Figure 5.1 Schematic diagram of Refrigeration system.

At that pressure refrigerant losses its latent heat and liquefies. Then the refrigerant passes through the drier/filter where any residual moisture or foreign particles present, these are plugged the flow rate of refrigerant into the evaporator is controlled by the expansion device. Where its pressure and consequently temperature is lowered to the saturation temperature at the corresponding pressure. The low temperature vapour enters evaporator where it absorbs heat from the surrounding medium and evaporators. The compressor draws the cold vapour and the cycle repeats. The schematic diagram of experimental setup is shown in figure 5.1 and photographic view in figure 5.2.

Operating Instructions:

1) Place the machine in the proper position where its level is horizontal and it is well ventilated.
2) Give 230 volts, 50 Hz and single-phase electric supply to the unit.
3) Fill the colorimeter or isothermal bath with clean water
4) Start the compressor by putting the switch ON.
5) The pump in the calorimeter will equalize the temperature in the tank.
6) Put ON the supply of heater.
7) Refrigerant circulated through the tube absorb heat from the water and equal amount of heat supplied from the heater to maintain the temperature of the bath practically constant.
8) Load = Refrigeration effect.
9) Record all the readings as per the observation table
10) Allow at least Half an hour running time for the correct results
11) Calculate the results as per the procedure mentioned.

CAUTION:

- Always start the machine only after ensuring adequate water level in the tank.
- Do-not switch on the heater in the dry tank
- Do-not tamper with the temperature as well as the pressure settings.

Technical Specifications:

Component	Specifications
Compressor	Hermetically sealed. Emerson make
Capacity	500 watts @ rated test condition
Condenser	Forced convection air coole
Drier/Filter	Molecular sleeve type
Expansion Device	Capillary tube and Thermostatic expansion valve
Evaporator	Shell and coil type
HP/LP cut out	Provided
Pressure gauges	2 numbers, (Bourdon tube)
Temperature indicator	Provided (As well as wells are provided to measure temperature at varies point using ordinary thermometer)
Energy meter	Provided for compressor and heater
Refrigerant	R-134 a

Standard Values and Formulas:

Standard Barometric Pressure	**1.013 bar = 1.013 x 105 N /m2**
Density of Water	**1000 kg / m3 = 1 kg / litre**
Specific heat of water	**4.18 kJ/kg K**
Gas Constant for Air	**287 J / kg K**
Specific Gravity of R-134a at 400 C	**1.2**
1 Ton of Refrigeration effect	**3500 Watts = 3.5 kJ / s**
Density of air at 250 C	**1.1 kg/m3**
1 kWHr (kilowatt-hour)	**3600 kJ**
1 bar	**14.5 psig**

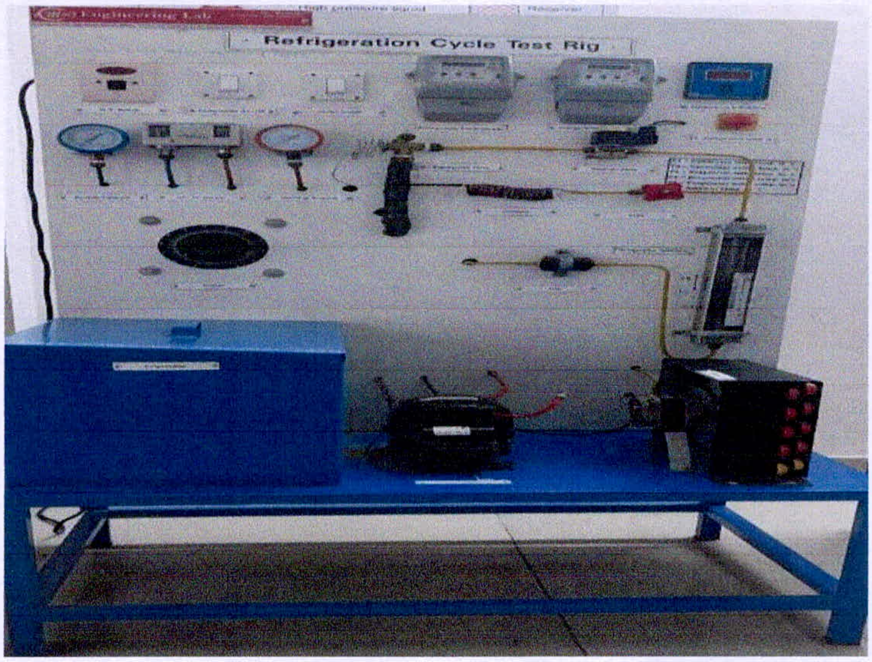


Figure 5.2 Photographic view of Refrigeration Cycle Test Rig.

Observation Table
(Note-Take first reading when heater starts)

Time	Refrigerant temp. (°C)				Water temperature °C	Energy meter (kWhr) compressor.	Energy meter (kWhr) heater.	Refrigerant Pressure Psig		Refrigerant flow lph
						E1 – time for 10 pulses	E2 – time for 10 pulses	Suction	Discharge	
Hrs	After evaporator - 1	After compressor - 2	After condenser - 3	After Expansion - 4	5			P1	P2	Vr

Calculations:

1. To calculate actual C.O.P. of the system:

A. Method:1

Actual refrigeration effect	=	Heater load
	=	Energy meter reading
		Time for 20 pulses
		Energy meter constant = 3200 pulses per kWhr.
		$N = \frac{\text{Number of pulses} \times 3600}{t_{Heater} \times \text{Energy meter constant(Heater)}}$
Actual refrigeration effect	=	

Actual Compressor work w	=	Time for 20 pulses
		Energy meter constant= 3200 pulses per kWhr.
		$W = \frac{\text{Number of pulses} \times 3600}{t_{compressor} \times \text{Energy meter constant(compressor)}}$
Actual Compressor work w	=	

Actual coefficient of performance	=	Actual refrigeration effect/ Actual compressor work
	=	N/W
	=	

B. Method:2

Actual refrigeration effect (N)	=	Mass of Water in tank*Specific heat of water* (Final temperature of water- intimal temperature of water)/ Duration of trail
	=	
Actual refrigeration effect (N)		

Actual coefficient of performance	=	Actual refrigeration effect/ Actual compressor work
	=	N/W
	=	

2. To calculate theoretical C.O.P. of the system:

We have

Average suction pressure ($P_{scution\ gauge}$) =……………………… bar

Average discharge pressure ($P_{discharge\ gauge}$) =……………………… bar

Absolute suction pressure= Suction gauge pressure+ barometric pressure = ……………….bar

Absolute discharge pressure= discharge gauge pressure+ barometric pressure =…………….. bar

Accordingly,

Enthalpies of refrigerant at salient points are

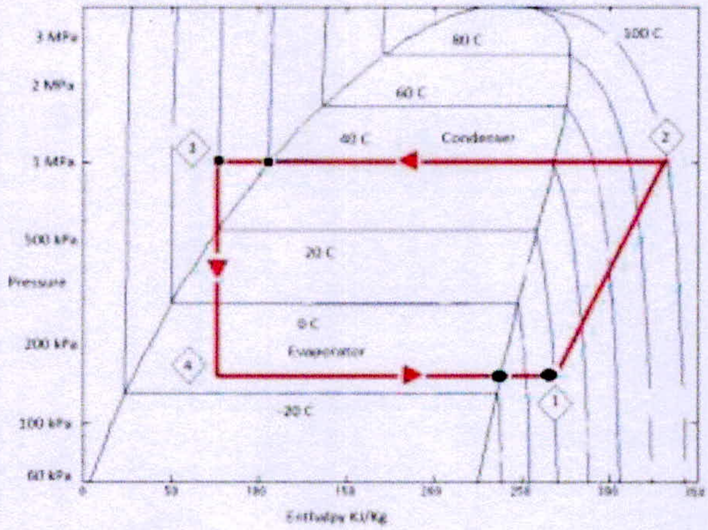


Figure 5.3. P-h Chart of R-134a

Accordingly,

Enthalpy of refrigerant at inlet of compressor h1 =____________ kJ/kg

Enthalpy of refrigerant at outlet of compressor h2 =____________ kJ/kg

Enthalpy of refrigerant after condensation h3 =____________ kJ/kg

Enthalpy of refrigerant after expansion h4 =____________ kJ/kg

Theoretical refrigeration effect = N = h1-h4= ____________ kJ/kg= h2-h1

Theoretical compressor work = W = ___________kJ/kg

Coefficient of performance = C.O.P. = N/W =__________________

(Note: These valves of enthalpies can be calculated with the help of P-h chart of R- 134a)

3. To calculate Carnot C.O.P. of the system:

$$\text{Carnot C.O.P.} = \frac{T_L}{T_H - T_L}$$

T_L= Saturation temperature to corresponding evaporator pressure (bar)

T_H=Saturation temperature to corresponding condenser pressure (bar).

4. To calculate Relative C.O.P. of the system:

$$\text{Relative C.O.P.} = \frac{\text{Actual C.O.P.}}{\text{Therotical C.O.P.}} = \frac{\ldots\ldots\ldots}{\ldots\ldots\ldots} = ---$$

Conclusion:

1. Understand the working of vapour compression cycle and function of each component.
2. It is observed that Carnot C.O.P. > theoretical C.O.P. > actual C.O.P. due to the losses at varies points.

Aim: To conduct trial on Air-conditioning Cycle test rig for recognizing Principle of operation and Actual Working of a system and To Calculate COP of System.

Objective:

1. To Study of vapour compression cycle for Air conditioner.
2. To calculate actual COP.
3. To study different air conditioning processes:
   a. Humidification
   b. Dehumidification
   c. Cooling
   d. Heating
   e. Heating and Humidification
   f. Heating and Dehumidification
   g. Cooling and Humidification
   h. Cooling and Dehumidification

Specifications:

1. Compressor: hermetically sealed.
2. Condenser: Forced convection air cooled
3. Expansion valve: thermostatic expansion valve
4. Evaporator: Immerse type direct expansion
5. Flowmeter: rotameter
6. Condenser and Evaporator fan: Axial flow type
7. Heater: 1000W

Theory:

Simple Vapour Compression

Figure shows the schematic diagram of simple vapour compression refrigeration system.

It consists of following parts:

1. Compressor

The low pressure and temperature of refrigerant from the evaporator is drawn into the compressor through the inlet and suction valve as it is compressed to high temperature and pressure. This high temperature and pressure vapour refrigerant is discharged into the condenser through the delivery pipe.

2. Condenser

The condenser or cooler consists of pipe in which the high pressure and temperature refrigerant is cooled and condensed. The refrigerant while passing through the condenser gives up heat to the surrounding which consists of condensing medium which is normally air or water.

3. Expansion valve

It is also called as throttle valve and its use is to allow the refrigerant under high temperature and pressure to pass at controlled rate after reducing its high temperature and pressure some of the refrigerant evaporates as it passes through the expansion valve and the graded portion is vapourised in the evaporator at low temperature and pressure.

4. Evaporator

It consists of coils of pipe in which the liquid vapour refrigerant at low pressure and temperature is evaporated and changed to the vapour refrigerant at low temperature and pressure. In evaporating the liquid vapour refrigerant absorbs the latent heat of vapourisation from the medium which is to be cooled.

Psychrometric Terms:

1. **Dry Air:** the pure dry air is mixture of number of gases such as Nitrogen, Oxygen, Carbon Dioxide, Hydrogen, Argon and Helium.
2. **Moisture Air:** It is the mixture of dry air and water vapour.
3. **Saturated Vapour:** It is mixture of dry air and water vapour when the air has diffused the maximum amount of water vapour in it.
4. **Degree of Saturation:** It is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour is same mass of dry air when it is (saturated) at the same temperature.
5. **Humidity:** It is the mass of the vapour present in 1 kg of water and generally expressed in terms of grams per kg of dry air.

6. **Absolute Humidity:** It is the mass of water vapour present in 1 m3 of dry air and is generally expressed in terms of gm/ m3.
7. **Relative Humidity:** It is the ratio of actual mass of water vapour in given volume of moist air to the mass of water vapour in same volume of saturated air.
8. **Dew Point Temperature:** It is the temperature of air recorded by the thermometer when the moisture present in it begins to condense.

PRECAUTIONS:

1. Before taking the readings ensure that the sensing bulb of wet bulb thermometer is properly wetted by soft cloth.
2. Do not start the heater while conducting the experiment for calculating COP.
3. Keep the heater ON during dehumidification process.

Procedure:

4. Keep the test rig on levelled surface.
5. Give 230 V, 50 Hz, and single-phase stabilized power supply to the system and ensure that all the electrical connections are properly made.
6. Start the evaporator fan.
7. Start the compressor.
8. Allow the system to reach the steady state. This can be achieved by turning it for at least 15 minutes.
9. Make the provision to collect condensed moisture.
10. Take readings as per observation table.

Observations:

1. Air velocity = 3.5 m/s.
2. Inlet air duct area = 0.1225 m^2
3. Density of air = 1.1 kg/ m^3

Observation Table:

Time for 10 imp of Energy Meter:

Where,

T1 = Condenser Inlet /compressor outlet temperature

T2 = condenser outlet /liquid line temperature

T3 = evaporator inlet temperature

T4 = evaporator outlet temperature

T5= Air inlet temperature

T6 = Air outlet temperature

SR. NO	PROCES	INLET DBT	INLET WBT	OUTLET DBT	OUTLET WBT	REMARKS
1.	Heating					Only heater ON
2.	Cooling					Only lamp ON
3.	Humidification					Humidification
4.	Humidification and Cooling					Humidification and lamp ON
5.	Heating and Dehumidification					Humidification and heater ON
6.	Cooling and Dehumidification					Dehumidification and Lamp ON

CALCULATION: **$m = Q*\rho$**

Now,

Inlet DBT = 92°F = (92-32)/1.8 °C = 33.5°C

Outlet DBT = 58°F = (58-32)/1.8 °C = 14.44°C

Refrigeration Effect = m. δh

From chart,

h1 = h2 =

Refrigeration Effect = m. δh

Now work done by compressor

$$C_w = \frac{n \times 3600}{t_c \times EMC_c} \quad Kw.$$

SR. NO.	TIME	INLET DBT	TEMP WBT	OUTLET DBT	TEMP WBT	LP PSI	HP PSI
1							
2.							
3.							
4							
5.							

SR. NO.	T1 °C	T2 °C	T3 °C	T4 °C
1.				
2.				
3.				
4.				
5.				

So COP (actual) = R.E/W.D

Thus, W.D. = COP = R.E/W.D.

P1 = Absolute suction pressure = $P_{atm} + P_g$, P2 = Absolute suction pressure

T1 =…….T2 =…….T3 =……..T4 =…………

By P-h Chart,

h1 =……kJ/kg h2=……..kJ/kg h3 = h4 =………..kJ/kg

COP (theoretical) = $(h_1 - h_4) / (h_1 - h_2)$

Conclusion: Hence, we have studied vapour compression cycle for Air conditioner and study different air conditioning processes also Calculated

1. Theoretical COP =
2. Actual COP =

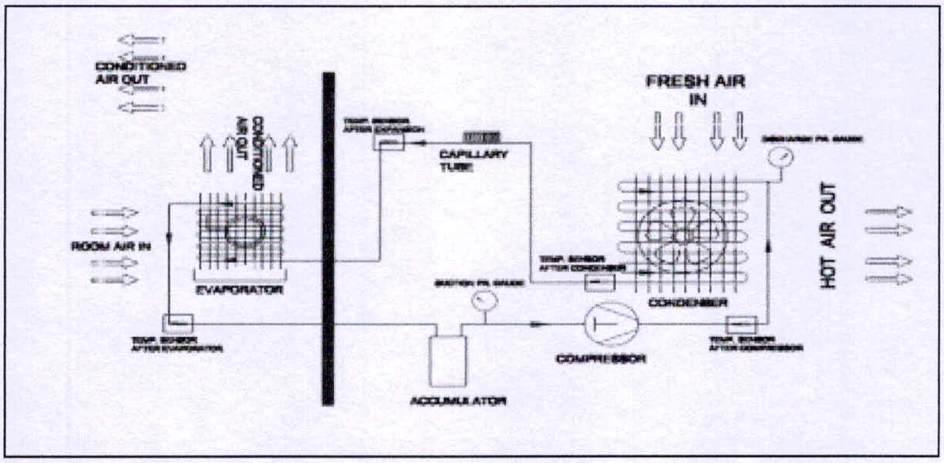


Figure 6.1 Schematic diagram of Refrigeration system

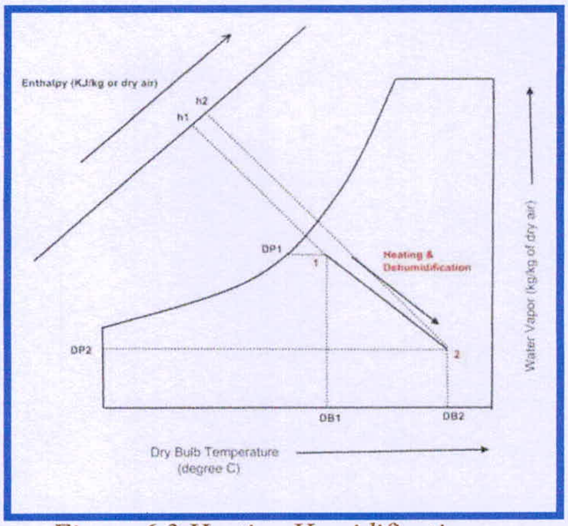


Figure 6.3 Heating Humidification

Figure 6.2 Photographic view of Refrigeration Cycle Test Rig

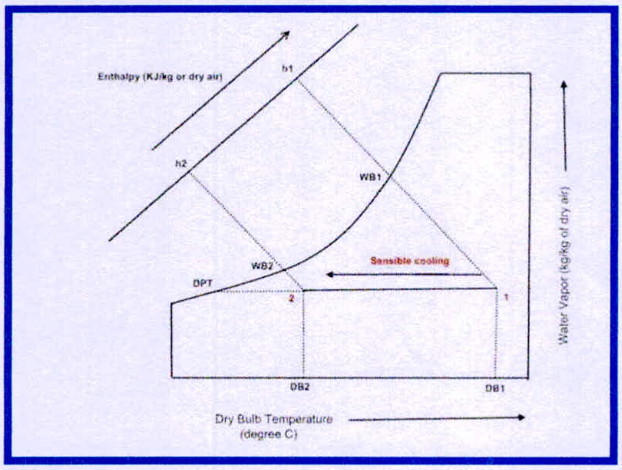


Figure 6.4 Heating

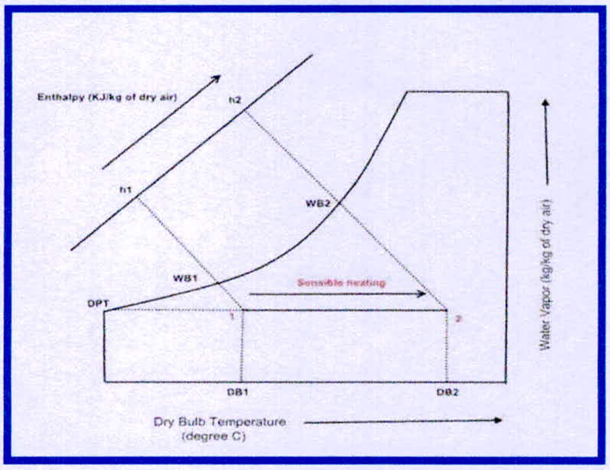


Figure 6.5 Cooling

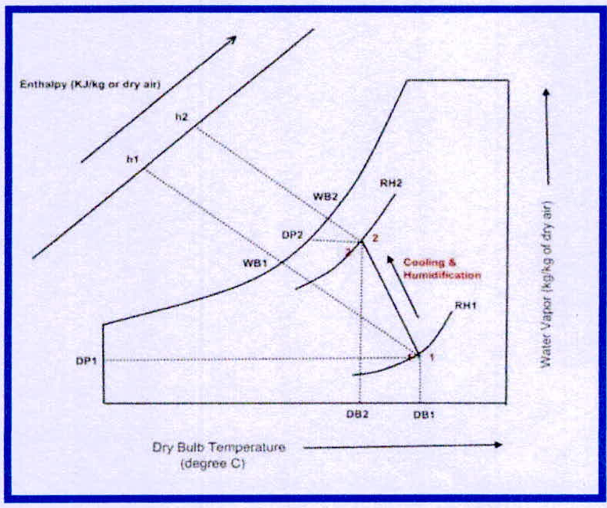


Figure 6.6 Cooling Humidification

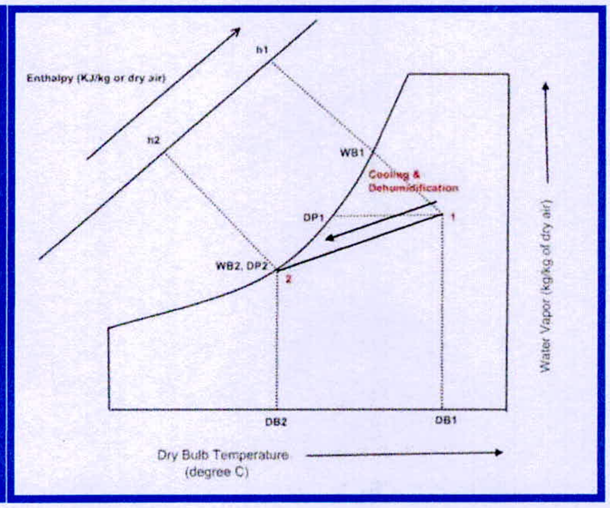


Figure 6.7 Cooling Dehumidification

Aim: To conduct trial on Heat Pump test rig for recognizing Principle of operation and Actual Working of a system and To Calculate COP of System.

Objective:

1. To recognize principle of operation and working of heat pump system.
2. To calculate theoretical, actual and relative C.O.P. of the system

Working:

The apparatus consists of refrigeration system with water-cooled shell coil type evaporator and condenser. A hermetically sealed compressor using R-134a refrigerant, Compresses the refrigerant and sends to the condenser.

Liquid refrigerant from the condenser passes through flow meter and drier/filter to capillary tube, where it is throttled to low pressure and temperature. The low temperature refrigerant passes to evaporator, boils in evaporator while absorbing heat from the water surrounding the coil and this low pressure superheated refrigerant returns to compressor.

The condenser and evaporator are shell and coil type with continuous water flow. Flow rates of condenser and evaporator can be changed to obtain different working temperatures for condenser and evaporator. Heat collected in evaporator, heat rejected to condenser and input to the system can be measured and performance of the system can be evaluated as refrigeration cycle or as a heat pump. The schematic diagram of mechanical heat pump is shown in figure 1.

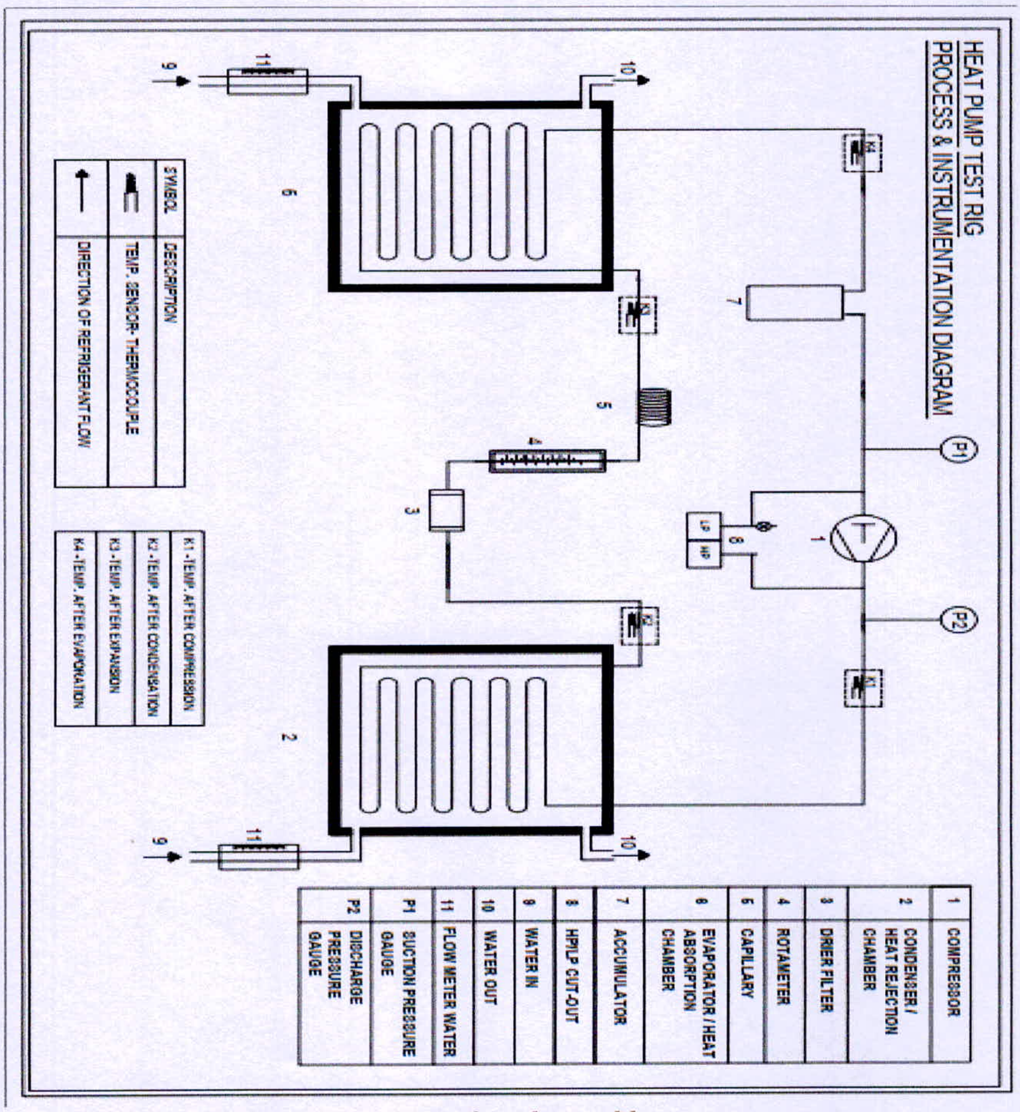


Figure 7.1. Schematic diagram of mechanical heat pump system.

Specifications:

1. Compressor - Hermetically sealed Emerson Climate Tech compressor,
2. Refrigerant -R-134a
3. Condenser - Shell and coil type condenser.

4. Evaporator - Shell and coil type evaporator.
5. Expansion device – capillary tube.
6. Measurements -

   A. Pressure gauges for condensing and evaporating pressure - 2-nos.

   B. Wattmeter for compressor input measurement.

7.Controls - Overload protector for compressor.

8. Necessary switches and fuse.

Experimental Procedure:

1. Connect the water supply to the unit.
2. Fill both the tanks to 10 liters of clean potable quality of water.
3. Record initial temperature of water in both the tanks
4. Water inlet temperature should be taken before switching on the compressor
5. Switch 'ON" the main supply. Switch 'ON' the compressor.
6. The temperature on the hot side will start steadily increasing and that from the cold side shall be reducing.
7. When the hot side (condenser side) reaches about 50° C, stop the machine.
8. Record the time between initial and final readings.
9. Note down all the readings and complete the observation table.
10. May you need conduct another set of readings, drain the water completely with the help of drain valves provided at the bottom and refill the tanks with fresh water and repeat the procedure.

Standard Values and Formulas

Standard Barometric Pressure	1.013 bar = 1.013 x 10^5 N /m^2
Density of Water	1000 kg / m^3 = 1 kg / liter
Specific heat of water	4.18 kJ/kg K
Gas Constant for Air	287 J / kg K
Specific Gravity of R-134a at 40 °C	1.2
1 Ton of Refrigeration effect	3500 Watts = 3.5 kJ / s

Density of air at 25 °C	1.1 kg/m3
1 kWHr (kilowatt-hour)	3600 kJ
1 bar	14.5 psig

Observation Table:

Sr.No.	Observations	Readings	Unit
1	Start time		Sec.
2	End time		Sec
3	Cond. water quantity		Liters
4	Evaporator water quantity		Liters
5	Condensing pressure Pc		(psig)
6	Evaporating pressure Pe		(psig)
7	Compressor input time for 10 pulses		sec
8	Temperature after compression		°C
9	Temperature after condensation		°C
10	Temperature after expansion		°C
11	Temperature after evaporation		°C
12	Condenser/ evaporator initial temp		°C
13	Condenser water final temperature (5)		°C
14	Evaporator water final temperature (6)		°C

CAUTION:

- ✓ Do not exceed the condenser side temperature beyond 50 °C
- ✓ Always use fresh water for new set of trials.
- ✓ Keep the tanks clean and dry when not in use.
- ✓ Do not tamper with any of the settings.
- ✓ Keep the unit at least 300 mm away from walls.

Figure 7.2. Photographic view of cascade refrigeration system.

Calculations:

1. To calculate Theoretical C.O.P.

Accordingly,

1. Enthalpy of refrigerant at inlet of compressor h1 =______________ kJ/ kg
2. Enthalpy of refrigerant at outlet of compressor h2 =______________ kJ/ kg
3. Enthalpy of refrigerant after condensation h3 =______________ kJ/ kg
4. Enthalpy of refrigerant after expansion h4 =______________ kJ/ kg

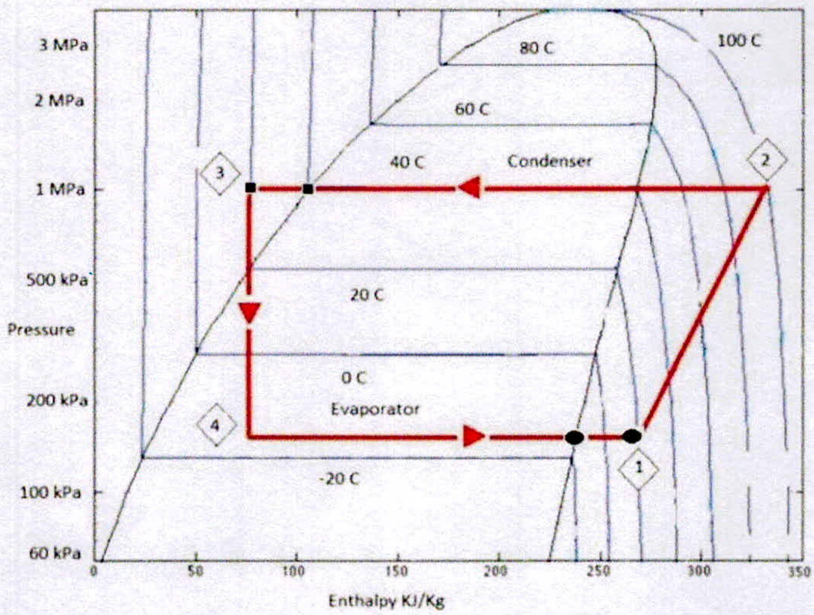


Figure 7.3. P-h Chart of R-134a

5. Theoretical refrigeration effect = N = h1-h4= __________kJ/kg

6. Theoretical compressor work = W = h2-h1 = _________kJ/kg

7. Coefficient of performance = C.O.P. = N/W = _____________

(Note: These valves of enthalpies can be calculated with the help of P-h chart of R- 134a)

Conclusion: Hence, we have evaluated the working Principle of Heat Pump and got the actual C.O.P. of system is….

Aim: To conduct trial on Domestic refrigeration test rig for recognizing Principle of operation and Actual Working of a system and To Calculate COP of System.

Objective:

1. To understand principle of operation and working of vapour compression system.
2. To calculate theoretical, actual and relative C.O.P. of the system

Introduction: Domestic refrigerators use a low temperature vapor compression refrigeration cycle for producing cold temperatures. The scientific unit consists of such a cycle with various measurements provided. A heater provided inside evaporator imposes load over the system. Various measurements provided enable students to understand various parameters in a domestic refrigerator.

Specifications:

1) Compressor - 'Immerson' make Hermetically sealed compressor, using refrigerant R-134a.
2) Finned tube air cooled condenser.
3) flow rate is in lph
4) Capillary tube as expansion device.
5) Evaporator box with heater inside and heater control.
6) Measurements and Controls –
   a) High- and low-pressure cutout.
   b) Thermostat.
   c) Filter/ drier for refrigerant.
   d) Pressure gauges for condensing and evaporating pressures.
   e) Multichannel digital temperature indicator for measuring temperatures at various points.
   f) Energy meters for compressor and heater input measurement.
   g) Necessary switches and valves.

Operating Instructions:

1) Place the machine in the proper position where its level is horizontal and it is well ventilated.
2) Give 230 volts, 50 Hz and single-phase electric supply to the unit.
3) 'ON' the main switch, compressor and heater.
4) Adjust the heater input such that the room temperature (T5) is near to the atmospheric temperature.
5) Note down the various readings and complete the observation table.

Precautions:

1) Never start the heater before starting the compressor.
2) Do not operate any of the valves as they are provided strictly for servicing purpose only.
3) Close the door of the evaporator box before starting the compressor.

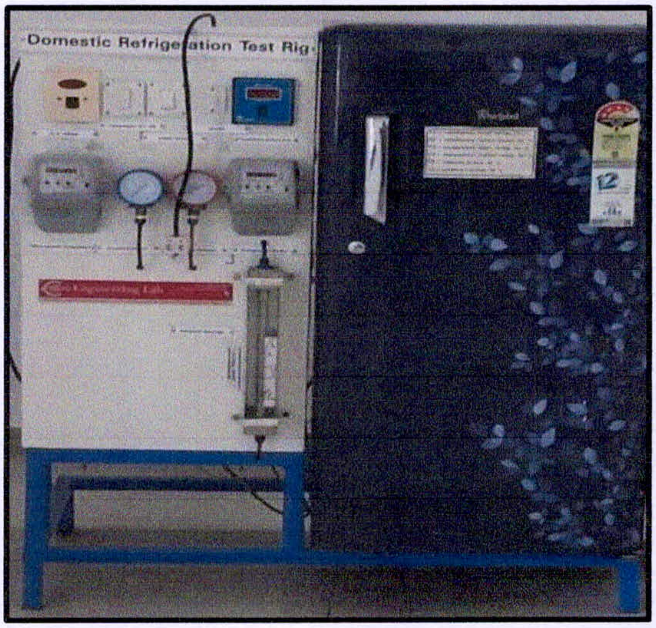


Figure 8.1 Photographic view of Refrigeration Cycle Test Rig

Observation

(Note-Take first reading when heater starts)

1) Condensing pressure = Kg /cm^2 gauge.

2) Evaporating pressure = Kg /cm^2 gauge.

3) Refrigerant temperatures -

i) Condenser inlet 'T1' = ^{o} C

ii) Condenser outlet 'T2' = ^{o} C

iii) Evaporator inlet 'T3' = ^{o} C

iv) Evaporator outlet 'T4'= ^{o} C

4) Room temperature 'T5' = ^{o} C

5) Refrigerant flow, Q = LPH.

6) Compressor input (Time for 5 Rev. of energymeter.), t_c = Sec.

7) Heater input (Time for 5 Rev. of energymeter.), t_h = Sec.

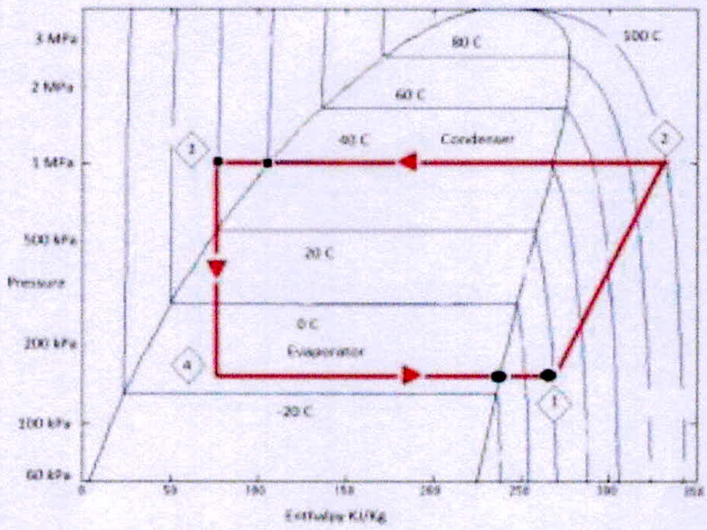


Figure 8.2 P-h Chart of R-134a

Calculations-

1) Theoretical COP - Plot the cycle on p-h chart, using the condensing and evaporating pressures and temperatures.

Find out enthalpies.

Refrigerating effect = **Heo - Hei**

Compressor work = **Hci - Heo**

$$\text{COP theo.} = \frac{\text{Heo - Hei}}{\text{Hci - Heo}}$$

2) Mass flow rate of refrigerant- as per compressor flow is 1 lph

volume flow rate, **Q = LPH.x 10^{-3} m^3 / hr**

Specific volume of refrigerant at condensing pressure **V_s = m3/ Kg.**

Mass flow rate, $m = \dfrac{Q}{V_s}$ **Kg / hr.**

3) Theoretical refrigerating capacity.

R.E. theo = m x (Heo - Hei) KJ / h r.

4) Actual refrigerating effect - As room temperature is constant, nearly all the heat given by the heater is absorbed by the refrigerant. Hence, actual refrigerating effect = heater input.

$$R.E._{act} = \frac{3600 \times 5}{T_h \times 900} \text{ Kw.}$$

Where, T_h is time required for 5 revolutions of heater energy meter disc.

5) Actual compressor work -

$$C.W._{act} = \frac{3600 \times 5}{T_c \times 900}$$

6) Actual COP -

$$COP_{act} = \frac{R.E._{act}}{C.W._{act}}$$

Conclusion: Understand the working principle of operation and working of vapour compression system. Actual COP

Aim: To conduct trial on Ice Plant test rig for recognizing Principle of operation and Actual Working of a system and To Calculate COP of System.

Objective:

1. To study of refrigeration cycle in ice plant and determination of its C.O.P.
2. To Study of variation of various parameters on time for the formation of ice. Viz. ice block thickness, brine temperature, etc.
3. Study of ice plant as a commercial unit i.e. determination of running cost, cost of ice production etc.
4. By taking the readings every hour, the variations in the various parameters against time can be plotted as a graph viz. suction and discharge pressure, compressor power, brine temperature, etc.

Test Procedure:

Test includes following stages,

1) Preparation of brine.
2) Charging the system.
3) Conducting the trial.

1) Preparation of Brine.

All the ice plants use indirect refrigeration system. In this a refrigerating medium called secondary refrigerant or brine is cooled by direct expansion of refrigerant and it is pumped to the spaced to be cooled. These systems are used where danger due to leakage of refrigerant is important and in locations and fluctuating temperatures.

In addition to acting as heat carrying medium brine should have certain other properties. The freezing point of brine should be as low as possible so that it will not freeze at lowest temperatures in the cycle. Also, it should not precipitate when contaminated with refrigerant through accidental leakage.

For preparation of brine, the ice cans filled with water are placed over the ice can frames and fresh water and propylene glycol is filled in the main tank with the ratio of 7:3 respectively till the required level.

2) Charging The System

Initially, the system is charged with CO2 upto the pressure of about 250 PSIG and leaks are detected. After removing the leaks, the system is evacuated by a vacuum pump and kept evacuated. The vacuum is observed for at least a day for conformation of leak-proof operation of the system.

When leaks are completely removed, system is charged with small amount of R-12 refrigerant and the compressor is run for about 1 hour to wash the system by gas. The gas is than purged out and the system is again evacuated.

After second evacuation, small quantity of the refrigerant is added so that pressure gauge shows the reading of about 20 to 30 PSIG. Now start the compressor, so that high and low pressures are obtained on discharge and suction sides of the compressor respectively.

Go on adding the gas slowly till the suction pressure gauge shows the reading of 5 to 10 PSIG. At the same time, high pressure would be about 100 to 140 PSIG depending upon the ambient conditions.

3) Conducting A Trial.

When the brine is prepared and the system is charged as above, the plant becomes ready for trial. The refrigerant circuit is started. The condenser fan and the stirrer motor are put 'ON'. When the brine temperature comes below 0^{o}c, the cans are filled with fresh water and loaded in the freezing tank.

Take various readings as indicated in the observation table. The formation of the ice in the form of flakes will be observed. As time passes more and more flakes will be formed and the ice will go on solidifying at the same temperature. The formation of ice will start from the walls of the can towards the center. Go on noting down the condition of ice. It will be noted that, ice formation takes place earlier in the thinner cans than the cans of greater width. Thus, smaller is the diameter or width, earlier is the ice formation.

After 4 hours of running, all the cans will be found with solid ice. Now, the operation of the plant can be stopped. Whenever ice is needed, the required ice can is taken out of the main tank. Tap water is poured outside the can. As the can is turned upside down, ice block comes out of the can. This operation is known as 'thawing'.

Specifications:

1. Compressor - Hermetically sealed Emerson Climate Tech compressor,
2. Refrigerant -R-134a
3. Condenser - Shell and coil type condenser.
4. Evaporator - Shell and coil type evaporator.
5. Expansion device – capillary tube.
6. Measurements -

   A. Pressure gauges for condensing and evaporating pressure - 2-nos.

   B. Wattmeter for compressor input measurement.

7.Controls - Overload protector for compressor.

8. Necessary switches and fuse.

Experimental Procedure:

1. Connect the water supply to the unit.
2. Fill both the tanks to 10 liters of clean potable quality of water.
3. Record initial temperature of water in both the tanks
4. Water inlet temperature should be taken before switching on the compressor
5. Switch 'ON" the main supply. Switch 'ON' the compressor.
6. The temperature on the hot side will start steadily increasing and that from the cold side shall be reducing.
7. When the hot side (condenser side) reaches about 50^{o} C, stop the machine.

8. Record the time between initial and final readings.
9. Note down all the readings and complete the observation table.
10. May you need conduct another set of readings, drain the water completely with the help of drain valves provided at the bottom and refill the tanks with fresh water and repeat the procedure.

Standard Values and Formulas

Standard Barometric Pressure	1.013 bar = 1.013 x 10^5 N /m^2
Density of Water	1000 kg / m^3 = 1 kg / liter
Specific heat of water	4.18 kJ/kg K
Gas Constant for Air	287 J / kg K
Specific Gravity of R-134a at 40 °C	1.2
1 Ton of Refrigeration effect	3500 Watts = 3.5 kJ / s
Density of air at 25 °C	1.1 kg/m3
1 kWHr (kilowatt-hour)	3600 kJ
1 bar	14.5 psig

Observation Table:

Sr.No.	Observations	Readings	Unit
1	Start time		Sec.
2	End time		Sec
3	Cond. water quantity		Liters
4	Evaporator water quantity		Liters
5	Condensing pressure Pc		(psig)
6	Evaporating pressure Pe		(psig)
7	Compressor input time for 10 pulses		sec
8	Temperature after compression		°C
9	Temperature after condensation		°C
10	Temperature after expansion		°C
11	Temperature after evaporation		°C

12	Condenser/ evaporator initial temp		°C
13	Condenser water final temperature (5)		°C
14	Evaporator water final temperature (6)		°C

Caution:

- ✓ Do not exceed the condenser side temperature beyond 50 °C
- ✓ Always use fresh water for new set of trials.
- ✓ Keep the tanks clean and dry when not in use.
- ✓ Do not tamper with any of the settings.
- ✓ Keep the unit at least 300 mm away from walls.

Figure 7.1 Photographic view of cascade refrigeration system

Calculations:

1. To calculate Theoretical C.O.P.

Accordingly,

1. Enthalpy of refrigerant at inlet of compressor h1 =______________ kJ/ kg
2. Enthalpy of refrigerant at outlet of compressor h2 =______________ kJ/ kg
3. Enthalpy of refrigerant after condensation h3 =______________ kJ/ kg
4. Enthalpy of refrigerant after expansion h4 =______________ kJ/ kg

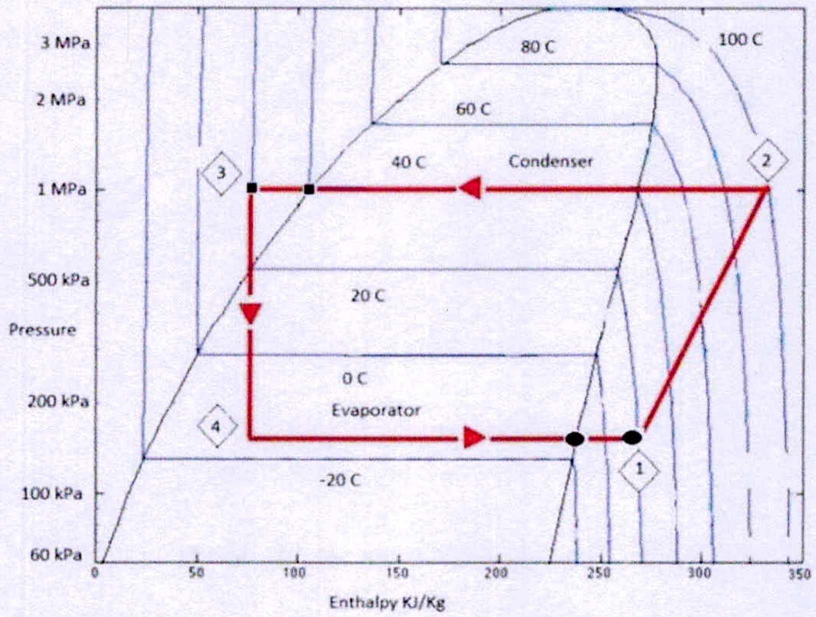


Figure 7.2 P-h Chart of R-134a

5. Theoretical refrigeration effect = N = h1-h4= ___________kJ/kg
6. Theoretical compressor work = W = h2-h1 = _________kJ/kg
7. Coefficient of performance = C.O.P. = N/W = ______________

(Note: These valves of enthalpies can be calculated with the help of P-h chart of R- 134a)

Conclusion: Hence, we have evaluated the working Principle of Heat Pump and got the actual C.O.P. of system is….

Aim: To conduct trial on Water Cooler test rig for recognizing Principle of operation and Actual Working of a system and To Calculate COP of System.

Objective:

1. To understand principle of operation and working of a Water-Cooling System
2. To determine Coefficient of Performance of the system.

Working:

The Water Cooler test set up enables students to study and understand vapour compression cycle, its components, principle and working. All the components are mounted on rigid steel frame. The trainer consists of a hermetically sealed compressor, forced convection air-cooled condenser, filter / drier, expansion device and coil wound type evaporator. Separate pressure gauges are provided to record suction and discharge pressures and digital temperature indicators for various temperatures.

The refrigerant used is R-134a which is environment friendly. The water cooler consists of an insulated stainless-steel tank around which evaporator tubes are wound and soldered. The tubes are made of refrigerated grade annealed copper tubes. This is a direct expansion type evaporator. The heat absorbed by the refrigerant is passed through water which is stored in the tank as shown in figure10.1.

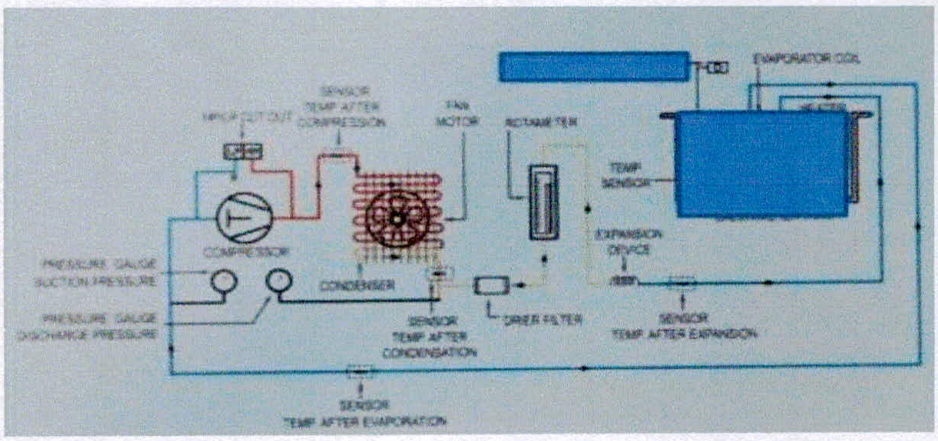


Figure 10.1 Schematic diagram of Water Cooler Test rig

Specifications:

A. Refrigeration System

Parameter	Description
Capacity	20 Liters water storage
Compressor	Hermetically sealed
Condenser	Forced convection air cooled.
Condenser fan	Axial flow type
Evaporator	Direct expansion type
Expansion device	Capillary Tube
Accumulator	Copper / M.S. shell suction line accumulator provided.
Insulation	Polyurethane Foam (PUF)
Refrigerant	R-134 a.

B. Controls & Indications

Temperature	Thermostat with Indication & 6 channel digital display
Pressure	Pressure gauges 2 Nos. provided

C. Electrical System

Supply	230 Volts, 50 Hz, 1 phase.
Input power	500 Watts.
Rated current	2.8 Amps.
Energy-meters	Provided for compressor

D. Construction

Water Tank	Stainless Steel
Outer body	Stainless steel / or powder coated.
Size	1000 x 1200 x 450 (L X H X D) mm

Operating Instructions:

1. Place the machine in the proper position where its level is horizontal and it is well ventilated.
2. Give 230 volts, 50Hz, and 1 phase supply to the unit.
3. Fill water in the tank up to over flow level.
4. Switch ON the main switch.
5. Connect the water supply to the feeding.
6. Start the compressor by putting the switch ON.
7. The tank temperature will start dropping down.
8. Record all the readings as per the observation table.
9. Calculate the results as mentioned in the manual

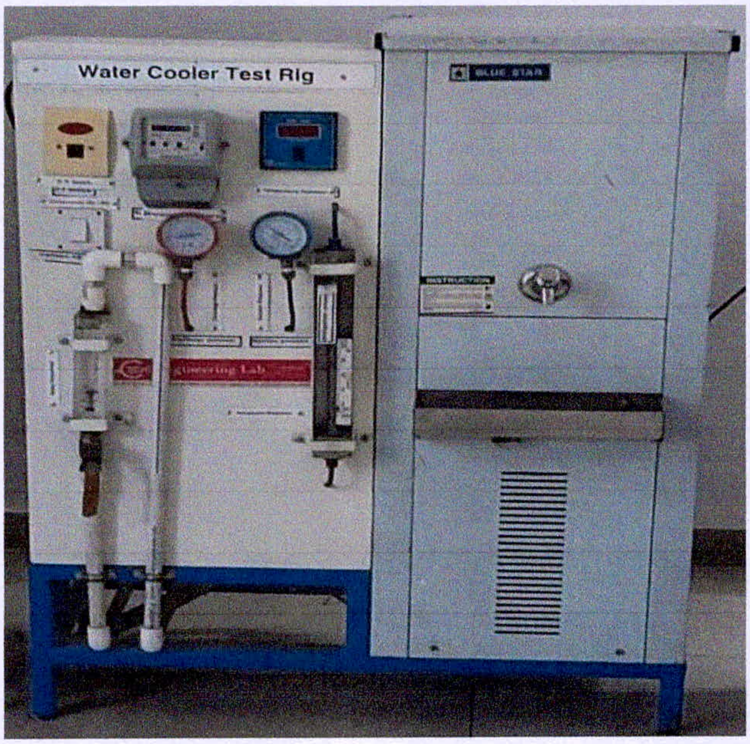


Figure 10.2 Photographic view of Water Cooler Test rig.

Standard Values and Formulas

Standard Barometric Pressure	1.013 bar = 1.013 x 10^5 N /m^2
Density of Water	1000 kg / m^3 = 1 kg / liter
Specific heat of water	4.18 kJ/kg K
Gas Constant for Air	287 J / kg K
Specific Gravity of R-134a at 40 °C	1.2
1 Ton of Refrigeration effect	3500 Watts = 3.5 kJ / s
Density of air at 25 °C	1.1 kg/m3
1 kWHr (kilowatt-hour)	3600 kJ
1 bar	14.5 psig

Observation Table:

Sr.No.	Observations	Readings	Unit
1	Start time		Sec.
2	End time		Sec
3	Water quantity in Water Tank		Liters
4	Condensing pressure Pc		(psig)
5	Evaporating pressure Pe		(psig)
6	Compressor input time for 10 pulses		sec
7	Temperature after compression		°C
8	Temperature after condensation		°C

Calculations:

1. To calculate Theoretical C.O.P.

Accordingly,

1. Enthalpy of refrigerant at inlet of compressor h1 =_____________ kJ/ kg
2. Enthalpy of refrigerant at outlet of compressor h2 =_____________ kJ/ kg
3. Enthalpy of refrigerant after condensation h3 =_____________ kJ/ kg
4. Enthalpy of refrigerant after expansion h4 =_____________ kJ/ kg

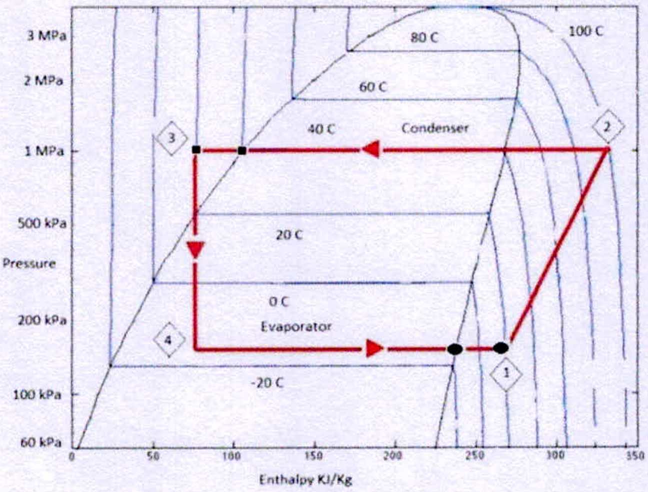


Figure 7.3. P-h Chart of R-134a

5. Theoretical refrigeration effect = N = h1-h4= __________kJ/kg

6. Theoretical compressor work = W = h2-h1 = _________kJ/kg

7. Coefficient of performance = C.O.P. = N/W = _____________

(Note: These valves of enthalpies can be calculated with the help of P-h chart of R- 134a)

2. To calculate Actual C.O.P. of the system

$$\text{Actual C.O.P.} = \frac{\text{Heat aborbed in evporator}}{\text{Work supplied to compressor}}$$

Heat absorbed in the evaporator from water: $m_w \times C_{pw} \times (T_{W1} - T_{w2})$

Where,

m_w = mass of water in evaporator tank (m^3)

C_{pw} = specific heat of water (kJ/kg K)

T_{w1} = Initial temperature of water (°C)

T_{w2} = Final temperature of water (°C)

Work supplied to the compressor $W = \dfrac{\text{Number of pulses} \times 3600}{T_{compressor} \times \text{Energy meter constant(compressor)}}$

3. To calculate Carnot C.O.P. of the system:

$$\text{Carnot C.O.P.} = \frac{T_L}{T_H - T_L}$$

T_L= Saturation temperature to corresponding evaporator pressure (bar)

T_H=Saturation temperature to corresponding condenser pressure (bar).

4. To calculate Relative C.O.P. of the system:

$$\text{Relative C.O.P.} = \frac{\text{Actual C.O.P.}}{\text{Therotical C.O.P.}} = \frac{\dots\dots\dots}{\dots\dots\dots} = ---$$

Conclusions:

1. Understand the working of vapour compression cycle and function of each component.
2. It is observed that Carnot C.O.P. > theoretical C.O.P. > actual C.O.P. due to the losses at varies points.

Applications

As water is palatable at 12 to 15 °C, it used in offices, schools, colleges, restaurants, factories for drinking water storage and cooling.

Questions:

A. What are different components and controllers used in water cooler?

B. What is the temperature range of drinking water?

C. What are the benefits of drinking of cold water?

D. List out leading manufacturer of water cooler in the India (at least three)

E. Write the technical specifications of water coolers (leading manufactures in India at least three)

Aim: To Understand Working of Electrolux Refrigerator and to Determine its COP.

Objective:

- To study different components of Electrolux VAR system.
- To determine C.O.P. of Electrolux VAR System.

Apparatus:

Gross volume 41 litres, refrigerant water, ammonia, hydrogen, electrically heated generator, natural convection type condenser, natural evaporator, energy consumption 1.07KWH per 24 Hrs.

Theory:

Absorption refrigerators are often used for food storage in recreational vehicles. The principle can also be used to air-condition buildings using the waste heat from a gas turbine or water heater. Using waste heat from a gas turbine makes the turbine very efficient because it first produces electricity, then hot water, and finally, air-conditioning (called cogeneration/trigeneration). Absorption refrigerators are a popular alternative to regular compressor refrigerators where electricity is unreliable, costly, or unavailable, where noise from the compressor is problematic, or where surplus heat is available.

The domestic absorption type refrigerator was developed from an invention by Carl Munters and Baltzer Von Platen. This system is often called "Munters Platen System".

This type of refrigerator is also called "Three-fluid absorption system". The three fluids used in this system are ammonia, hydrogen and water.

- The "ammonia" is used as a refrigerant because it possesses most of the desirable properties. Though it is toxic, and not otherwise preferred in domestic appliances, it is very safe in this system due to absence of any moving parts in the system and, therefore, there is the least chance of any leakage.
- The "hydrogen" being the lightest gas, is used to increase the rate of evaporation (the lighter the gas, faster is the evaporation) of the liquid ammonia passing through the

evaporator. The hydrogen is also non-corrosive and insoluble in water. This is used in the low-pressure side of the system.

- The "water" is used as a solvent because it has the ability to absorb ammonia readily.

Electrolux refrigeration is an absorption type refrigeration system. In absorption refrigeration system, the vapour is drawn from the evaporator by absorption into liquid having high affinity for refrigerant. The refrigerant is expelled from the solution by application of heat and its temperature is increased. This refrigerant in the vapour form passes to the condenser gets liquefied where heat is rejected and the refrigerant gets liquefied. This liquid again flows to the evaporator at reduced pressure and the cycle is completed.

Absorber: The main function of the absorber is the absorption of the refrigerant vapour by its weak or poor solution in a suitable absorbent, forming a strong or rich solution.

Condenser: It condenses the vapour refrigerant into the liquid by condenser fan and passes it into the receiver tank for recirculation.

Evaporator: It evaporates the liquid refrigerant by absorbing the heat into vapour refrigerant and sends back to next run. The flow of fluids in the system has been shown in the diagram with different shadings and the index of these shadings also indicated in diagram.

Vertical generator in which an aqua solution of ammonia can range itself from distilled water at the bottom of the generator to strong ammonia vapour at the surface of liquid.

A water separator which is provided to remove water vapour so that they should not enter the condenser, get condensed there and pass on to evaporator where chocking might occur due to its freezing. The water vapour is formed in the boiler as some of the water may evaporator on application of heat to the boiler. The separator is jacked with liquid ammonia at pressure of about 14 bar gauge for which the saturation temperature is about 40°C. The dehydrate ammonia gas condensed to liquid in the condenser and gravitates to 'U' tube which acts as seal for the gas to enter the evaporator or any gas passing from evaporator to condenser.

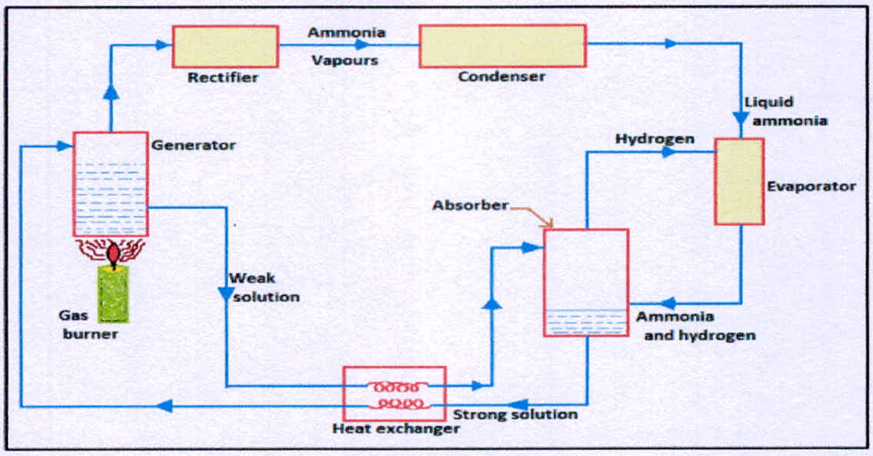


Figure11.1- Schematic Diagram of domestic Electrolux type refrigerator

In the evaporator, ammonia liquid comes across an atmosphere of hydrogen at about 12 bar pressure. The plant is charged to a pressure of about 14 bars. Hence due to Dalton's law of partial pressure. The pressure of ammonia gas should fall to about 2 bar gauge and the saturation temperature corresponding to about 2 gauges is about -10°C. The temperature surrounding the evaporator is much high than this. Thus, ammonia evaporates and produces the refrigerating effect i.e. absorbs the latent heat of vaporization at 2 bar gauge and about -10°C from the space to be refrigerated.

In order to ensure continues action, hydrogen gas has to be removed from ammonia vapour. This is done in the absorber where a descending spray of very dilute ammonia liquid moseys the ascending mixture of ammonia vapour and hydrogen. Ammonia vapour is readily absorbed with evaluation of heat so that absorber has to be water jacketed or air cooled, otherwise evaporation may take place in this unit and the absorption may cease.

Heat exchanger: Liquid heat exchanger is placed between absorber and the generator. This weak liquid gets cooled and strong liquid gets heated. Thus, is economized and better thermal efficiency is obtained. This heat exchanger is counter flow type. The strong solution from the absorber is preheated on its way to generator or boiler and the dilute solution on its way to absorber is cooled. This cooling of weak liquid also helps absorption and reduces the cooling of absorber by external source.

Principle and working of Electrolux Refrigerators:

Figure drawn below shows a schematic diagram of an "Electrolux refrigerator". It is a domestic refrigerator and is the best-known absorption type of refrigerator. Here pump is dispensed with. The small energy supply is by means of a heater which may be electric or gas as shown figure11.1.

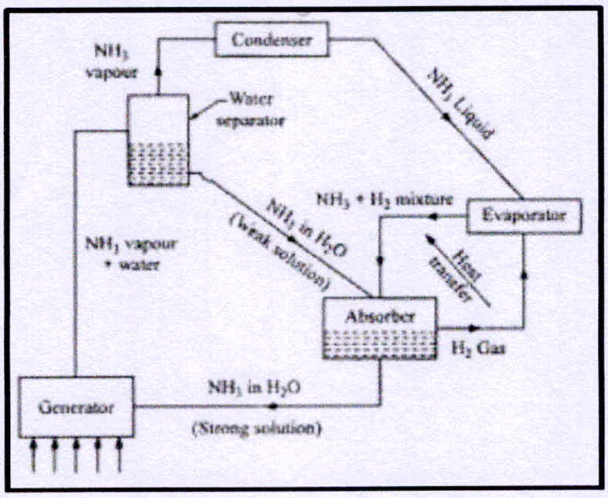


Figure 11.2 Schematic diagram of Electrolux Refrigerator (Vapour Absorption System).

Principle:

The principle involved makes use of the properties of gas-vapor mixtures. If a liquid is exposed to an inert atmosphere, it will evaporate until the atmosphere is saturated with the vapor of the liquid. This evaporation requires heat which is taken from the surroundings in which the evaporation takes place. A cooling effect is thus produced. The partial pressures of the refrigerant vapor (in this case ammonia) must be low in the evaporator, and higher in the condenser. The total pressure throughout the circuit must be constant so that the only movement of the working fluid is by convection currents. The partial pressure of ammonia is kept low in requisite parts of the circuit by concentrating hydrogen in those parts.

Working:

(1) Strong ammonia solution flows from the absorber vessel through heat exchanger to the generator.

(2) When the ammonia solution is heated in the generator by applying heat from the external source, bubbles of ammonia gas raise from the generator and passes to condenser through rectifier.

(3) The ammonia vapour is removed from the solution and passes into the condenser. Weak ammonia solution left behind in the generator flows to the absorber through the heat exchanger.

(4) Air circulating over the fins of the condenser, cool down the vapour, condensing it into liquid ammonia, which flows under gravity to the evaporator where it meets the hydrogen gas.

(5) The hydrogen in the evaporator lowers the ammonia vapour pressure and makes it evaporate.

(6) This process extracts heat from the evaporator, which in turn extracts heat from the food storage space. Thereby the temperature inside the refrigeration is lowered.

(7) The mixture of hydrogen and ammonia passes from the evaporator to the absorber. Weak ammonia solution is fed from the generator system through heat exchanger.

(8) As it returns to the absorber vessel, it absorbs the ammonia from the ammonia/hydrogen mixture and gets ready for another round in the generator.

The ammonia liquid leaving the condenser enters the evaporator and evaporates into the hydrogen at the low temperature corresponding to its low partial pressure. The mixture of ammonia and hydrogen passes to the absorber into which is also admitted water from the separator. The water absorbs the ammonia and the hydrogen returns to the evaporator. In the absorber the ammonia therefore passes from the ammonia circuit into water circuit as ammonia in water solution. This strong solution passes to the generator where it is heated and the vapor given off rises to the separator. The water with the vapor is separated out and a weak solution of ammonia is passed back to the absorber, thus completing the water circuit. The ammonia vapor rises from the separator to the condenser where it is condensed and then returned to the evaporator. The photographic view shown in figure11.2.

Figure 11.3 Photographic view of Refrigeration Cycle Test Rig.

The actual plant includes refinements and practical modifications (which are not included here). The following points are worth noting:

1. The complete cycle is carried out entirely by gravity flow of the refrigerant.
2. The hydrogen gas circulates only from the absorber to the evaporator and back.
3. With this type of machine efficiency is not important since the energy input is small.
4. It has not been used for industrial applications as the C.O.P. of the system is very low.

Role of Hydrogen:

i) By the presence of hydrogen, it is possible to maintain uniform total pressure throughout the system and at the same time permit the refrigerant to evaporate at low temperature in the evaporator corresponding to its partial pressure. Thus, the condenser and evaporator pressures of the refrigerant are maintained as below

ii) In the condenser only ammonia is present, and the total pressure is the condensing pressure.

iii) In the evaporator hydrogen and ammonia are present; their relative masses are adjusted such that the partial pressure of ammonia is the required evaporator pressure.

These are achieved without the use of pumps or valves.

Experimental Procedure:

1. Ensure that all ON/OFF switches given on the panel are at OFF position.
2. Switch On the main supply.
3. Switch On the refrigerator.
4. Record the temperature when the steady state is achieved.

Observation Table:

SR. No.	T1	T2	T3
1			
2			
3			
4			

Calculations:

$$\text{COP}=\frac{T_3(T_1-T_2)}{T_1(T_2-T_3)}$$

Nomenclature:

COP – Co-efficient of performance

T1 – Temperature of generator, K

T2 – Temperature of condenser, K

T3 – Temperature of evaporator, K

Conclusion:

We have studied different components of Electrolux VAR system and determine C.O.P. of Electrolux VAR System.

Aim: To conduct trial on cascade refrigeration test rig for recognizing the working of a system

Introduction: The Cascade Refrigeration System describe with the basic principles that are used to create the refrigeration effect. A cascade system consists of two or three separate simple cycles operating in conjunction with each other at different temperature levels. The connecting point is a heat exchanger between the stages. This interstate heat exchanger is the condenser for the first stage and the evaporator for the second stage. Beginning with the low-pressure cycle, the vapor from the evaporator is compressed in the first stage compressor and goes to the interstate heat exchanger where it gives up its heat to the second evaporator coil. The condensed liquid then flows to the first stage expansion valve and the evaporator, competing the low-pressure cycle. The vapor which is generated in the coil in the heat exchanger, due to the heat it had absorbed, is compressed in the second, its heat going to the cooling chamber. Each stage is an independent single cycle, and for this reason has some advantages over the compound compressors. There is some loss in the cascade system because a temperature difference must exist in the heat exchanger in order that the heat from the first stage will flow into the second stage. At the present work, the use of "R-404a" in the low stage and "R-134 in the high stage.

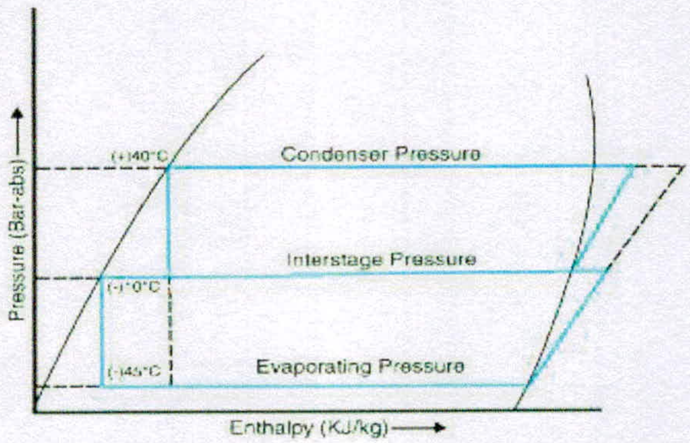


Figure 12.1 Pressure vs enthalpy Chart of Cascade Refrigeration System

CSMSS CHH. SHAHU COLLEGE OF ENGINEERING, KANCHANWADI, PAITHAN ROAD, AURANGABAD				LABORATORY MANUAL
PRACTICAL EXPERIMENT INSTRUCTION SHEET				
EXPERIMENT TITLE: TRIAL ON CASCADE REFRIGERATION TEST RIG				
DEPARTMENT: **MECHANICAL ENGINEERING**		LABORATORY: **CSMSS/ENGG/MECH/RAC LAB**		
LABORATORY MANUAL NO.: **CSMSS/ENGG/MECH/RAC-12**		YEAR:**2024-25**		
CLASS: **THIRD/ FINAL YEAR**	PART: **VI/ VIII**	SUBJECT: **REFRIGERATION AND AIR CONDITIONING**		PAGE: 77 of 83

Objective: To recognize the working of cascade refrigeration system.

A cascade system is a multistage application in which two separate refrigerant systems are interconnected in such a manner that one provides the means of heat rejection (condenser) for the other. The lower system, therefore may operate at a much lower temperature.

Cascade system has the additional feature, over compound systems of permitting the use of different refrigerants in each cycle of the cascade.

Working:

Initially, when the compressor is started, the refrigerant is compressed at high pressure, and then it enters into the shell and coil type condenser, where the flowing water absorbs all the heat. Then it enters into the drier /filter, flow meter it goes into the expansion device where its expansion take place and pressure drops. Then it enters into the cascade condenser where it takes heat from the low side refrigerant (R134 in the low side system compressor discharges refrigerant at high pressure, then it enters into the oil separator where compressor oil gets separated from the refrigerant.

Then refrigerant goes into de-super heater where its heat gets absorbed by flowing water, then it goes into cascade condenser (i.e. high side evaporator) where its heat is rejected and it becomes in liquid from. After passing through drier/filter, expansion device it goes into low side evaporator where it absorbs heat from chamber, it converts into low-pressure vapour state, then it goes into the compressor.

R134 is having high standing pressure so it becomes trouble for compressor starting. So, to avoid it refrigerant is stored in the expansion chamber where the pressure takes place. It is connected in series with the compressor inlet line.

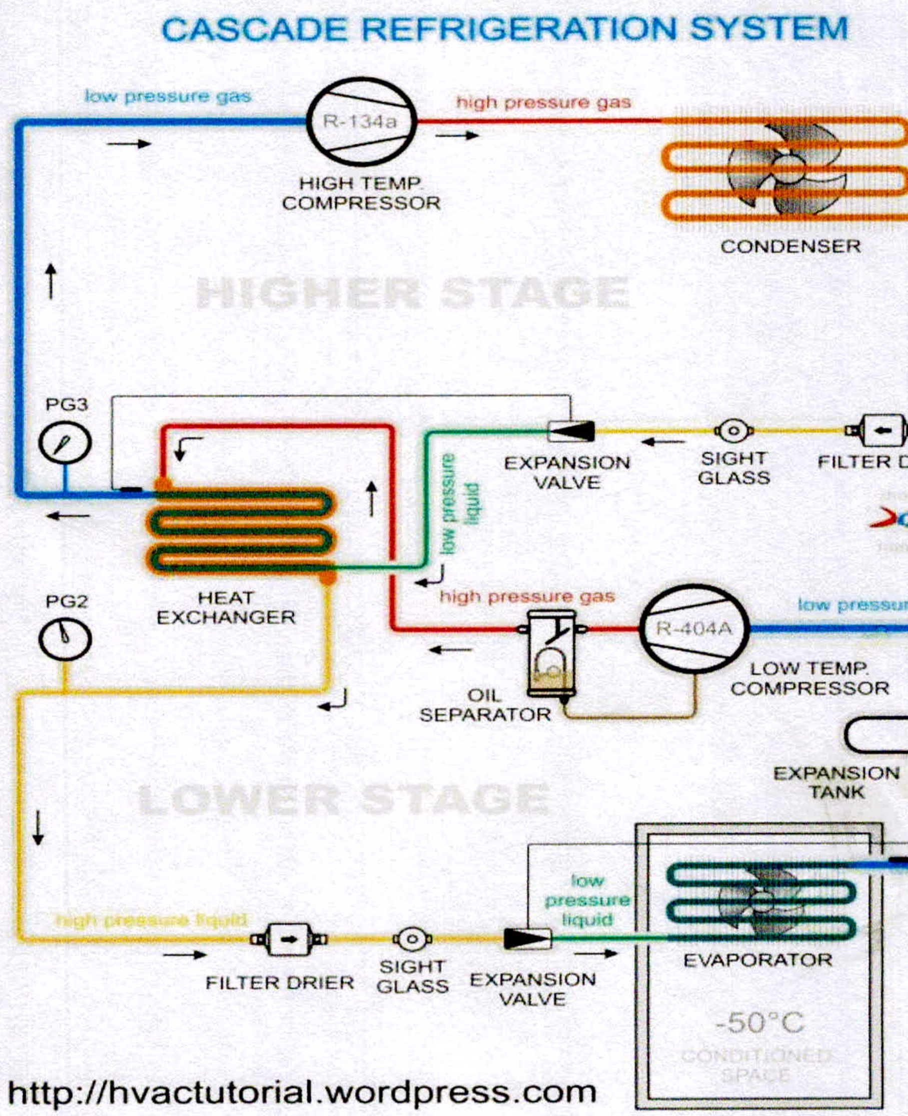


Figure 12.2 Cascade Refrigeration System

Figure 12.3. Photographic view of cascade refrigeration system

Specifications:

A. High-Side

Components	High side
Compressor	Hermetically sealed, Emerson makes
Accumulator	Dry all
Condenser	Forced convection air cooled
Drier/filter	Provided
Expansion device	Provided
Flow-meter	Provided
Evaporator	Coil in coil type
De-super heater	Not required
Expansion chamber	Not required
Oil-separator	Not required
HP/LP cut-out	Provided
Pressure gauges	Provided
Energy meter	Provided
Temp..Scanner	Provided
Temp. Controller	Sub zero
Insulation	Puf
Temperature attained at the evaporator	**- 15 deg celsius**
Refrigerant	**R-23**
Supply	230 Volts, 50 Hz, 1 Phase

B. Low-side

Components	Low side
Compressor	Hermetically sealed, Emerson makes
Accumulator	Dry all
Condenser	Coil in coil type
Drier/filter	Provided
Expansion device	Provided
Evaporator	Natural convection type
De-super heater	Shell and coil type
Expansion chamber	Provided
Oil-separator	Danfoss make
HP/LP cut-out	Provided
Pressure gauges	Provided
Energy meter	Provided
Temp.scanner	Es point
Temp. Controller	Selectron
Heater	Provided
Dimmer for heater	Provided
Insulation	Puf

Procedure:

1. Put the machine in the proper position where its level is horizontal and it is well ventilated. The machine must have at least 2.0 meters clearances from all sides.
2. Start the main switch and after that start compressor.
3. Check suction & discharge pressures,
4. Allow the unit to run for 15-20 minutes to bring down the temperature of after expansion in the range -10°c to -15°c.
5. After attaining the temperature of after expansion starts the compressor for low side.
6. Again, allow the unit to run for 1½-2 hours to bring down the temperature of cascade temperature (i.e. temperature for low side on thermostat) to -40°c.
7. Now, start the heater after that set the dimmer so that cascade temperature remains constant.
8. Take all the readings (temp at various points and pressures, energy meter reading etc.) as per the observation table for Low Side System and High Side System.

Observation table:

Part1: High Side System **Refrigerant: R-134**

				Refrigerant Temperatures						
Sr. No	Time	Suction pressure Kg/cm^2	Discharge Pressure Kg/cm^2	After compression	After condensation	After expansion	After evaporation	Cascade condenser Temp.	Energy meter	Refrigerant flow LPH
1										
2										

Part2: Low Side System **Refrigerant: R-404a**

				Refrigerant Temperatures						
Sr. No	Time	Suction pressure Kg/cm^2	Discharge Pressure Kg/cm^2	After compression	After condensation	After expansion	After evaporation	Cascade condenser Temp.	Energy meter	Refrigerant flow LPH
1										
2										

Calculations & Results:

Refrigeration effect at low side N2	heater load	
	Time for 10 pulses	
	11.25/t	
Compressor work at low side W2	**Time for 10 pulses**	
	11.25/t	
C.O.P. on Low Side	**N2/W2**	
Refrigerant effect on high sideN1	**Condenser heat rejection on low side**	
	Compressor Work on Low Side + Refrigeration Effect on Low Side	
Compressor work on high side W1		
C.O.P. on High Side	**N2/W2**	
Results	**Actual**	**Theoretical**
C.O.P. on Low Side		
C.O.P. on High Side		
Overall C.O.P.		

Conclusion:

By using cascade refrigeration system, it is found that very low temperature & cascade refrigeration system is efficient than single stage refrigeration system. The actual C.O.P. of system (on low side) is…. The actual C.O.P. of the system (on high side) is….and the overall C.O.P. of the system is ….. Heat absorbed by R404a is …..kg/min and Heat absorbed by R23 is …….kg/min