Military Institute of Science & Technology (MIST), Dhaka

Department of Mechanical Engineering

ME-104
Thermodynamics Sessional
LEVEL-1, TERM-I
Contact Hr: 3 Credit: 1.5

Name of the Experiments

1. (a) Determination of Flash Point of Liquid Fuel
   (b) Study of Sling Psychrometer
2. Viscosity Test of Liquid Substance
3. Study and Calibration of Pressure Gauge by Dead Weight Tester
4. Study of Compressor, Condenser, and Evaporator of Split and Window Air conditioner
5. Study of Vapor Compression Refrigeration Cycle (Refrigeration and Air-conditioning Unit)
6. Study of Mechanical Heat Pump
7. Determination of Calorific value of Gaseous Fuel by Gas Calorimeter
8. Determination of Carbon Residue of a Given Fuel
9. Proximate Analysis of Coal
10. (a) Study of IC Engine
    (b) Study of Industrial Boiler

GENERAL LABORATORY RULES& SAFETY INSTRUCTIONS

- **BE PREPARED.** Read and fully comprehend the lab procedure as outlined in the lab manualbefore you begin any experiment. If you do not understand the procedure, ask your instructor/TA.
- **THINK SAFETY.** Work deliberately and carefully. No horseplay.
- **ALL LABORATORY STUDENTS MUST BE SUPERVISED.** Never work alone.
- **KNOW THE HAZARDS OF ANY MATERIALS OR MACHINERY YOU ARE WORKING WITH.** The laboratory manual and/or instructor will review specific safety issues on individual experiments before performing any tests.
- **ALL STUDENTS MUST WEAR APPROPRIATE SAFETY EQUIPMENT.** Safety goggles must be worn when any laboratory experiment is being performed. Additional safety equipment must be utilized based on specific experiment requirements.
- **ALL STUDENTS MUST WEAR APPROPRIATE LABORATORY ATTIRE.** No open-toedshoes; no loose-fitting clothing; Jewelry should be removed; long hair should be tied back
- **NO FOOD OR BEVERAGE IN THE LABORATORY.**
- **KNOW EMERGENCY PROCEDURES.** Make a note of fire escape routes and emergencyphone locations.
- **NEVER ATTEMPT UNAUTHORIZED EXPERIMENTS OR PROCEDURES.**
- **NEVER TOUCH ANY HEATED OR COLD OBJECT WITH BARE HAND.**
- **DO NOT LEAN, HANG OVER OR SIT ON THE LABORATORY TABLES.**
- **REPORT ANY PERCEIVED SAFETY HAZARDS.** Immediately report any spills, equipment malfunctions, injuries or other perceived safety hazards to your Instructor / TA /or staff member.
- **KEEP YOUR WORK AREA CLEAN.**
- **FAILURE TO CONFORM WITH ANY OF THE ABOVE RULES MAY RESULT IN NOT BEING ALLOWED TO PARTICIPATE IN THE LABORATORY EXPERIMENT.**

EXPERIMENT NO: 1 (A)

Name of the Experiment: Determination of Flash Point of Liquid Fuel

1. Objectives

i. Learn about Flash point and Fire point of a liquid fuel.

ii. Observe the flash point of various types of liquid fuel.

2. Theory

Flash Point: The flash point of a liquid is defined as the lowest temperature at which a substance generates a sufficient amount of vapor to form a (vapor/air) mixture that can be ignited (piloted ignition). At that temperature, the vapor pressure of the liquid provides a vapor concentration that equal to the lower flammability limit. If ignition is attempted when the liquid reaches its flash point, a flash flame will occur but the flame will not sustain. The cloud will burn and the fire will self-extinguish because the energy released by the combustion and transferred to the remaining fuel is not sufficient to produce enough vapors to sustain the flame.

The flash point is an important concept in fire investigation and fire protection because it is the lowest temperature at which a risk of fire exists with a given liquid. It is crucial in many circumstances to establish the presence of some liquids and to know their flash point during the investigation process.

Fire Point: The fire point is defined as the lowest temperature at which vapors of the material will catch fire and continue burning even after the ignition source is removed. The fire point is higher than the flash point because the vapor amount produced at the flash point are not sufficient enough to ignite the fuel continuously.

Flash and fire points depend upon the volatility of the fuel. Volatility is the tendency of the substance to vaporize, and it is directly related to the vapor pressure of the fuel at that particular temperature. The fuel exhibiting higher vapor pressure at a given temperature is said to be more volatile than the one exhibiting lower vapor pressure at the same temperature. Hence the lower the NBP (normal boiling point), the higher the volatility, which is in turn inversely proportional to its flash and fire point.

3. **Specimen:** Diesel or kerosene

4. **Procedure**

a) **Power Supply:** Connect the Seta flash tester with the electric power supply line and switch on the tester by the power switch available at the back portion of the tester.

b) **Setting of the time interval**

i) Press and hold the set timer button until the display board showing "SET TEST TIME AUTO." Then release the set timer button.

ii) Turn the control knob to the timer in minute intervals up to 30 minutes or to the auto mode. If the control knob will not move for more than four seconds, the setting shows that the display will be stored.

iii) The time set is the interval between the cup reaching the set temperature and the audible prompt for the flash test sounding.

iv) The auto setting automatically selects the time interval depending on the temperature setting as follows

Flash point up to 100°C	1 minute
Flash point above 100°C	2 minutes

c) **Setting the test Temperature**

i) Press and hold down the set temperature button until the display changes toshow. (xx.x = cup temperature)

ii) Turn the control knob to set the test temperature. The selected temperature will be shown on the bottom line of the display board.

iii) After a short delay, the top line of the display board will change to show the sample cup temperature as it heats up.

d) **Inject the sample**

i) Wait until the audible warning (beep) is heard and the bottom line of the display board shows 'READY'. It indicates that the seta flash tester has reached and stabilized at the set temperature.

ii) Close and lock the lid and make sure that the shutter is closed

iii) Load the syringe with the correct amount of sample.

e) **Start the timer**

i) Press the set timer button and the display will count down the time set.

ii) Open the on/off gas valve by pushing it up. Light the pilot jet and test jet by using ignite. If necessary, adjust the pilot test jets.

f) **Test the sample**

i) When the timer reaches zero, an audible warning (beep) will be heard. Apply the test jet tothe sample by slowly opening and closing the shutter over approximately 2.5 seconds.

ii) If a flash is detected, the bottom line of the display board will show "FLASH."

iii) Record the result as 'flash' or 'no flash' and the test temperature.

g) **Complete the test**

i) Result from the flash detector probe by pressing the reset (set temperature) button.

ii) Extinguish the pilot and test jet flame by pushing the on/off the gas valve on the canisterdown to the off position.

iii) Unlock and open the lid.

iv) When the sample cup cools down, clean the sample cup, lid and shutter and visually inspect the sample well 'O' Ring seal for damage.

v) If necessary, set a different test temperature and repeat the test sequence with a new portionof the sample.

Student Name:

Student ID:

5. Result

Table-1 (A): (Experimental data and calculation)

No of Obs	Sample Name	Sample Amount (in ml)	Flash Temperature (in °C)	Flash Time (in sec)	Remarks
1.					
2.					
3.					
4.					
5.					

Assignment:

a) What are flash point and fire point of a fuel?

b) What is volatility of a fuel?

c) How boiling point and volatility affect the flash point and fire point?

d) Explain the necessity of determining flash point and fire point of fuels.

e) What are the safety measures that should be followed while determining the flash point and fire point in the laboratory?

EXPERIMENT NO-1(B)

Name of the Experiment: Study of Psychrometer

1) Objectives

i) To find relative humidity, Absolute humidity.

ii) Dew point and enthalpy of air using psychometrics chart.

2) PROCEDURE

The sling psychrometer is used to determine the humidity of the air. This instrument has two similar thermometers mounted on a frame to read dry bulb temperature and the other wet-bulb temperature. The bulb of the wet-bulb thermometer is covered with wet wick distilled water. The thermometer and wetted wick are whirled in the air. The water evaporates into the surrounding unsaturated air, causing the general conditions around the wet thermometer bulb to be similar to, and closely approximate to, and those of adiabatic saturation. After sufficient whirling, the thermometer reaches equilibrium conditions. Both temperature should be read quickly in order to get dependable readings.

The sling psychrometer should be rotated at a speed of 180 to 240 rpm. Clean water must be used since the slightest trace of oil on the wick cause errors. The wick should be kept thoroughly wet when readings are being done.

DEFINITION OF DIFFERENT TERMS

The psychrometry is a branch of engineering, which deals with the study of moist air i.e. dry air mixed with water vapor or humidity. It also includes the study of behavior of dry air and water vapor mixture under various sets of conditions.

Though the earth's atmosphere is a mixture of gases including nitrogen (N_2), oxygen (O_2), argon (Ar) and carbon dioxide (CO_2), yet for the purpose of psychrometry, it is considered to be a mixture of dry air and water vapor only.

Psychrometric Terms: Though there are many Psychrometric terms, yet the following are important from the subject point of view:

1. Dry Air: The pure dry air is a mixture of a number of gases such as nitrogen, oxygen, carbon dioxide, hydrogen, argon, neon, helium etc. But nitrogen and oxygen have the major portion of the combination.

2. Moist air: It is a mixture of dry air and water vapor. The amount of water vapor, present in the air, depends upon the absolute pressure and temperature of the mixture.

3. Saturated air: It is a mixture of dry air and water vapor, when the air has diffused the maximum amount of water vapor into it. However, when the saturated air is cooled, the water vapor in the air starts condensing, and the same may be visible in the form of fog or condensation on cold surfaces.

4. Degree of saturation: It is the ratio of actual mass of water vapor in a unit mass of dry air to the mass of water vapor in the same mass of dry air when it is saturated at the same temperature.

5. Humidity: It is the mass of water vapor present in 1 kg of dry air, and is generally expressed in terms of gram per kg of dry air (g / kg of dry air). It is also called specific humidity or humidity ratio.

6. Absolute humidity: It is the mass of water vapor present in 1 m^3 of dry air, and is generally expressed in terms of gram per cubic-meter of dry air (g/m^3 of dry air). It is also expressed in terms of grains per cubic meter of dry air.

7. Relative humidity: It is the ratio of actual mass of water vapor in a given volume of moist air to the mass of water vapor in the same volume of saturated air at the same temperature and pressure. It is briefly written as RH.

8. Dry bulb temperature: It is the temperature of air recorded by a thermometer, when it is not affected by the moisture present in the air. The dry bulb temperature (briefly written as DBT) is generally denoted by t_d or t_{db}.

9. Wet bulb temperature: It is the temperature of air recorded by a thermometer, when its bulb is surrounded by a wet cloth exposed to the air. Such a thermometer is called wet bulb thermometer. The wet bulb temperature (briefly written as WBT) is generally denoted by t_w or t_{wb}.

10. Wet bulb depression: It is the difference between dry bulb temperature and wet bulb temperature at any point. The wet bulb depression indicates relative humidity of the air.

11. Dew Point Temperature: It is the temperature of air recorded by a thermometer, when the moisture (water vapor) present in it begins to condense. It is, usually, denoted by t_{dp}.

12. Dew point depression: It is the difference between the dry bulb temperature and dew point temperature of air.

Psychrometer

A psychrometer is a hygrometer made up of two thermometers that are identical. One thermometer's bulb is kept wet, causing it to record a lower temperature than the dry-bulb thermometer due to evaporative cooling.

A psychrometer is a device for measuring air humidity. It does so by measuring the temperature difference between a dry bulb thermometer and a wet bulb thermometer that has lost some moisture due to evaporation.

A psychrometer tests both the dry and wet bulb temperatures at the same time. A wet wick mounted over the thermometer bulb is used to determine the temperature of the wet bulb. Practically any kind of thermometer can be used.

PROCEDURE

i) Open the instrument. The frame and tubes are set at right angles to the case, which will act asthe handle.

ii) Thoroughly wet the wick covering the Wet Bulb and the 'wick' in the container by lifting off the container lid and holding the wicking container under the cold tap. **Hot water must not be used as it may damage the thermometers.** Replace the lid on the wicking container and remove any surplus water from the Dry Bulb area before use. The wick will remain moist for several hours. Always check the wick is wetted before taking any readings.

iii) To take a reading, set the psychrometer at right angles and, holding the case, rotate the framefor 15 to 20 seconds at between 2 and 4 revolutions per second.

iv) Stop revolving the instrument and note the Wet and Dry Bulb temperatures.

v) Subtract the Wet-bulb Temperature from the Dry Bulb temperature to determine theDepression.

vi) Use the tables provided to compare the Dry bulb Temperature with the Depression and readoff the %RH.

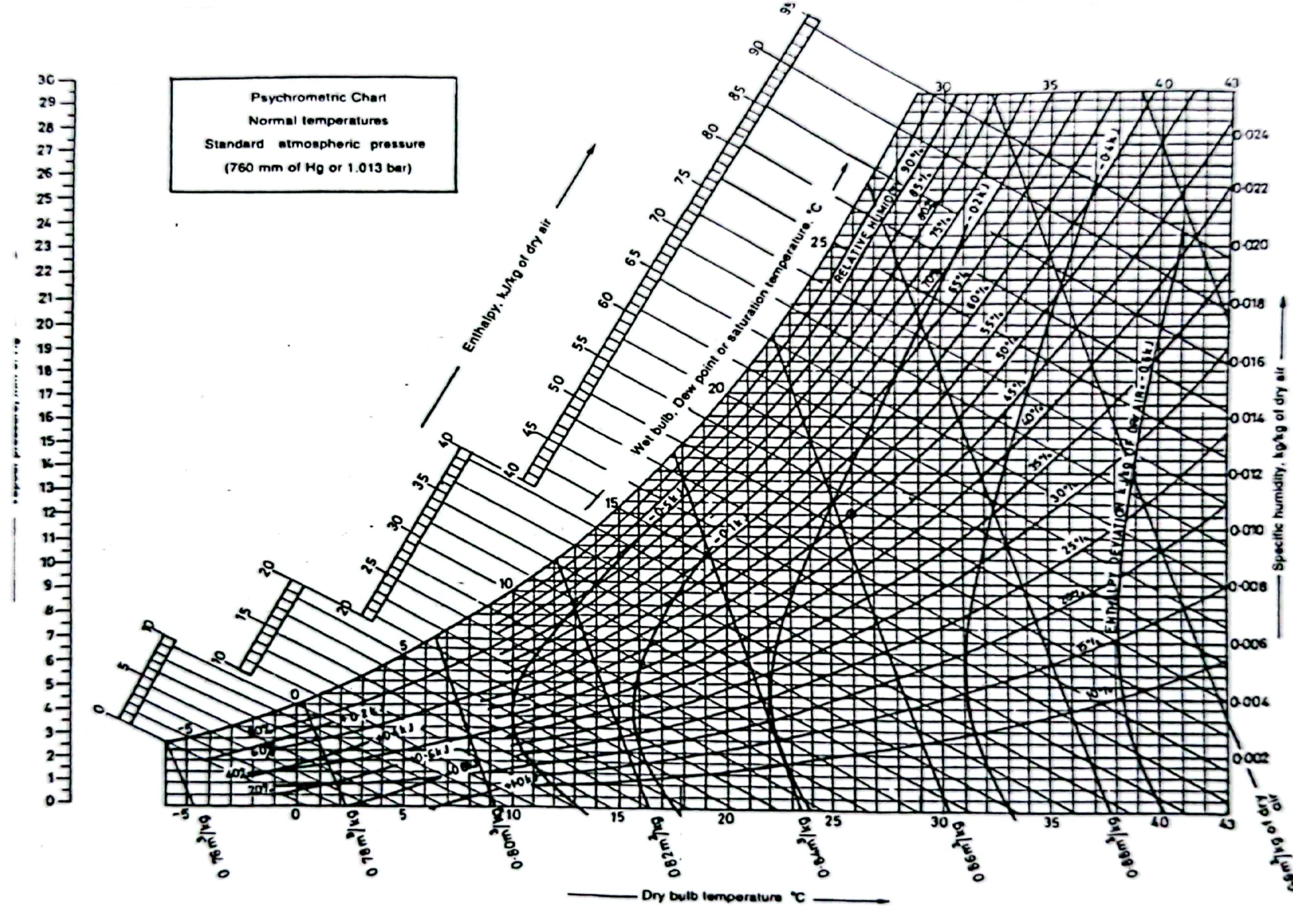
Student Name:

Student ID:

6. Result

Table-1 (B): (Experimental data and calculation)

No of Obs	Dry Bulb Temperature (°C)	Wet Bulb Temperature (°C)	Specific Humidity	Relative Humidity	Dew Point (°C)	Enthalpy (kJ/Kg)	Specific Volume (m^3/Kg)
1.							
2.							
3.							
4.							
5.							



Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
Enthalpy, kJ/kg of dry air
Wet bulb, Dew point or saturation temperature, °C
RELATIVE HUMIDITY
ENTHALPY DEVIATION kJ/kg OF DRY AIR
Dry bulb temperature °C
Specific humidity, kg/kg of dry air
Sensible heat factor
0.76 m³/kg
0.78 m³/kg
0.80 m³/kg
0.82 m³/kg
0.84 m³/kg
0.86 m³/kg
0.88 m³/kg
0.9 m³/kg of dry air

%Relative Humidity Tables for Aspirated Psychrometer readings in °C

Reading of Dry Bulb °C (columns 1–25); Depression of Wet Bulb °C (rows)

Depression of Wet Bulb °C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
0.5	91	92	92	92	93	93	93	94	94	94	94	94	95	95	95	95	95	95	95	96	96	96	96	96	96
1.0	83	84	84	85	86	86	87	87	88	88	88	89	89	90	90	90	90	91	91	91	91	92	92	92	92
1.5	-	76	77	78	79	79	80	81	82	82	83	83	84	84	85	85	86	86	86	87	87	87	88	88	88
2.0	-	68	69	70	72	73	74	75	76	77	77	78	79	79	80	81	81	82	82	83	83	83	84	84	84
2.5	-	-	62	63	65	66	67	69	70	71	72	73	74	74	75	76	77	77	78	78	79	79	80	80	81
3.0	-	-	54	56	58	60	61	63	64	65	66	68	69	70	71	71	72	73	74	74	75	76	76	77	77
3.5	-	-	-	49	51	53	55	57	58	60	61	63	64	65	66	67	68	69	70	70	71	72	72	73	74
4.0	-	-	-	42	45	47	49	51	52	54	56	57	59	60	61	62	64	65	65	66	67	68	69	69	70
4.5	-	-	-	-	38	41	43	45	47	49	51	53	54	56	57	58	59	60	61	62	63	64	65	66	67
5.0	-	-	-	-	32	35	37	40	42	44	46	48	49	51	52	54	55	56	58	59	60	61	62	62	63
5.5	-	-	-	-	-	29	31	34	36	39	41	43	45	47	48	50	51	52	54	55	56	57	58	59	60
6.0	-	-	-	-	-	23	26	29	31	34	36	38	40	42	44	46	47	49	50	51	52	54	55	56	57
6.5	-	-	-	-	-	-	20	23	26	29	31	34	36	38	40	41	43	45	46	48	49	50	51	52	54
7.0	-	-	-	-	-	-	14	18	21	24	26	29	31	33	36	37	39	41	43	44	46	47	48	49	50
7.5	-	-	-	-	-	-	-	12	16	19	22	24	27	29	31	34	35	37	39	41	42	44	45	46	47
8.0	-	-	-	-	-	-	-	7	11	14	17	20	23	25	27	30	32	34	35	37	39	40	42	43	44
8.5	-	-	-	-	-	-	-	-	6	9	13	16	18	21	24	26	28	30	32	34	35	37	39	40	41
9.0	-	-	-	-	-	-	-	-	1	5	8	11	14	17	20	22	24	27	29	30	32	34	36	37	38
9.5											4	7	10	14	16	18	21	23	25	27	29	31	33	34	36
10.0											.	3	6	9	12	15	17	20	22	24	26	28	30	31	33
10.5											.	.	2	5	8	11	14	16	19	21	23	25	27	28	30
11.0											.	.	.	2	5	8	10	13	15	18	20	22	24	26	27
11.5											.	.	.	.	1	4	7	10	12	15	17	19	21	23	25
12.0											.	.	.	.	.	1	4	7	9	12	14	16	18	21	22
12.5											.	.	.	.	.	.	1	4	7	9	11	13	16	18	19
13.0											.	.	.	.	.	.	.	.	3	6	8	11	13	15	17
13.5											.	.	.	.	.	.	.	.	.	3	6	8	10	12	14
14.0											.	.	.	.	.	.	.	.	.	.	3	5	8	10	12
14.5											.	.	.	.	.	.	.	.	.	.	.	3	5	7	10
15.0											.	.	.	.	.	.	.	.	.	.	.	.	3	5	7
15.5											.	.	.	.	.	.	.	.	.	.	.	.	.	3	5
16.0											.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
16.5											.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.0											.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.5											.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.0											.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Reading of Dry Bulb °C (columns 26–50); Depression of Wet Bulb °C (rows)

Depression of Wet Bulb °C	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0.5	96	96	96	96	96	96	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97
1.0	92	92	93	93	93	93	93	93	93	93	94	94	94	94	94	94	94	94	94	94	94	94	94	95	96
1.5	88	89	89	89	89	90	90	90	90	90	90	91	91	91	91	91	91	91	91	91	92	92	92	92	92
2.0	85	85	85	86	86	86	86	87	87	87	87	87	88	88	88	88	88	88	89	89	89	89	89	89	89
2.5	81	82	82	82	83	83	83	83	84	84	84	85	85	85	85	85	86	86	86	86	86	86	87	87	87
3.0	78	78	79	79	79	80	80	80	81	81	81	82	82	82	82	83	83	83	83	83	84	84	84	84	84
3.5	74	75	75	76	76	77	77	77	78	78	78	79	79	79	80	80	80	80	81	81	81	81	82	82	82
4.0	71	71	72	72	73	73	74	74	75	75	76	76	76	77	77	77	78	78	78	78	79	79	79	79	80
4.5	67	68	69	69	70	70	71	71	72	72	73	73	74	74	74	75	75	75	76	76	76	76	77	77	77
5.0	64	65	65	66	67	67	68	69	69	70	70	70	71	71	72	72	72	73	73	73	74	74	74	75	75
5.5	61	62	62	63	64	64	65	66	66	67	67	68	68	69	69	70	70	70	71	71	71	72	72	72	73
6.0	58	59	59	60	61	62	62	63	64	64	65	65	66	66	67	67	68	68	68	69	69	70	70	70	71
6.5	55	55	56	57	58	59	60	60	61	61	62	63	63	64	64	65	65	66	66	67	67	67	68	68	68
7.0	51	52	53	54	55	56	57	58	58	59	60	60	61	61	62	62	63	63	64	64	65	65	66	66	66
7.5	49	50	51	52	52	53	54	55	56	56	57	58	58	59	60	60	61	61	62	62	63	63	63	64	64
8.0	46	47	48	49	50	51	52	52	53	54	55	55	56	57	57	58	58	59	59	60	60	61	61	62	62
8.5	43	44	45	46	47	48	49	50	51	51	52	53	54	54	55	56	56	57	57	58	58	59	59	60	60
9.0	40	41	42	43	44	45	46	47	48	49	50	51	51	52	53	53	54	55	55	56	56	57	57	58	58
9.5	37	38	40	41	42	43	44	45	46	47	48	48	49	50	51	51	52	53	53	54	54	55	55	56	56
10.0	34	36	37	38	39	41	42	43	44	44	45	46	47	48	48	49	50	51	51	52	52	53	53	54	54
10.5	32	33	34	36	37	38	39	40	41	42	43	44	45	46	46	47	48	49	49	50	50	51	51	52	53
11.0	29	30	32	33	34	36	37	38	39	40	41	42	43	44	44	45	46	47	47	48	48	49	50	50	51
11.5	26	28	29	31	32	33	35	36	37	38	39	40	41	42	42	43	44	45	45	46	47	47	48	48	49
12.0	24	25	27	28	30	31	32	34	35	36	37	38	39	40	40	41	42	43	43	44	45	45	46	47	47
12.5	21	23	25	26	27	29	30	31	33	34	35	36	37	38	38	39	40	41	42	42	43	44	44	45	46
13.0	19	21	22	24	25	27	28	29	30	32	33	34	35	36	37	37	38	39	40	41	41	42	43	43	44
13.5	16	18	20	21	23	24	26	27	28	30	31	32	33	34	35	36	36	37	38	39	40	40	41	42	42
14.0	14	16	18	19	21	22	24	25	26	28	29	30	31	32	33	34	35	36	36	37	38	39	39	40	41
14.5	12	14	15	17	19	20	22	23	24	26	27	28	29	30	31	32	33	34	35	35	36	37	38	38	39
15.0	9	11	13	15	17	18	20	21	23	24	25	26	27	28	29	30	31	32	33	34	35	35	36	37	37
15.5	7	9	11	13	15	16	18	19	21	22	23	24	26	27	28	29	30	31	31	32	33	34	35	35	36
16.0	5	7	9	11	13	14	16	17	19	20	21	23	24	25	26	27	28	29	30	31	31	32	33	34	34
16.5	3	5	7	9	11	12	14	15	17	18	20	21	22	23	24	25	26	27	28	29	30	31	32	32	33
17.0	.	3	5	7	9	10	12	14	15	17	18	19	20	22	23	24	25	26	27	28	28	29	30	31	32
17.5	.	.	3	5	7	8	10	12	13	15	16	18	19	20	21	22	23	24	25	26	27	28	29	29	30
18.0	.	.	1	3	5	7	8	10	12	13	15	16	17	18	20	21	22	23	24	25	26	26	27	28	29

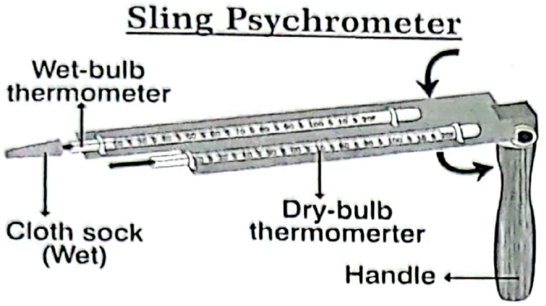
Aspirated Psychrometer

Instructions for use

1. Open the wick container, wet the wick thoroughly and ensure the wick on the thermometer bulb is wet.
2. Hold the thermometer case horizontally and rotate the thermometer frame for 15 to 20 seconds (3 to 4 rotations / second).
3. Record temperatures of the wet bulb (first) and dry bulb & calculate the wet bulb depression (ie the difference between the two readings).
4. Use these tables to determine the % Relative Humidity from the dry bulb temperature and the wet bulb depression

Sling Psychrometer

Instructions for use



Principles

The Sling Psychrometer determines %Relative Humidity by measuring the evaporation of water into the surrounding air.

Two thermometers are placed in flowing air, one thermometer bulb being covered by a wet wick. Evaporation from the wetted bulb causes its temperature to be depressed relative to that of the dry bulb.

In dry air evaporation will be rapid and the depression will be greater, giving a low %RH reading.

In humid air there will be little evaporation and the depression will be small, giving a high %RH reading.

If the air is completely saturated no evaporation can take place so both the wet and dry bulb thermometers will give the same reading. This equates to 100%RH.

The %RH can be determined using the tables provided.

Replace the lid on the wick container and remove any surplus water from the Dry Bulb area before use.
The wick will remain moist for several hours. Always check the wick is wetted before taking any readings.

③ To take a reading set the psychrometer at right angles and, holding the case, rotate the frame for 15 to 20 seconds at between 3 and 4 revolutions per second.

④ Stop revolving the instrument and note the Wet and Dry Bulb temperatures.

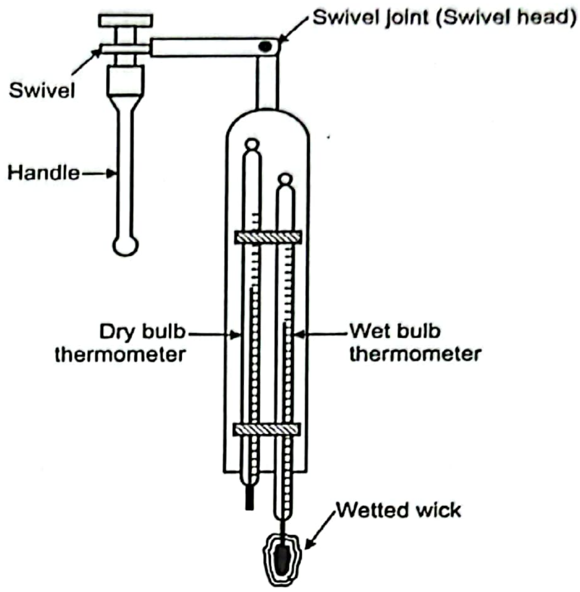
⑤ Subtract the Wet Bulb temperature from the Dry Bulb temperature to determine the Depression.

⑥ Use the tables provided to compare the Dry Bulb

Taking a reading

① Open the instrument. The frame and tubes are set at righ angles to the case, which will act as the handle.

② Thoroughly wet the wick covering the Wet Bulb and the wick in the container by lifting off the container lid and holding the wick container under the cold tap.
Hot water must not be used as it may damage the thermometers.



Maintenance and spare parts

If the wick becomes worn or dirty it can be cut off and replaced with wick from the wick container. The wick container can be opened and a new length of wick withdrawn.

Broken thermometers can be replaced by lifting the retaining bar at the swivel end of the frame and sliding the tubes away from the bulb.

A Spares Kit comprising two replacement thermometers and a spare length of wick is available for the sling psychrometer. When ordering the spares kit please state whether you require spirit or mercury filled thermometers and whether they should read in °C or °F.

Assignment:

a) Show the Dehumidification of moist air by cooling processes on the skeleton psychrometric chart.

b) What do you understand by the term 'Psychrometry'?

c) Why wet bulb temperature is lower than dry bulb temperature?

d) What do you understand by dew point temperature?

e) What are the factors that require our attention while using sling psychrometer?

EXPERIMENT NO-2

Name of the Experiment: Viscosity Test of Liquid Substance

1. **Objective:** Determination of the kinematic viscosity & SAE number of liquid substance.

2. **Specimen:** Different types of liquid substance.

3. **Procedure**

i) Switch on the power supply.

ii) Set temperature by using 'Seta Temperature Controller' device.

iii) Keep the sample to the 'Sample Cup' after setting the pin with ball-valve.

iv) Wait a few minutes until the temperature is same between 'Seta Temp Controller' and'silicon Oil'.

v) Now record the temperature of sample from the Sample Cup.

vi) Place a receiving flask under the 'Saybolt Cup Jet' of 'Sample Cup'.

vii) Remove the pin with ball-valve. Watch, count and record the sample (60ml) dropping timeuntil the cup is empty by using a stop watch.

4. **Equation:** Kinematic Viscosity, $\vartheta = 0.22t - \frac{180}{t}\ mm^2/sec$, where r is the kinematic viscosity and t is the time in sec.

Student Name:

Student ID:

5. Result

Table-1 :(Experiment data and calculated result)

No of Obs	Sample Name	Temperature of the Sample (in °C)	Recorded Time (in sec)	Results	Remarks
1.					
2.					
3.					
4.					
5.					

Assignment

a) **What is viscosity of a fluid? What is the significance of Newton's law of viscosity?**

b) **Write down the differences between kinematic and dynamic viscosity.**

c) **What is SAE number? What do you understand by SAE 20W50?**

d) **Why do we need to determine the viscosity of liquids? Write down the importance of multi grade oil in automobile.**

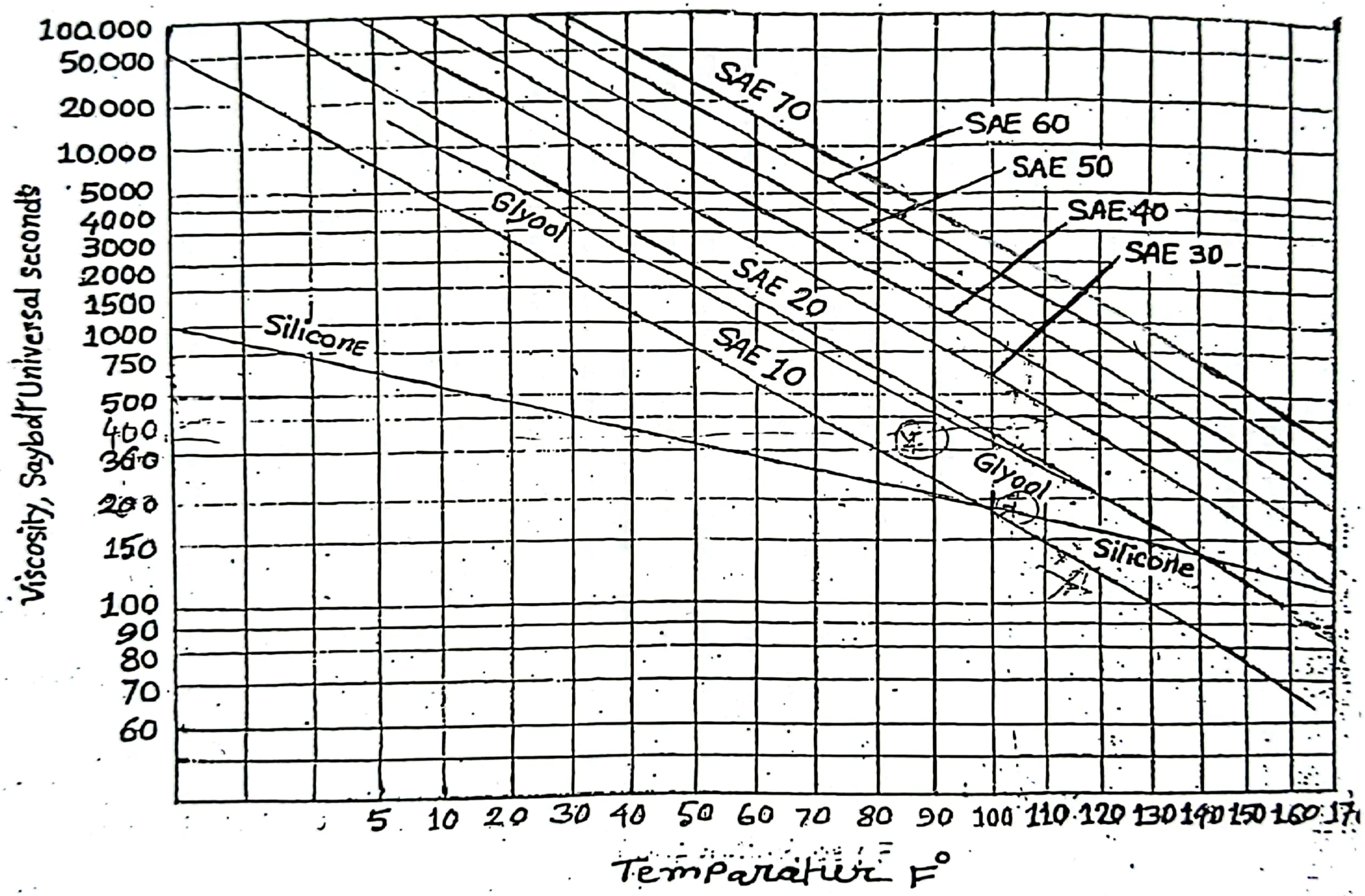


FIG. 267. ASTM viscosity chart.

EXPERIMENT NO: 03

Name of the Experiment: Study and Calibration of Pressure Gauge by Dead Weight Tester

INTRODUCTION

The dead weight tester is a primary measuring instrument, being designed to be used for calibratingthe secondary measuring instruments and generating standard pressure for various tests.

BOURDON TUBE PRESSURE GAUGE

When a curved tube of approximately elliptical cross section is subjected to an internal pressure, it has a tendency to straighten. If one end of the tube is fastened there will be definite movement of the other which depends on the magnitude of the applied pressure. If the pressure within the tube is reduced below that surrounding of the tube, it will have a tendency to curve still further in a smaller arc. The tube itself resists and if not stretched beyond its elastic limit, will return to its original position when the pressure is removed. Such a tube is the so called Bourdon tube pressure gauge. By means of a suitable linkage, the motion of the free end of the tube is transmitted to a rack and pinion which rotates a needle mounted on the face of the gauge.

Bourdon tube pressure gauge are often classified

1. Pressure gauge (for pressure above atmospheric)
2. Vacuum gauge (for pressure below atmospheric)
3. Combination gauge (for both vacuum and small positive gauge pressure)

Pressure gauges are normally graduated in pounds per square inch. Although for special applications they may have other graduations, such as feet of water. Vacuum gauges normally are graduated in inches of mercury. The vacuum part of combination gauges generally is graduated in inches of mercury and pressure part in psi.

DEAD WEIGHT TESTER

The most satisfactory method of calibration of pressure gauges is to use a dead weight gauge tester.In the dead weight tester, a pressure is impressed on oil, which transmits this pressure equally to known area and to the gauge under test. Thus the piston and the weight give knowledge of the true oil pressure which is acting on the gauge.

OPERATION PROCEDURE

1) Open the ram cylinder stop valve, release valve, and gauge valve in which a gauge is mounted. Then, fully turns counterclockwise the fine adjust pump, and close the release valve.

2) Put weight (each weight is stamped with the nominal pressure) corresponding to the specifiedpressure. Be sure to add the weight of the ram plate itself.

   For a combination system dead weight type pressure gauge of non-P_a unit, put a conversion weight on the ram plate of P_a unit, and then weight of non-P_a unit.

   When using the gauge in non-P_a unit, do not add the pressure of the ram plate because the pressure of the ram plate and conversion weight indicated on the conversion weight as 1A & 1B.

   To generate pressure of two different units using a set of ram cylinder, the masses of theweights of each unit must be changed.

   To change the ram plate, the mass of which is determined on the basis of the P_a unit, intoother than the P_a unit, you must correct its mass with a conversion weight.

   For example, the ram plate itself generates a pressure of 0.05 MPa. A conversion weight putthe ram generates pressure of 1 kg f/cm^2.

3) Pressurize the Gauge with the pre-loading pump and find adjustment pump line referring to the indications on the monitor gauge until the ram plate rises about 12 mm above the cylindertop *1 Turning the weights clockwise slightly will generate the specified pressure. In this state, read the indication on the gauge.

4) To raise pressure in steps, put weights corresponding to the specified pressure sequentially and repeat the procedure in (3).

5) Decrease the weight in similar manner and again note the corresponding pressure gauge reading.

6) Find the error and percentage error.

7) Plot percentage error against observed gauge reading and observed pressure against actual

pressure on different graph papers.

8) Discuss the curves and the experiment as a whole.

Student Name:

Student ID:

DATA SHEET

Area of Piston: ……………………

Wt. Piston & weight platform: …………………

No of Obs.	Actual pressure	Pressure gauge reading			%Error
		Up	Down	Mean	
1					
2					
3					

Assignment

a) What is calibration process? Write down the necessity of calibration.

b) Why is it called a dead weight tester?

c) What affects the accuracy of a dead weight tester?

d) Convert 1 kg f/cm^2 to Pa.

e) Write down the working principle of Bourdon pressure gauge.

f) Define absolute, gauge and vacuum pressure.

g) What are the limitations of a dead weight tester?

EXPERIMENT NO – 04

Name of the Experiment: Study of Compressor, Condenser, and Evaporator of Split and Window Air Conditioner.

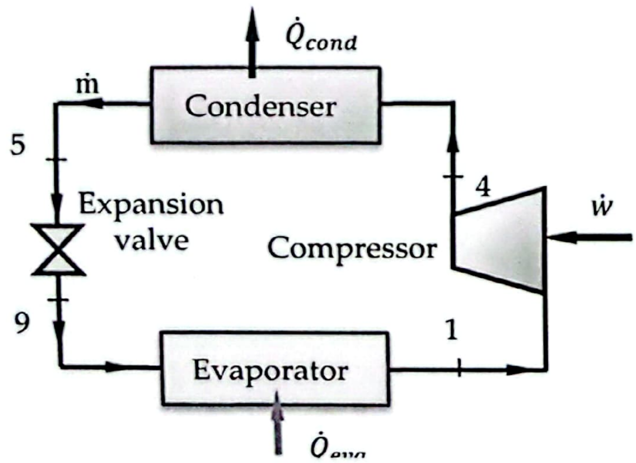
Objectives

- To learn the functions of the different components of Refrigeration and Air conditioning system
- To identify the components of the Refrigeration and Air conditioning system
- To learn the importance of Refrigerant

Vapor Compression Refrigeration System

The Vapor Compression Refrigeration system uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. All such systems have four components:

1. **Compressor** (Generally a Reciprocating Compressor)
2. **Condenser** (It condenses the high-pressure gaseous refrigerant and acts as storage tank)
3. **Expansion Device** (Also called a throttle valve. May be a globe valve or simply a capillary tube)
4. **Evaporator** (Also termed as cooling coil. It is generally a copper coil with high surface area)



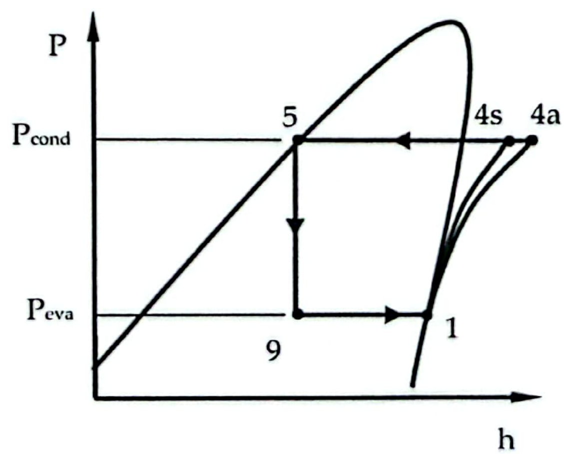
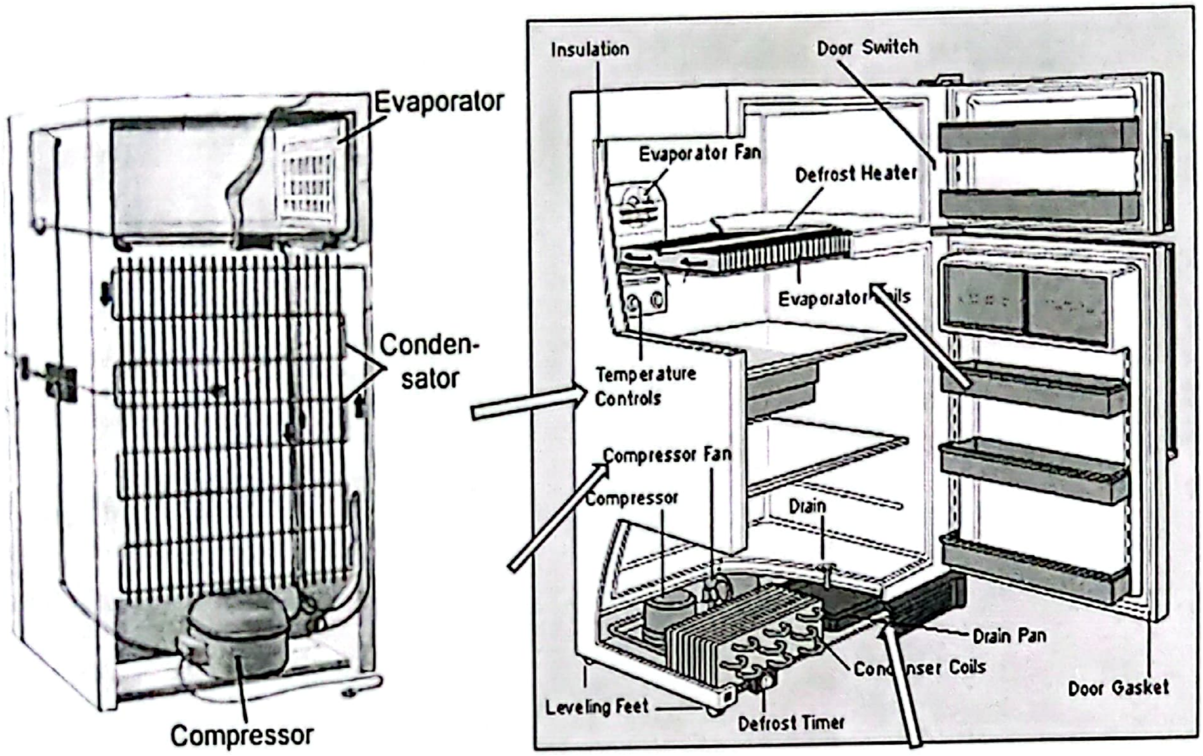


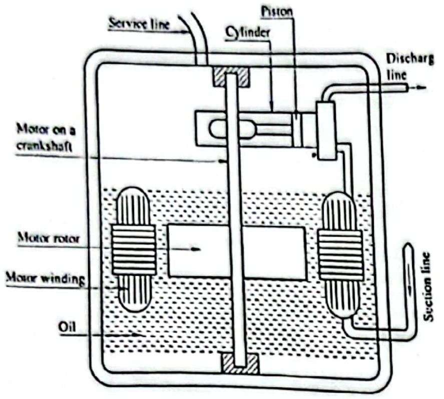
Figure: Schematic Diagram of VCRS with P-h diagram

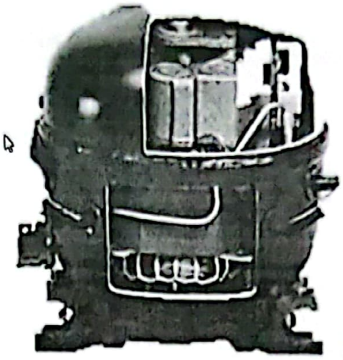


Compressors

The purpose of the compressor in the vapor compression cycle is to compress the low-pressuredry gas from the evaporator and raise its pressure to that of the condenser. Compressors can be:

- **Hermetic/sealed/welded**
- **Semi-hermetic/accessible hermetic**
- **Open**





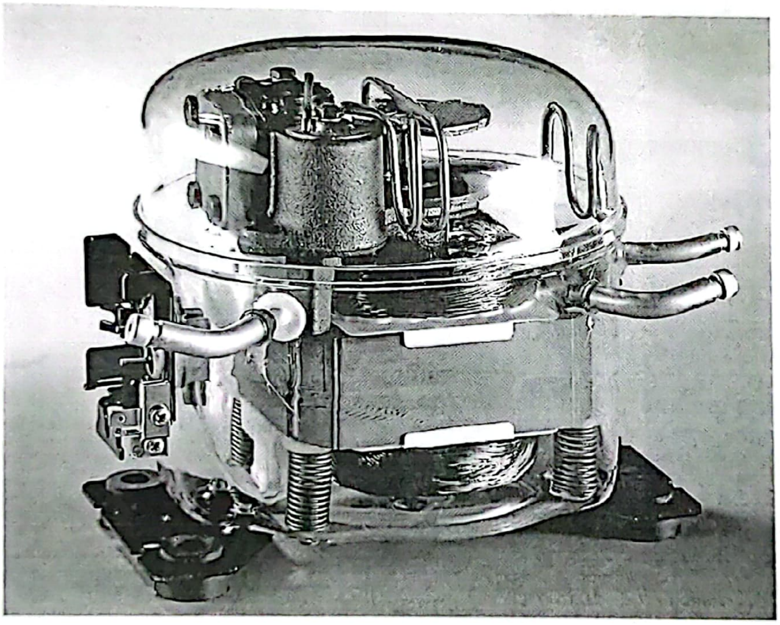
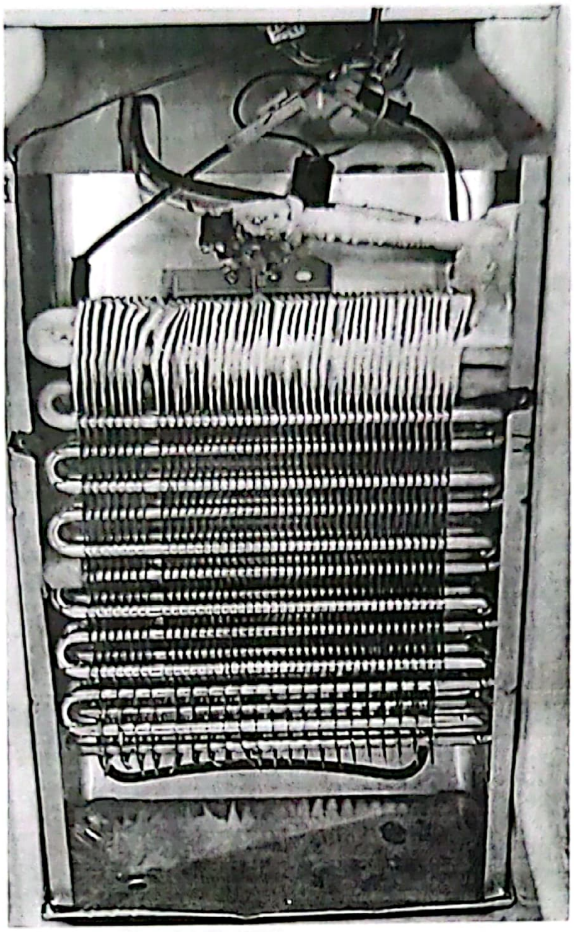


Figure: Hermetically sealed Compressor

Evaporator

The evaporator is located inside a refrigerator and is the part that makes the items in the refrigerator cold. As the refrigerant turns from liquid into gas through evaporation it cools the area around it, producing the proper environment for storing food.

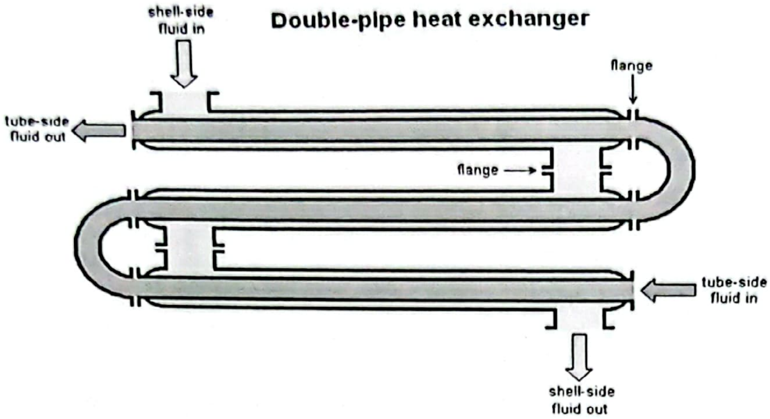


Condenser

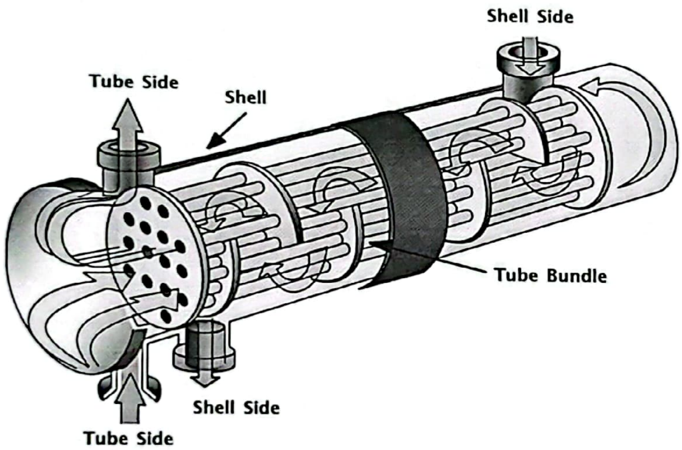
Based on the cooling medium used, condensers used in refrigeration systems can be classified into the following three categories:

1. Water-cooled condensers

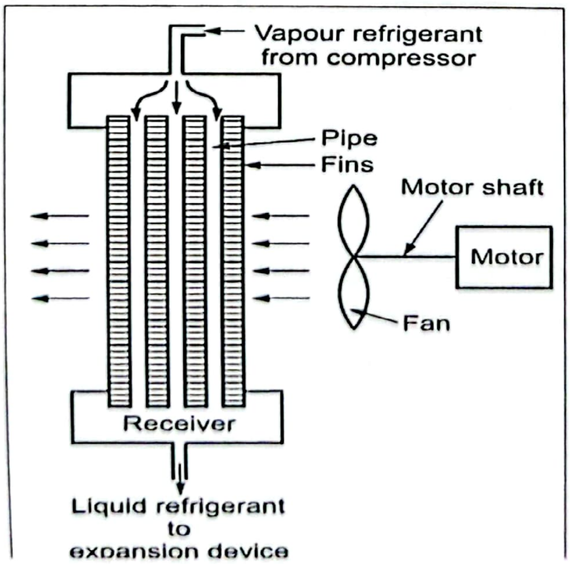
a. Double-tube condenser



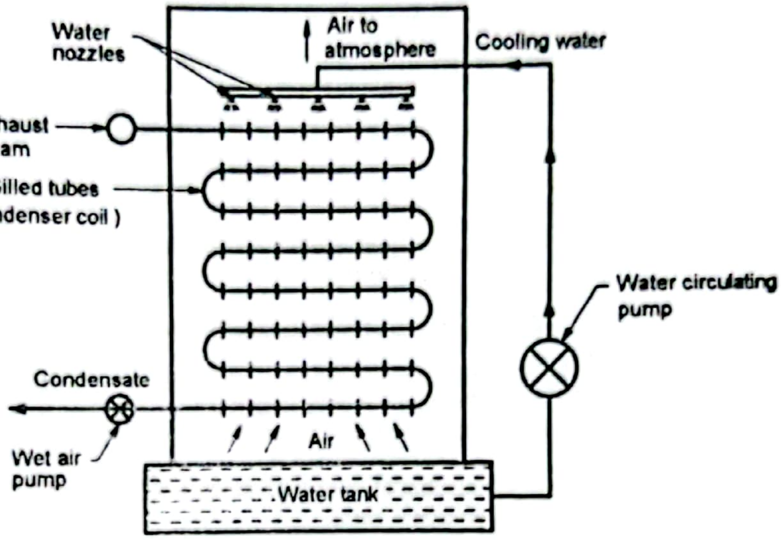
b. Shell-and-tube condenser



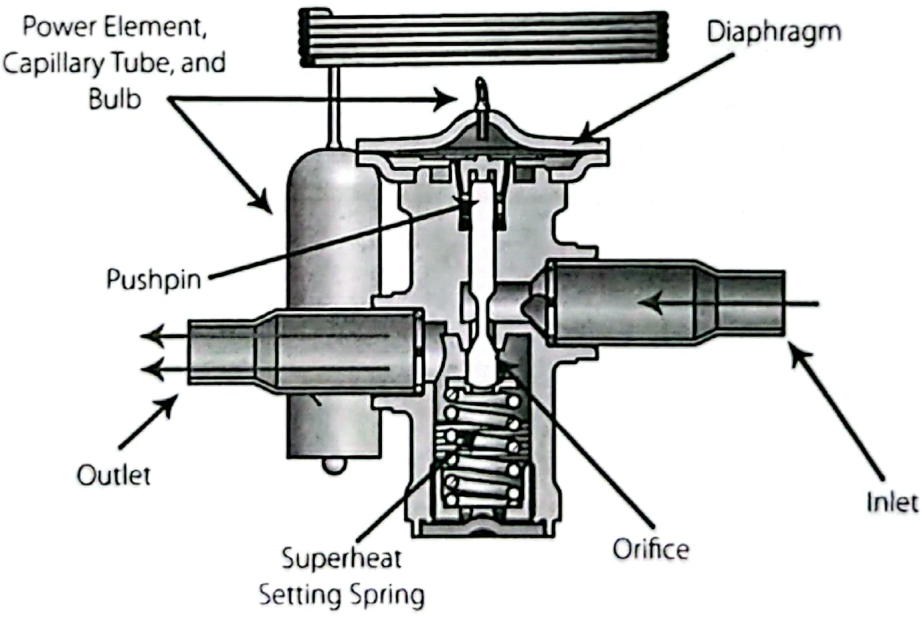
2. Air-cooled condensers



3. Evaporative condenser



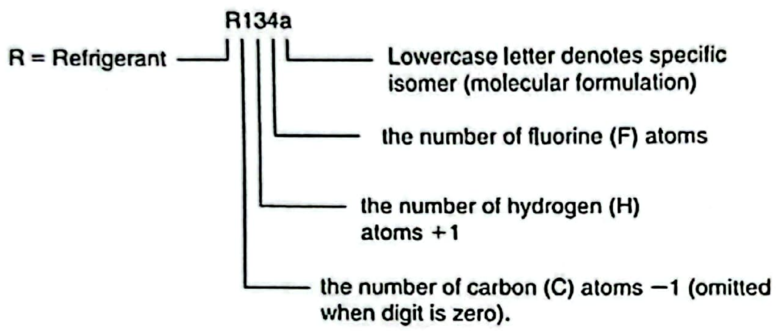
Expansion valve



TXV (Thermostatic expansion valve)

Refrigerant

Refrigerants are well known as the fluids providing a cooling effect during the phase change from liquid to vapor. These are used in refrigeration, air conditioning, and heatpump systems, as well as process systems.



Types of Refrigerants

Refrigerants are classified into different groups depending on their chemical composition. The most common refrigerant groups include:

- Chlorofluoro carbons (CFCs)
- Hydrofluoro carbons (HFCs)
- Hydro chloro fluoro carbons (HCFCs)
- Natural Refrigerants

Air Conditioning Systems

Air conditioning is the cooling and dehumidification of indoor air for thermal comfort. In a broader sense, the term can refer to any form of cooling, heating, ventilation, or disinfection that modifies the condition of air. An air conditioner (often referred to as AC) is an appliance, system, or mechanism designed to stabilize the air temperature and humidity within an area (used for cooling as well as heating depending on the air properties at a given time), typically using a refrigeration cycle but sometimes using evaporation, commonly for comfort cooling in buildings and motor vehicles.

Air Conditioning is the most important application of refrigeration. "Air Conditioning is the process of air treatment which controls the temperature, humidity, cleanliness and distribution of the air simultaneously to meet the requirements of a conditioned space." An air conditioner serves the purpose of an air cooler, air heater and an air cleaner.

Basic Air conditioning system:

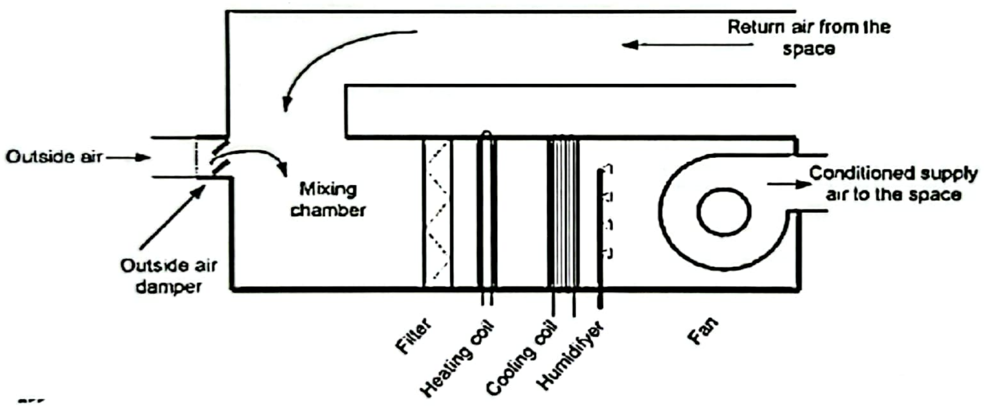


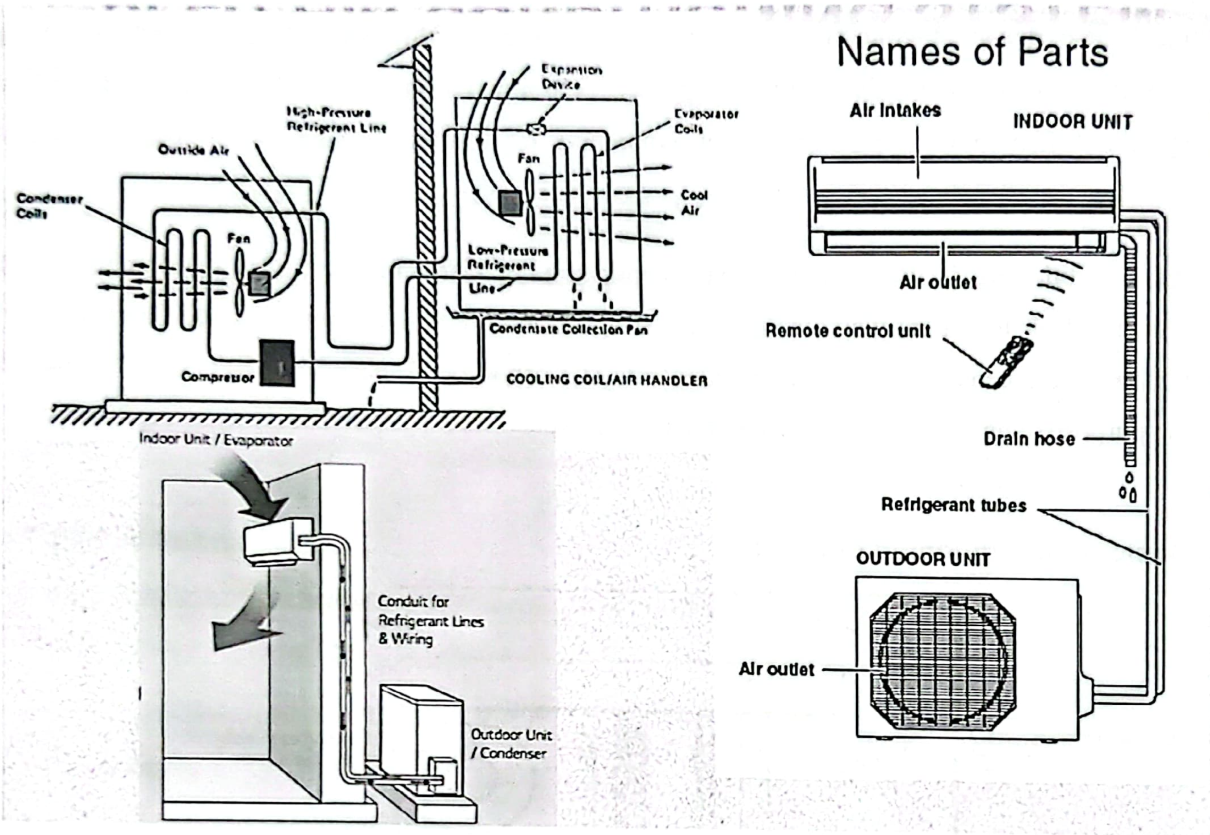
Figure: Basic Air conditioning system

In many buildings there is a variety of spaces with different users and varyingthermal loads. When a system is designed to provide independent control in different spaces, each space is called a zone.

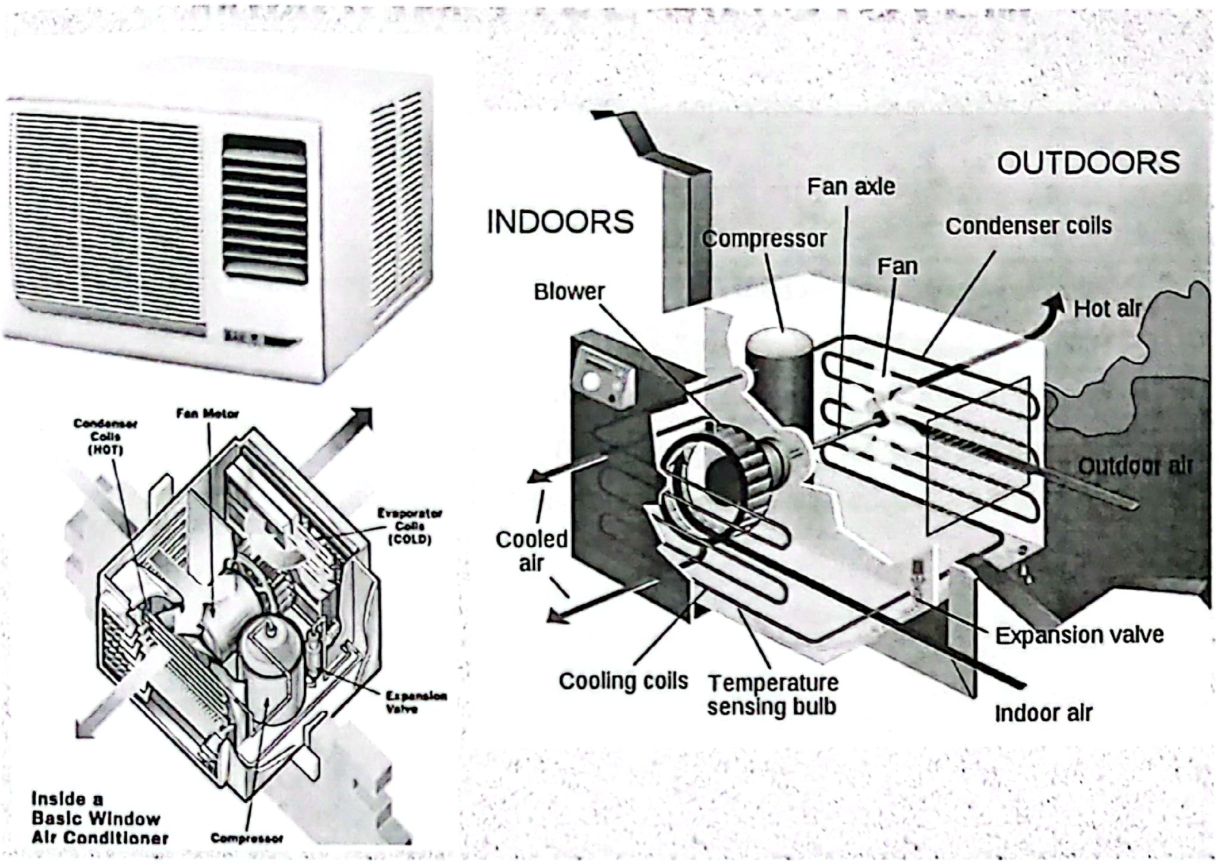
Unitary Refrigeration-based systems

- Single Package Units
- Split Package Units
- Single Package Units

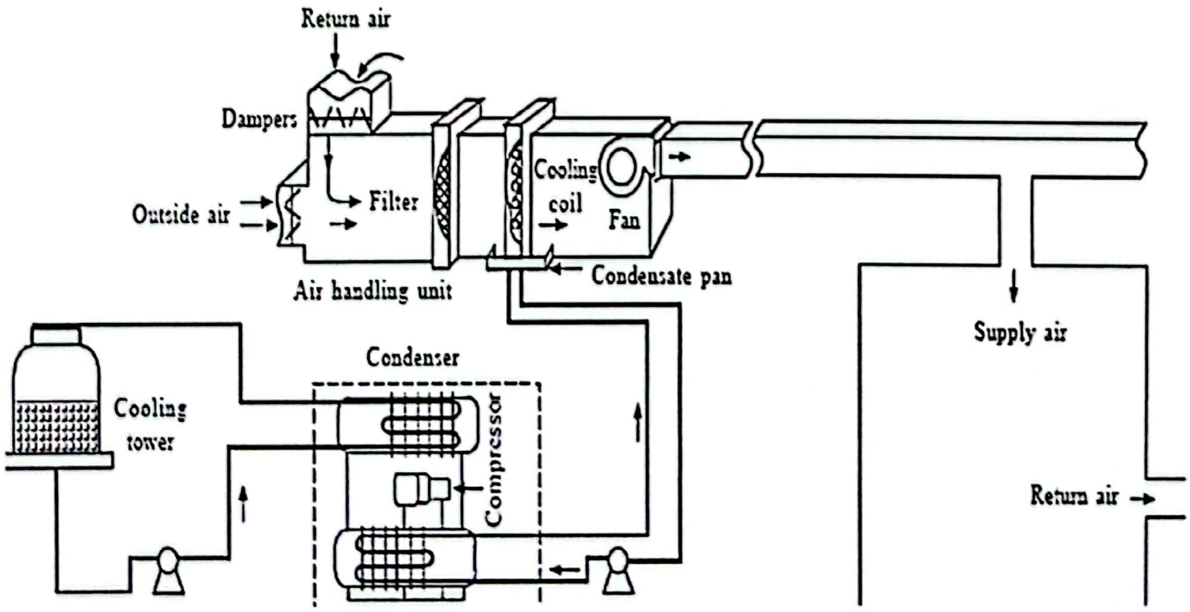
Split Package Units



Window Type A/C



Split Package Units Chiller Type or Central A/C



Assignment

a) What are the differences between split and window AC?

b) What is dehumidification process?

c) What is the function of dampers in air conditioning unit?

d) Describe the term Air Handling Unit (AHU).

e) What is the disadvantage of a hermetically sealed compressor?

EXPERIMENT NO-05

Name of the Experiment: Study of Vapor Compression Refrigeration Cycle (Refrigeration and Air-conditioning Unit).

1. Objective

a. To study a refrigeration unit

b. To calculate the COP of a vapor compression refrigeration cycle.

c. To study cooling and dehumidification process with the help of the Psychrometric chart.

d. Performance of cooling and dehumidification process with the help of the refrigeration unit.

2. Apparatus

Name - Air Conditioning Laboratory Unit
Model - A660/05026
Country of origin - England

3. Equation used

a. $COP = \frac{Q_{evap}}{W_{Comp}} = \frac{h_1 - h_4}{h_2 - h_1}$

b. $m_a = 0.504 \sqrt{h/v_a}$

c. $m_w = m_a(W_1 - W_2)$

d. $h_w = m_w C_{pw} t_w$

e. $m_a(h_{a_1} - h_{a_2}) = m_r(h_{r_1} - h_{r_4})$

f. $m_a(h_{a_1} - h_{a_2}) = m_r(h_{r_1} - h_{r_4}) + m_w h_w$

g. $m_a(h_{a_1} - h_{a_2}) - m_a(W_1 - W_2)h_w = m_r(h_{r_1} - h_{r_4})$

4. **Schematic Diagram.**

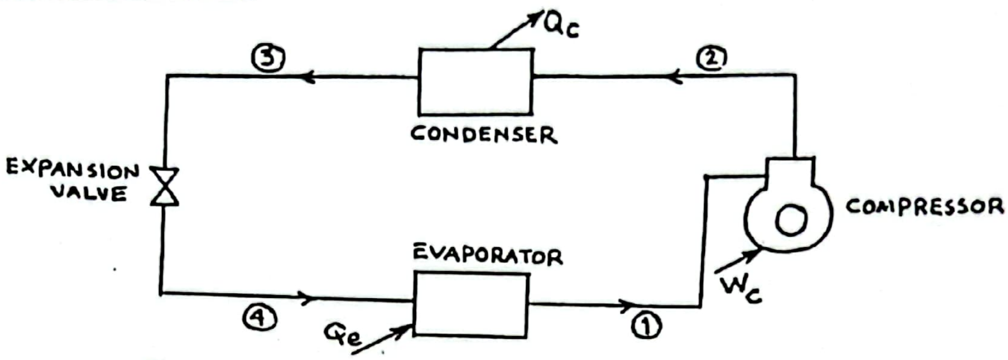


Figure 1: Schematic Diagram of Standard Vapor Compression Cycle.

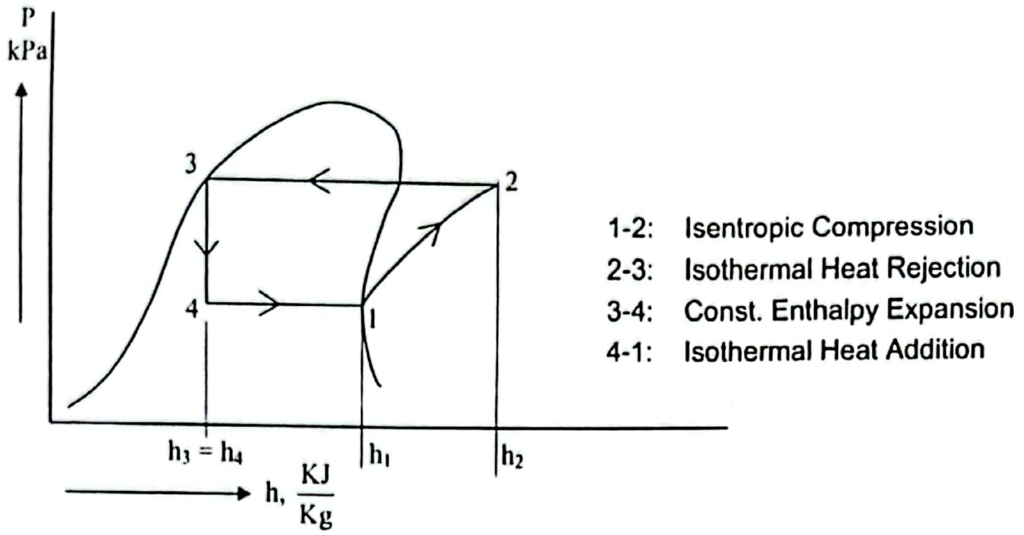


Figure 2: P-h Diagram for Standard Vapor Compression Cycle.

5. Major Component

The major components of vapor compression refrigeration cycle are

- Compressor
- Condenser
- Expansion device
- Evaporator

6. Cooling and Dehumidification

It occurs when air passes over a surface having surface temperature lower than the dew point temperature of air or when water having surface temperature lower than the dew point temperatureof air is sprayed. In this psychrometric process.

Dry Bulb Temperature	→ Decrease
Wet Bulb Temperature	→ Decrease
Relative Humidity	→ Decrease/Increase/Constant
Humidity Ratio	→ Decrease
Enthalpy	→ Decrease

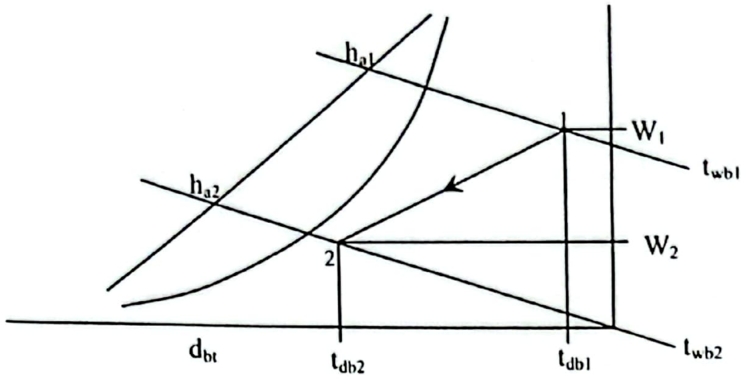


Figure 3: Cooling and Dehumidification process in Psychrometric Chart.

The refrigeration cycle, and the cooling dehumidification process are shown in the figure below.

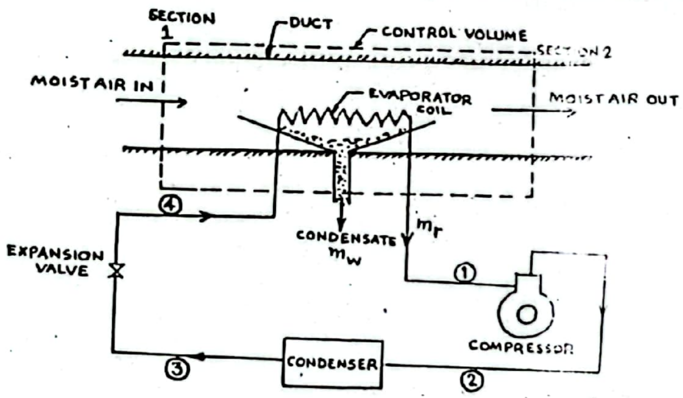


Figure 4: Schematic Diagram of Experimental Set up

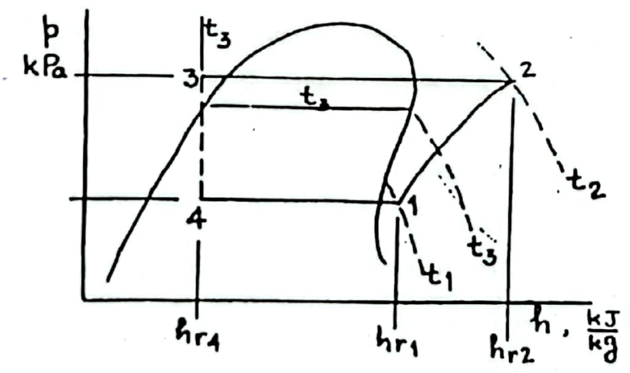


Figure 5: P-h Diagram for Experimental Process.

The energy balance for the control volume can be written as (assuming an adiabatic system)

$m_a h_{a_1} + m_r h_{r_4} = m_a h_{a_2} + m_r h_{r_1} + m_w h_w$

Or, $m_a\left(h_{a_1} - h_{a_2}\right) = m_r\left(h_{r_1} - h_{r_4}\right) + m_w h_w$...4(a)

Also, water vapor balance gives, $m_w = m_a\ (W_1 - W_2)$ ....4(b)

From eq (1) and (2), $m_a\left(h_{a_1} - h_{a_2}\right) - m_a\ (W_1 - W_2)h_w = m_r\left(h_{r_1} - h_{r_4}\right)$ ....4(c)

Note: For condensate, $h_w = m_w C_{pw} t_w$..4(d)

Where t_w is condensate temperature

The air flow rate m_a is measured by an orifice meter installed at the end of the air duct and is given by

$$m_a = 0.504\sqrt{h/v_a}$$

Where h= manometer reading, mm of water and v_a =Sp volume of air at orifice meter upstream, m^3/kg

The refrigeration flow rate m_r is directly read from the flow meter (Rota meter)

7. Procedure

i. Study carefully all the different components

ii. Open the water valve fully so allow water to flow through the condenser.

iii. Switch on the fan. Set the flow rate at a suitable value.

iv. Switch on the refrigeration compressor.

v. After steady condition has reached, record, record p_c, t_{r1}, t_{r2}, t_{r3} and m_r of the refrigeration cycle. Also record dry-bulb and wet-bulb temperatures of air at inlet and outlet of the evaporator coil.

vi. Record the manometer reading, mm of water. Also collect the condensed over a period of about 3 minutes and note its temperature. (If there is no condensate formed, you may humidify the air by injecting steam to the air before entering the evaporator coil)

vii. After all the readings are taken, switch off the compressor. After two minutes, switch off the fan, and close the condenser cooling water valve.

Student Name:

Student ID:

Data

Refrigeration Cycle
Table-1:

Ser No	P_{cond} (kPa)	P_{evap} (kPa)	tr1 (T_{13})	tr2 (T_{14})	tr3 (T_{15})	m_r (kg/min)
1.						
2.						
3.						
4.						

Air cycle

Table-2:

Ser No.	Air entering Evap.		Air leaving Eavp.		Manometer reading (mm of Water)
	t_{db1} (°C)	t_{wb1} (°C)	t_{db2} (°C)	t_{wb2} (°C)	
1.					
2.					
3.					

Using the above readings, check that the left hand side of equation (3) is equal to its right hand side. Also, check L.H.S of equation (2) with its R.H.S.

If there is no condensate formed, $m_w = 0$, i.e. $W_1 = W_1$ then

$$m_a(h_{a_1} - h_{a_2}) = m_r(h_{r_1} - h_{r_4}) \quad \text{......} 4(f)$$

Also calculate the COP of the refrigeration system.

$$COP = \frac{Q_{evp}}{W_{comp}} = \frac{h_1 - h_4}{h_2 - h_1} \quad \text{......} 4(g)$$

Assignment

a) **Why low pressure is maintained in the evaporator and high pressure in condenser?**

b) **Discuss the effect of weather condition on the amount of condensate water while performing this experiment.**

c) **Why wet bulb temperature was lower than the dry bulb temperature?**

d) **Sketch T-s and p-h diagram for the vapor compression cycles when the vapor after compression is i) dry saturated and ii) Superheated.**

EXPERIMENT NO – 6

Name of experiment: Study of Mechanical Heat Pump

Objectives:

(i) Determination of Power Input, Heat Output and Coefficient of Performance.

(ii) Production of Heat Pump Performance Curves over a range of source and delivery temperatures.

(iii) Comparison of Practical and Ideal Cycles on a p-h diagram and determination of energy balances for Condenser and Compressor.

(iv) Production of Heat Pump Performance curves based on the R134a properties at a variety of evaporating and compensating temperatures.

(v) Estimation of the effect of Compressor Pressure Ratio on Volumetric Efficiency.

Theory:

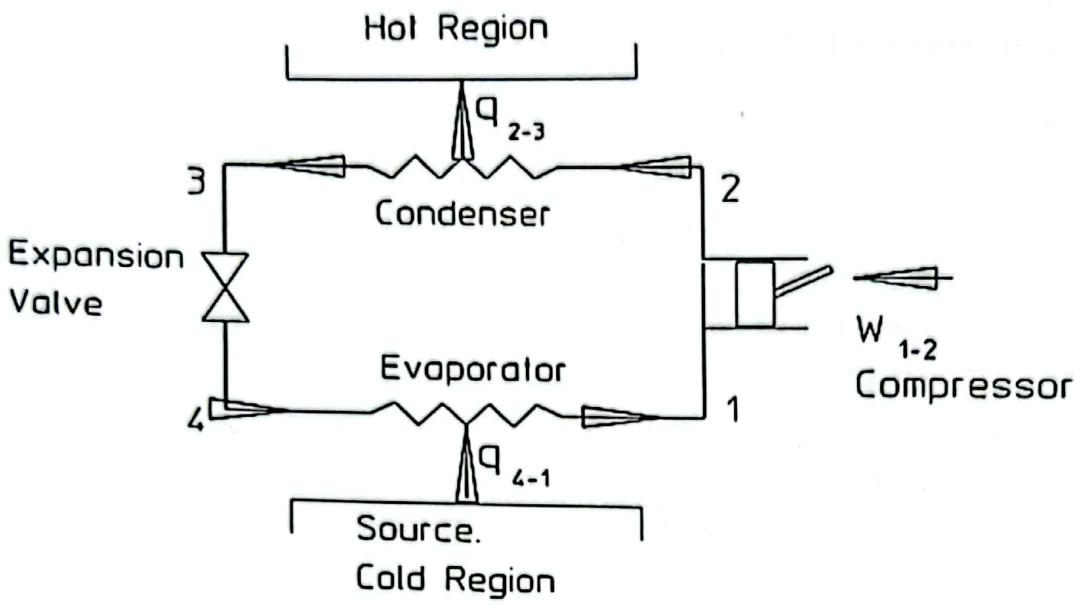
A heat pump is a machine whose prime function is to absorb heat from a low-grade source, and to deliver heat at a useful temperature, e.g. suitable for space heating or domestic hot water, although higher temperatures are possible in special circumstances.

To do this, a heat pump requires,

(i) A low-grade heat input (this is usually "free")

(ii) A high-grade energy input either in the form of work or as heat at a high temperature.

Practical heat pumps can deliver considerably more heat than is taken in as high-grade energy and, in suitable circumstances, can make a valuable contribution to energy conservation.



A heat pump utilizes the steam power station cyclic process in reverse. This results in the direction of the flow of heat also reversing:

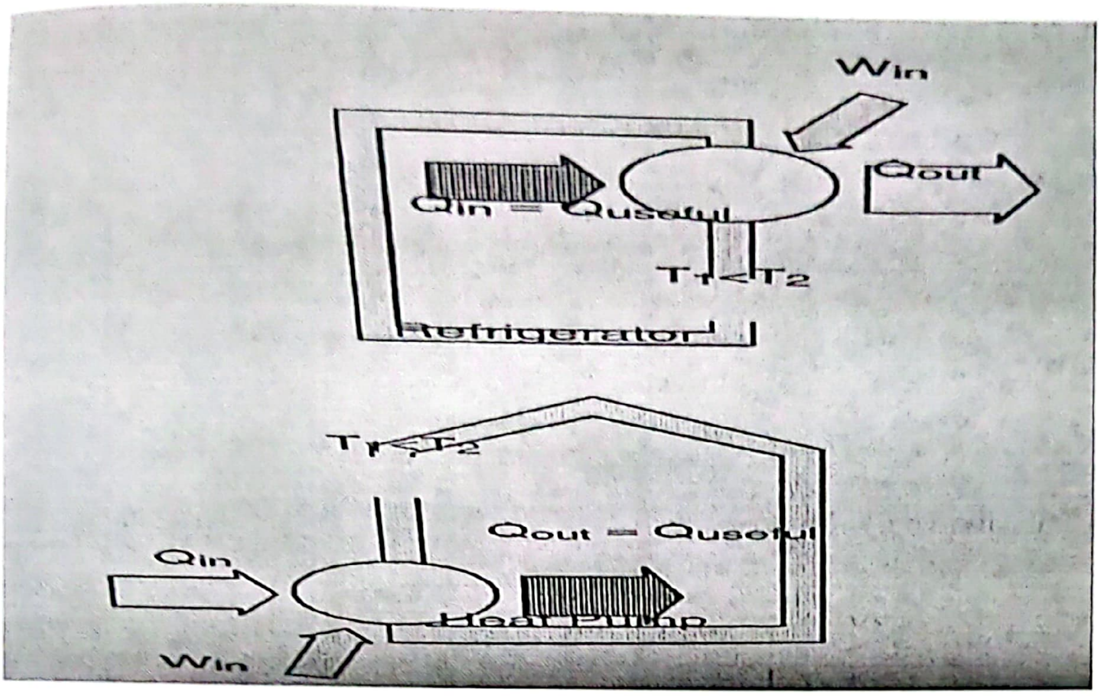
- A compressor compresses the vaporous working medium, during this process mechanical energy W_{IN} is absorbed.
- In the condenser the heat Q_{out} is drawn (at constant temperature) from the working medium and the medium condenses. The heat can be used, e. g., to heat water.
- In an expansion valve the liquid working medium expands, during this process it cools down.
- An evaporator facilitates the evaporation of the working medium while it absorbs heat Q_{in}. in this case the heat is drawn from the ambient air by the refrigerant.

The working medium is again fed to the compressor and the cyclic process starts again from the beginning.

Comparison between Heat Pump and Refrigerator

In respect of its function the heat pump is identical to the refrigerator. There heat is also pumped from a low energy level 1 (from the refrigerator) to a higher energy level 2 (to the ambient environment). While in the case of the heat pump the heat emitted Q_{out} is utilized, the benefit in the case of the refrigerator is however in the heat absorbed Q_{in}.

In each the work is the mechanical energy W_{in} necessary.



The advantage of processes with vaporous/liquid working media is the high energy transfer density. In the case of evaporation, the working medium absorbs the evaporation heat at low temperature differences. On condensing the medium emits this energy again.
For the working media used the evaporation heat is much larger than the amount of heat that can be transferred by means of the specific heat capacity of the vapour.

Experimental Set-up:

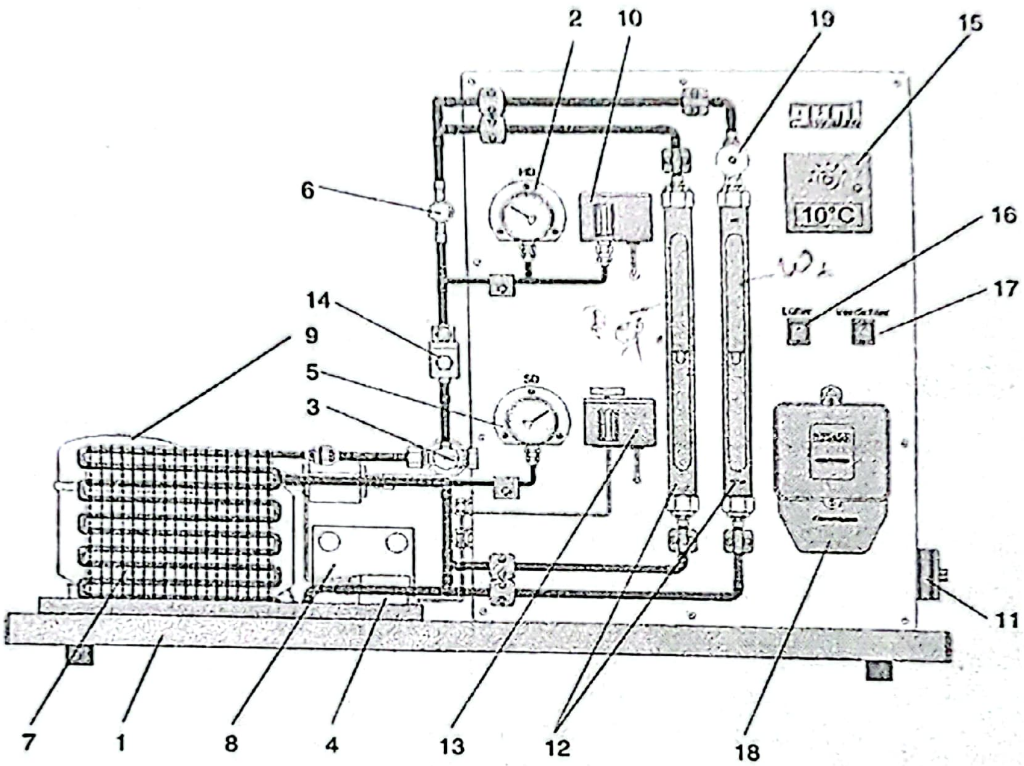


Fig: Layout of Mechanical Heat Pump

Diagram Key

1. Base Plate
2. Manometer for High Pressure side (HP)
3. Expansion Valve with Temperature Sensor
4. Temperature Sensor with thermostat
5. Manometer for low Pressure side (LP)
6. Sight glass for refrigerant
7. Evaporator
8. Condenser
9. Compressor
10. Press switch
11. Master switch
12. Flowmeter
13. Thermostat
14. Solenoid Valve
15. Measuring Point Switch
16. Fan Switch
17. Compressor Switch
18. Single Phase Meter
19. Needle Valve

10. Press stat

Procedure:

1. Turn on the water supply to a high flow rate.
2. Ensure that the receiver inlet and outlet valves are open by being `back seated' anti-clockwise.
3. Turn on the mains switch.
4. Switch on fans for evaporator using switch.
5. Then switch on the compressor switch.
6. After a short period of "gassing" in the R134a flow meter tube, the flow rate should stabilize. The heat pump may now be set to operate at any conditions within its capability. The unit is ready for use as soon as temperatures and pressures are sensibly constant.

Shutting Down:

Before shutting down, increase the condenser water flow rate to maximum for two or three minutes, then switch off and turn off the water supplies.

The water should not be left running.

Student Name:

Student ID:

Observation Table

a. Measure Values

Obs.	$\dot{m}_{water}$ in g/s	T_1 in °C	T_2 in °C	T_3 in °C	T_4 in °C	T_5 in °C	T_6 in °C	p_{HP} in bar	p_{LP} in bar	$\dot{m}_{Ref}$ in g/s	T 10 Rounds in s
1											
2											
3											
4											
5											

b. Calculated Values

Obs.	$\dot{m}_{water}$ in Kg/s	$\dot{m}_{Ref}$ in Kg/s	P_{el} in W	h_1 in KJ/KgK	h_2 in KJ/KgK	h_3 in KJ/KgK	h_4 in KJ/KgK
1							
2							
3							
4							
5							

Obs.	$\dot{Q}_{Comp}$ in W	$\dot{Q}_{Eva}$ in W	$\dot{Q}_{Cond}$ in W	η	ψ	λ in %	ΔT in °C	COP
1								
2								
3								

4								
5								

Calculation:

1. Electrical Power Input, $P_{el(10U)} = \frac{7200WS}{t}$ W

2. Heat supplied by Refrigerant from Compressor, $\dot{Q}_{Comp} = m_{ref} (h_2 - h_1)$ W

3. Heat rejected by Refrigerant in Condenser, $\dot{Q}_{Cond} = m_{ref} (h_2 - h_3)$ W

4. Heat absorbed by Refrigerant in Evaporator $\dot{Q}_{Eva} = m_r (h_1 - h_4)$ W

5. Compressor Efficiency, $\eta = \frac{\dot{Q}_{Comp}}{P_{el}}$

6. Compressor Pressure Ratio, $\psi = \frac{p_{2/3}}{p_{1/4}}$

7. Volumetric Efficiency, $\lambda = \frac{\dot{V}_{Real}}{\dot{V}_{Theo}} \times 100\%$

The Compressor swept Volume flow rate (assuming that it runs at 2850 rev. min^{-1})

$V_{Theo} = n_{Comp} \times V_{Cyl}$ {where $V_{Cyl} = 12.05\ cm^3$}

And Actual Flow Rate, $V_{Real} = \frac{m_{Ref}}{\ddot{\rho}_{Ref}}$ {The density of the saturated refrigerant steam $\acute{\rho}_{Ref}$ can be found in the table}

8. Temperature Difference $\Delta T = T_1 - T_{Ambient}$

9. $COP = \frac{\dot{Q}_{Cond}}{P_{el}}$

Precautions

- Use stabilized power supply.
- Drain the water from tanks after performing experiment.
- When apparatus is no longer in use condense the refrigerant.
- Use stop watch for time measurement.

Result

Assignment

a) What is a heat pump and how does it work?

b) What are the advantages and disadvantages of a heat pump?

c) Compare the coefficient of performance (COP) of a heat pump and a refrigerator.

d) What do you understand by evaporation and condensation?

e) What is the effect of Compressor Pressure Ratio on Volumetric Efficiency?

EXPERIMENT NO – 07

Name of the Experiment: Determination of Calorific value of Gaseous Fuel by Gas Calorimeter

Objectives

To find out the calorific value of natural gas using gas calorimeter.

Apparatus

Gas calorimeter, Wet-gas meter, Gas controller, Gas burner, Thermometers, Water container, Lighter

Identification of Components

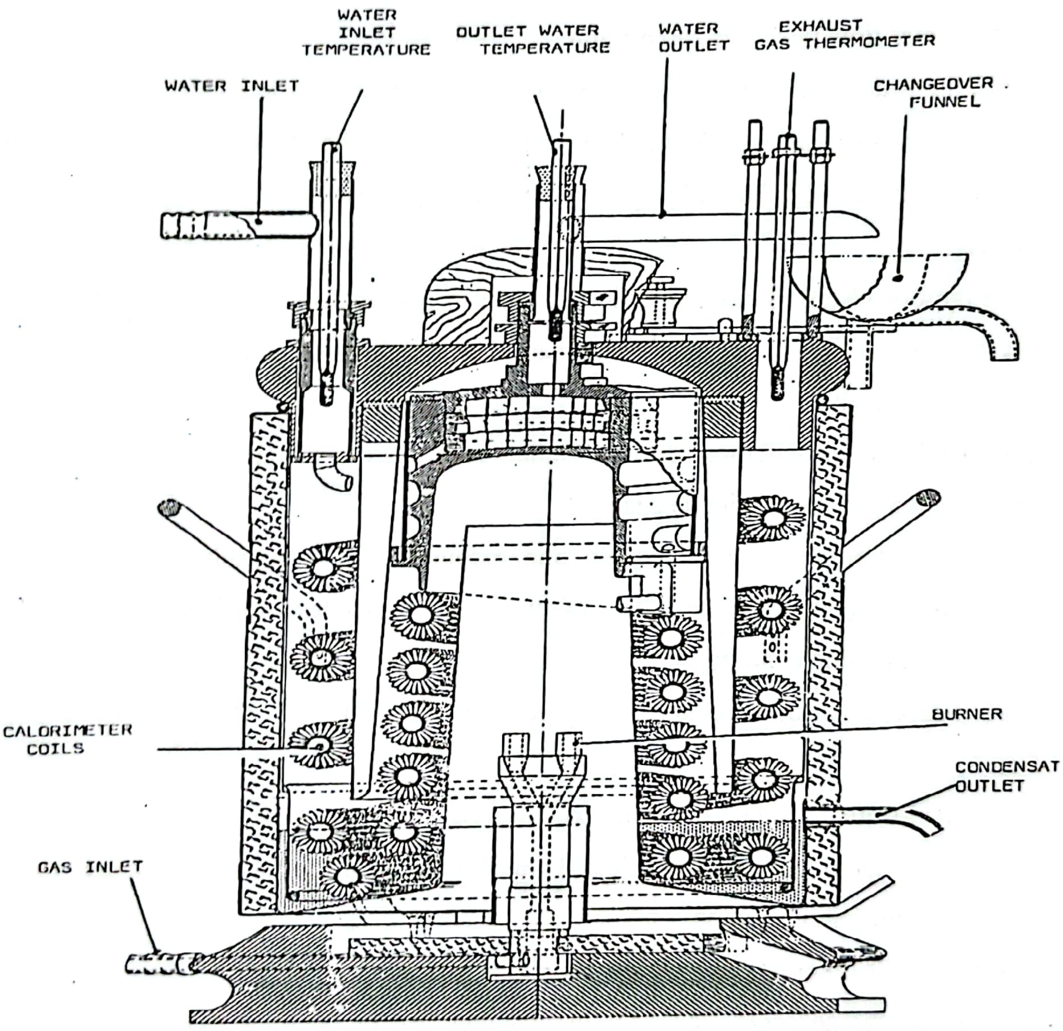


Figure 1: Sectioned view of a typical Boys calorimeter.

SUMMARY OF OPERATION PRODUCER

i) Connect a tube from the cooling water source to the inlet to calorimeter; the inlet is the connection at the perimeter of the top plate of the unit.

Connect a tube from the Calorimeter water outlet (at the center of the top plate) to the drain source.

ii) Connect a tube from the gas supply to the wet test meter (Hyde meter) gas supply inlet located at the top of near side.

iii) Connect a tube from Hyde meter outlet of the gas control value inlet. Connect a gas control valve outlet with the burner inlet located at the bottom plate of Calorimeter.

iv) Set the water flow rate: 150-200 ml/min

v) Check the water level at the definite level in the sight box of Hyde meter.

vi) Pull out the inner casing first and then outer casing from the calorimeter main body. Set the gas flow rate 1.5-2.5 liter/min by regulating the quadrant valve and ignite flame by gas lighter.

vii) After ignition check all gas connecting points by soap-bubble to ensure zero leakage.

viii) Put the outer casing on the calorimeter base plate and then place the inner casing around the flame very slowly.

ix) Observe the water outlet temperature. Outlet temperature must rise up. If not, flame may be extinguished and need to ignite again.

x) After ignition of the flame, set the minimum required position in quadrant valve.

xi) Allow the gas to burn and the water to flow through the calorimeter for a least 30 minutes to allow the operating condition in steady state.

xii) During experiment observe gas flow and cooling water flow to ensure the flow is perfectly OK.

xiii) After stabilization, collect the required data (viz., inlet gas flow temp., inlet water temp., outlet water temp., volume of collected water, volume of collected condensate, volume of gas, and time) for calculation.

xiv) For 2^{nd} and 3^{rd} observations gas flow should be increased.

xv) After collecting necessary data, stop the gas flow first by the main gas flow valve and then after 10-12 minutes stop the cooling water flow.

WARNING

i) Never stop cooling water flow while fuel gas is burning.

ii) When gas flow or cooling water flow discontinue at any time on analysis condition, stop the gas flow main valve.

iii) When water outlet temperature goes down, it means the flame is out. Try again to ignite the flame as early as possible.

iv) When water outlet temperature is abnormally high (above 60°C), stop the gas flow main valve. Otherwise, calorimeter will be seriously damaged.

v) Never connect Hyde meter with supply gas pressure above 48 mbar (20 ins of water).

FORMULA AND TABLE

$$Q_{gross} = \frac{m_w}{V_G} \times \Delta t Cw \times GVf$$

Where,

Q_{gross}=Gross calorific value, kJ/m^3

M_w=Quantity of water in Kg

V_G= Gas volume in m^3

Δt =Temperature difference in $^\circ$C

C_w= Specific heat of water (4.187 kJ/kg °C)

GVf = Gas volume factor

Student Name:

Student ID:

Table: observed data for determining calorific value.

Ser No	Gas Inlet Temp(°C)	Water		Water collected Kg	Condensate collected Kg	Gas flow (1 rev) m^3	Barometric pressure mmHg	Corresponding GVf	Time sec
		Inlet Temp (°C)	Outlet Temp (°C)						

Calculation

Gross (Higher) heating value (HHV)

Calorimeter value in MJ/m^3 & BTU/ft^3

Water inlet temperature	:
Water outlet temperature	:
Temperature difference (Δt)	:
Gas inlet temperature	:
Water collected (m_w)	:
Number of revolution	:
Gas volume (V_G)	:
Barometric pressure	: 760 mmHg
Corresponding GVf	:
Specific heat of water (C_w)	: 4.187 kJ/kg °C

$$Q_{gross} = \frac{m_w}{V_G} \times \Delta t Cw \times GVf$$

In $BTU/ft^3 = Q_{gross} \times 26.8413 =$........................ BTU/ft^3

Net (Lower) heating value(LHV)

$$Q_{net} = Q_{gross} - Q_{HE}$$

$$Q_{HE} = r \times C_W$$

Where

Q_{net} = Net (Lower) heating value

Q_{HE} = Heat of Evaporation

r = Heat of condensation of water = 2.454 kJ/gm at 20°C =2.454 MJ/kg

C_W = condensate in kg/m^3

During ....sec gas volume =2.36×10^{-3} m^3

And during .... sec condensate = ...gm = ...kg

C_W = (condensate kg)/(2.36×10^{-3})= ....kg/ m^3

$Q_{gross} = Q_{net} + Q_{HE}$

$Q_{net} = Q_{gross} - Q_{HE}$

$Q_{net} =$

In BTU/ft^3 = $Q_{net}\times26.8413$ =.................BTU/ft^3

Assignment

a) **What is calorific value of a fuel?**

b) **Why did you do the stirring while performing the experiment?**

c) **Write down the basic principle of a bomb calorimeter.**

d) **What are the safety measures that must be followed while using bomb calorimeter?**

e) **What is lower heating value (LHV) and higher heating value (HHV)?**

mmHg	27°C	28°C	29°C	30°C	31°C	32°C	33°C	34°C	35°C	36°C	37°C	38°C	39°C	40°C	mmHg
730	1.180	1.187	1.194	1.201	1.208	1.216	1.223	1.231	1.236	1.247	1.256	1.266	1.275	1.264	730
732	1.176	1.183	1.190	1.197	502.1	1.212	1.220	1.227	1.235	1.244	1.253	1.263	1.272	1.260	732
734	1.173	1.180	1.187	1.194	1.201	1.209	1.216	1.224	1.231	1.240	1.249	1.259	1.268	1.276	734
736	1.171	1.178	1.165	1.191	1.198	1.205	1.212	1.220	1.228	1.237	1.246	1.255	1.264	1.273	736
738	1.168	1.174	1.180	1.187	1.194	1.202	1.209	1.217	1.224	1.233	1.242	1.251	1.260	1.269	738
740	1.164	1.171	1.178	1.184	1.191	1.199	1.206	1.214	1.221	1.230	1.239	1.247	1.256	1.265	740
742	1.161	1.168	1.175	1.181	1.188	1.196	1.203	1.210	1.218	1.227	1.235	1.244	1.252	1.261	742
744	1.158	1.165	1.172	1.178	1.185	1.193	1.200	1.208	1.215	1.223	1.232	1.240	1.249	1.257	744
746	1.155	1.161	1.168	1.174	1.181	1.189	1.196	1.204	1.211	1.220	1.228	1.237	1.245	1.254	746
748	1.151	1.158	1.165	1.171	1.178	1.186	1.193	1.201	1.208	1.216	1.225	1.233	1.242	1.250	748
750	1.148	1.155	1.161	1.167	1.174	1.182	1.169	1.197	1.204	1.212	1.221	1.229	1.238	1.246	750
752	1.145	1.152	1.158	1.164	1.171	1.179	1.186	1.194	1.204	1.209	1.218	1.226	1.235	1.243	752
754	1.142	1.149	1.155	1.161	1.168	1.175	1.183	1.190	1.197	1.205	1.214	1.222	1.231	1.239	754
756	1.139	1.146	1.153	1.158	1.165	1.172	1.180	1.187	1.194	1.202	1.211	1.219	1.228	1.236	756
758	1.136	1.143	1.149	1.155	1.162	1.169	1.176	1.183	1.190	1.198	1.207	1.215	1.224	1.232	758
760	1.133	1.140	1.146	1.152	1.159	1.166	1.173	1.180	1.137	1.195	1.204	1.212	1.221	1.229	760
762	1.130	1.137	1.143	1.149	1.156	1.163	1.170	1.177	1.134	1.191	1.200	1.208	1.217	1.226	762
764	1.126	1.133	1.139	1.145	1.152	1.159	1.167	1.174	1.131	1.189	1.197	1.206	1.214	1.222	764
766	1.123	1.129	1.136	1.142	1.149	1.156	1.163	1.170	1.177	1.185	1.194	1.202	1.210	1.219	766
768	1.120	1.126	1.132	1.139	1.146	1.153	1.160	1.167	1.174	1.182	1.190	1.199	1.207	1.215	768
770	1.117	1.123	1.130	1.136	1.143	1.150	1.157	1.164	1.171	1.179	1.187	1.196	1.204	1.212	770
772	1.114	1.120	1.126	1.133	1.140	1.147	1.154	1.161	1.168	1.176	1.184	1.193	1.201	1.209	772
774	1.111	1.117	1.123	1.130	1.137	1.144	1.151	1.158	1.165	1.173	1.131	1.189	1.197	1.205	774
776	1.108	1.114	1.120	1.127	1.134	1.141	1.147	1.154	1.161	1.169	1.177	1.186	1.194	1.202	776
778	1.105	1.111	1.117	1.124	1.131	1.138	1.144	1.151	1.158	1.165	1.173	1.181	1.189	1.198	778
780	1.102	1.108	1.114	1.121	1.128	1.155	1.141	1.148	1.155	1.162	1.169	1.176	1.183	1.195	780

102, Great Clowes Street. Manchester M7 1RH. U.K.
Phone +44 161 833 0036 email sales@cussons.co.uk

Gas Volume Factors relative to 0°C and 760 mmHg. Note A formula for calculating the gas volume at other temperatures and Pressures is given in the text.

mmHg	10°C	11°C	12°C	13°C	14°C	15°C	16°C	17°C	18°C	19°C	20°C	21°C	22°C	23°C	24°C	25°C	26°C	mmHg
730	1.095	1.098	1.101	1.105	1.108	1.111	1.116	1.121	1.126	1.152	1.137	1.142	1.148	1.154	1.160	1.166	1.173	730
732	1.092	1.095	1.098	1.101	1.105	1.100	1.113	1.118	1.125	1.128	1.134	1.139	1.145	1.151	1.157	1.163	1.169	732
734	1.089	1.092	1.095	1.098	1.102	1.105	1.110	1.115	1.120	1.125	1.131	1.136	1.142	1.148	1.154	1.160	1.166	734
736	1.085	1.088	1.092	1.095	1.099	1.102	1.107	1.112	1.117	1.122	1.128	1.133	1.159	1.145	1.151	1.157	1.164	736
738	1.081	1.085	1.088	1.092	1.095	1.099	1.104	1.109	1.114	1.119	1.125	1.130	1.156	1.142	1.148	1.154	1.161	738
740	1.077	1.081	1.085	1.088	1.092	1.096	1.101	1.106	1.111	1.116	1.122	1.127	1.133	1.139	1.145	1.151	1.158	740
742	1.074	1.078	1.082	1.085	1.089	1.093	1.098	1.105	1.108	1.115	1.119	1.124	1.130	1.136	1.142	1.146	1.155	742
744	1.071	1.075	1.079	1.082	1.086	1.090	1.095	1.100	1.105	1.110	1.116	1.121	1.127	1.133	1.139	1.145	1.152	744
746	1.068	1.072	1.076	1.079	1.083	1.087	1.092	1.097	1.102	1.107	1.113	1.118	1.124	1.130	1.136	1.142	1.148	746
748	1.065	1.069	1.073	1.076	1.080	1.084	1.089	1.094	1.099	1.104	1.110	1.115	1.121	1.126	1.132	1.138	1.145	748
750	1.062	1.066	1.070	1.073	1.077	1.081	1.086	1.091	1.096	1.101	1.107	1.112	1.118	1.123	1.129	1.135	1.142	750
752	1.059	1.063	1.067	1.070	1.074	1.078	1.083	1.088	1.093	1.098	1.104	1.109	1.115	1.120	1.126	1.132	1.139	752
754	1.056	1.060	1.064	1.067	1.071	1.075	1.080	1.085	1.090	1.095	1.101	1.106	1.112	1.117	1.123	1.129	1.136	754
756	1.053	1.057	1.061	1.064	1.068	1.072	1.077	1.082	1.087	1.092	1.098	1.103	1.109	1.114	1.120	1.126	1.133	756
758	1.050	1.054	1.058	1.061	1.065	1.069	1.074	1.079	1.084	1.089	1.095	1.100	1.106	1.111	1.117	1.123	1.130	758
760	1.047	1.051	1.055	1.058	1.062	1.066	1.071	1.076	1.081	1.086	1.092	1.097	1.103	1.108	1.114	1.120	1.127	760
762	1.044	1.048	1.052	1.055	1.059	1.063	1.068	1.073	1.078	1.083	1.089	1.094	1.100	1.105	1.111	1.117	1.124	762
764	1.042	1.046	1.049	1.053	1.056	1.060	1.065	1.070	1.075	1.080	1.086	1.091	1.097	1.102	1.108	1.114	1.120	764
766	1.039	1.043	1.046	1.050	1.053	1.057	1.062	1.067	1.072	1.077	1.083	1.088	1.094	1.099	1.105	1.111	1.117	766
768	1.037	1.041	1.044	1.047	1.050	1.054	1.059	1.064	1.069	1.074	1.080	1.085	1.091	1.096	1.102	1.108	1.114	768
770	1.054	1.038	1.042	1.045	1.048	1.052	1.057	1.062	1.067	1.072	1.078	1.083	1.089	1.094	1.100	1.105	1.111	770
772	1.031	1.035	1.039	1.042	1.045	1.049	1.054	1.059	1.064	1.069	1.075	1.080	1.086	1.091	1.096	1.102	1.108	772
774	1.029	1.031	1.035	1.038	1.041	1.046	1.051	1.056	1.061	1.066	1.072	1.077	1.083	1.088	1.094	1.099	1.105	774
776	1.026	1.029	1.032	1.036	1.039	1.043	1.048	1.053	1.058	1.063	1.069	1.074	1.080	1.085	1.091	1.096	1.102	776
778	1.024	1.027	1.030	1.033	1.036	1.040	1.045	1.050	1.055	1.060	1.066	1.071	1.077	1.032	1.068	1.093	1.099	778
780	1.021	1.025	1.028	1.031	1.033	1.038	1.043	1.048	1.053	1.058	1.063	1.068	1.074	1.079	1.085	1.090	1.096	780

CUSSONS
—TECHNOLOGY Ltd—
102, Great Clowes Street. Manchester M7 1RH. U.K.
Phone +44 161 833 0036 email sales@cussons.co.uk

EXPERIMENT NO – 08

Name of the Experiment: Determination of Carbon Residue of a Given Fuel

1. **Objectives:** To find the percentage of carbon residue from various types of liquid, semi-liquid or solid fuel.
2. **Specimen:** Different types of liquid, semi-liquid or solid fuel.
3. **Standard Used:** ASTM D 4530-93
4. **Procedure**

4.1 Power ON

Turn the MAIN switch ON. The electricity is supplied to the tester, then the cooling fan starts turning, and the current oven temperature is shown in the controller display. The solenoid valve for nitrogen gas opens.

4.2 Nitrogen Gas Pressure and Flow Rate Adjustment

Adjust pressure controller for nitrogen gas until the nitrogen gas pressure gauge indicates 150kPa (0.15MPa: marked with green sign). This gas is used as an inert carrier gas.
If the pressure is below 80kPa, subsequent operations cannot be made due to the pressure switch function. (The programmable controller is reset.)

The procedure is as below.

(1) Pull the pressure controller knob to unlock.

(2) Rotate the knob clockwise to adjust the nitrogen gas pressure to 150kPa.

(3) Push the pressure controller knob to lock. It is not necessary to shut the pressure controller again after using this tester.

(4) Nitrogen gas should flow through the oven at 150ml/min. If the flow rate is not 150ml/min, adjust it accordingly with N2 needle valve for 150ml/min (0.15L/min by flow meter).

4.3 Preparation of Test Sample

Measure the sample into a sample vial. There are three kinds of sample vials; large, small and medium (optional). Choose either of them in accordance with the expected carbon residue range. Normally use small vials. For low (<0.5%) residue, medium or large vials allow more sample which improves precision; (According to JIS K 2270-98, 3.0±0.5g for medium vials or 5.0±0.5g for large vials which can be used for <0.2% sample.)

(1) Obtain weights of clean sample vials, and record the mass to nearest 0.1 mg.

(2) During weighing and filling, handle vials with forceps to help minimize weighing

errors.

(3) Transfer an appropriate weight of sample into a tared-sample vial, reweigh to nearest 0.1 mg and record.

(4) Place the loaded sample vials into vial holder.

4.4 Processing of Samples

1) With the oven at less than 100°C, place the vial holder into the oven chamber and secure lid. When placing the vial holder, care should be taken not to touch the thermocouple with sample basket feet.
2) Confirm the nitrogen gas pressure gauge indicates 150 kPa and the gas flow meter shows 150ml/min, then press the START switch.
3) The flow rate of nitrogen increases to 600 ml/min automatically for the first 10 minutes after pressing the START switch. If the flow rate is not 600 ml/min, adjust N2 needle valve for 600 ml/min (0.60L/min by flow meter).
4) After this, the temperature(l) and flow rate of nitrogen are controlled as indicated in Fig.2. To complete the temperature and flow program in 98 minutes.
5) The buzzer intermittently sounds for about 10 seconds and "P.End" is shown on the setting temperature display on the program controller.
6) After "P.End" is indicated, press the RESET switch. The programmable controller is reset the "P.End" disappears.
7) When temperature is less than 250°C, place the lid to the lid rest to cool down and remove the vial holder using hook for further cooling in desiccator.
8) Start the next test or turn the MAIN switch OFF after the oven temperature falls below 100°C.

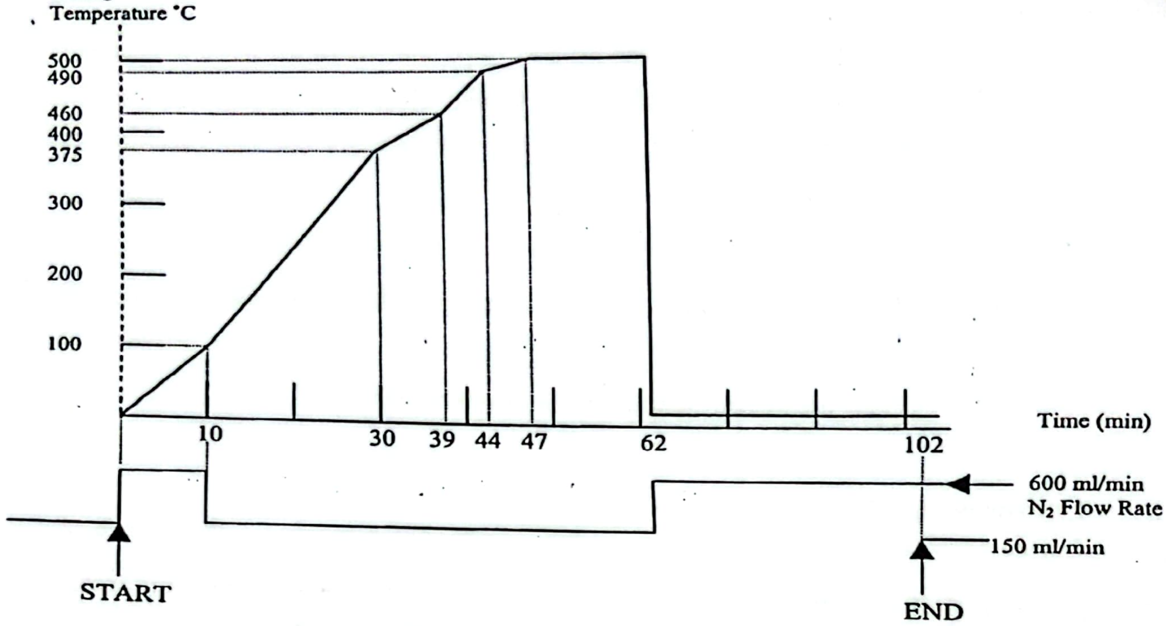


Figure 1: Temperature and flow Program Diagram

Student Name:

Student ID:

5. Result

Table-1: (Experimental data and calculated result)

No of obs.	Sample Name	Temp (°C)	Time (sec)	Weight of Sample (gm)	Weight of Carbon Residue (gm)	% of Carbon Residue	Remarks

6. Calculation

Weight of vial + 10 gm sample = W_1 gm

Weight of vial + Carbon Residue = W_2 gm

Loss of fuel = $(W_1 - W_2)$ gm

Carbon Residue, $A = 10 - (W_1 - W_2)$ gm

% of Carbon residue$= \frac{A}{10} \times 100$.

Assignment

a) What do you understand by carbon residue?

b) Briefly explain the temperature and flow program diagram.

c) How did you prepare the test sample? Write it in your own language.

d) What is the purpose of carbon residue test?

e) What are the safety measures that should be followed while performing carbon residue test?

EXPERIMENT NO – 09

Name of the experiment: Proximate Analysis of Coal

1. Objective

An analysis of coal that may be made with the minimum equipment is the proximate analysis (sometimes called an engineering analysis). The four constituents which are determined in this type of analysis are:

i) Moisture
ii) Ash
iii) Volatile matter
iv) Fixed carbon

2. Standard Used: ASTM D 22

3. Apparatus

a) Chemical balance having sensitivity of at least to 1/10 mg

b) Porcelain capsules (Royal, Meissen no. 2) about 7/8 in, in depth and 1.75 in. in diameter, with flat aluminum covers.

c) Electric oven with temperature regulation to 110°C (230°F) and heaving a renewal of air, at the rate of 2 to 4 times a minute. Air is dried by passing through sulfuric acid.

d) Electric muffle furnace with temperature regulation between 700°C and 750°C and with good air circulation.

e) Platinum crucible with tightly fitting cover 10 to 20 cu cm.

f) Electric tube furnace with temperature regulation to 950°C + 20°C.

g) Coal samples passed through no. 60 sieves and no. 20 sieves

Moisture determination

Preface

Some of the moisture in the coal is known as inherent moisture. It is inherently a part of the structure of the coal and cannot be readily separated from it. The rest of the moisture is called free moisture which will be heated and the length of time it is held at the elevated temperature is dependent on the temperature. It should be evident that there is no way of determining the true free moisture in coal.

Test procedure

i) Transfer with a spoon or spatula about 1 gm of the 60-mesh sample to one of the porcelain capsules previously heated and dried in desiccators.

ii) Cover the capsule and weigh.

iii) Then dry for 1 hour keeping uncovered in the preheated oven at about 107°C+ 3°C.

iv) Cool in a desiccator over sulfuric acid and then weigh.

v) The 20-mesh sample should be similarly treated, using a 5 gm portion and drying for 1.5Hr.

Ash Determination

Preface

During the heating process, there may be oxidation of some of the material constituents of the coal. The products of oxidation may or may not be driven off from the coal. In addition, there may be some decomposition of mineral constituents, with some of the products being vaporized. Although the procedure outlined below for ash determination will not give the absolute value of the ash in the coal, qualitative results may be obtained when conditions of the determinations are duplicated.

Test procedure

i) The porcelain capsules containing the dried coal from the moisture determination should be uncurbed and placed in the furnace when the furnace is cold.

ii) Gradually heat the sample.

iii) Stop the ignition between 700°C and 750°C, with occasional stirring with a platinum or nichrome wire, until all carbon particles disappear.

iv) Cool the sample in desiccators and then weigh.

v) Then continue alternate heating and weighing until weight is constant.

Volatile Meter Determination

Preface

In addition to moisture, coal contains volatile constituents, primarily hydrocarbons, which will be drive off by heating. It should be recognized that the amount of volatile matter found by this process is a function of the heating time and the temperature. To obtain qualitative results, both of these variables must be controlled.

Mechanical losses occur when some coals are heated rapidly due to the rapid release of volatile matter or steam. The mechanical losses are recognized by the "sparking" that occurs when the small fragments of the coal are heated to incandescence as they are being expelled. Therefore, care should be taken to avoid sparking. If any sparking occurs, the test results are worthless and the test procedure should be modified. A new coal sample should be slowly lowered into the furnace and gradually heated for a period of 5 to 10 min. The crucible may now be lowered into the regular position and heated at the standard temperature for a period of 7 min precisely.

Test procedure

i) Weigh a 1gm sample of 60 mesh coal in a platinum crucible, cover and place in a furnace chamber which has been preheated to 950°C+20°C (1742°F+36°F).

ii) Heat exactly 7 minutes

iii) Remove the coal without disturbing cover.

iv) Now weigh

v) Volatile matter = Loss of weight – minus moisture

Fixed carbon determination

Preface

The remainder of the carbon cannot that be driven off by heating is called fixed carbon.

There is no direct way of determining the fixed carbon in coal, and hence it must be calculated by subtracting the summation of moisture, ash and volatile matter weights from the original weight of the coal.

Although fixed carbon cannot be vaporized, some of it will burn quite rapidly in the presence of oxygen, particularly at the temperatures used in the volatile matter determination. Hence, care must be exercised to prevent oxygen from entering the close fitting cover on the crucible.

Assignment:

a) **What is proximate analysis? Describe the purposes of performing proximate analysis.**

b) **Describe the term 'Volatile Matter' in coal.**

c) **Why do you need to pay attention to prevent the entry of oxygen while performing proximate analysis?**

d) **what are qualitative analysis and quantitative analysis?**

EXPERIMENT NO – 10 (A)

Name of the Experiment: Study of IC Engine

Objectives

i. Identification and study of functions of different engine components.

ii. Study the different operational system of an IC engine.

Theory

The internal combustion engine (IC Engine) is a heat engine that converts heat energy (chemical energy of a fuel) into mechanical energy (usually made available on a rotating output shaft).

Classifications of IC Engines:

IC engines can be classified according to:

1. Number of cylinders – 1, 2, 3, 4, 5, 6-to-16-cylinder engines.
2. Arrangement of cylinders – Inline, V-type, Flat type, etc.
3. Arrangement of valves and valve trains – In-block camshaft, OHC, DOHC, etc.
4. Type of cooling – Air-cooled, Water-cooled, etc.
5. Number of strokes per cycle – 2-stroke, 4-stroke engines.
6. Type of fuel burned – Petrol, diesel, CNG, etc.
7. Method of ignition – Spark Ignition (SI), Compression Ignition (CI).

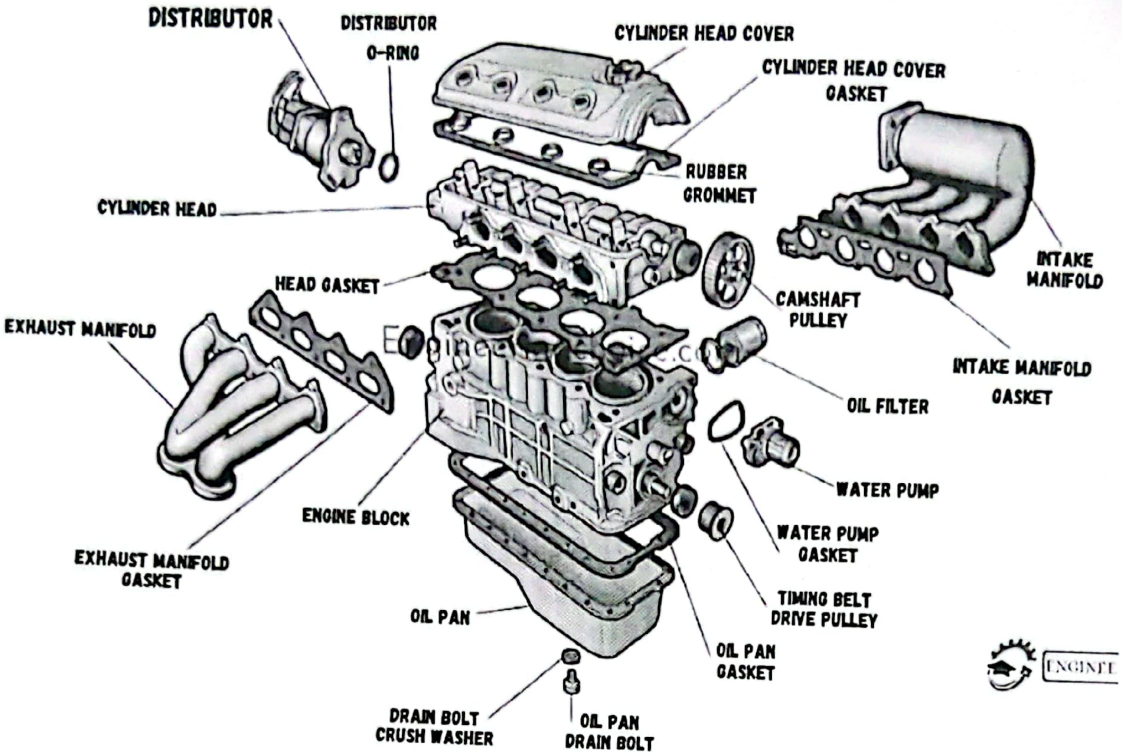


Figure: Different engine components

Constructional details of I.C. Engines

A cross-section of an air-cooled I.C. engine with principal parts is shown in Fig. (Air-cooled I.C. engine).

A. Parts common to both Petrol and Diesel engine:

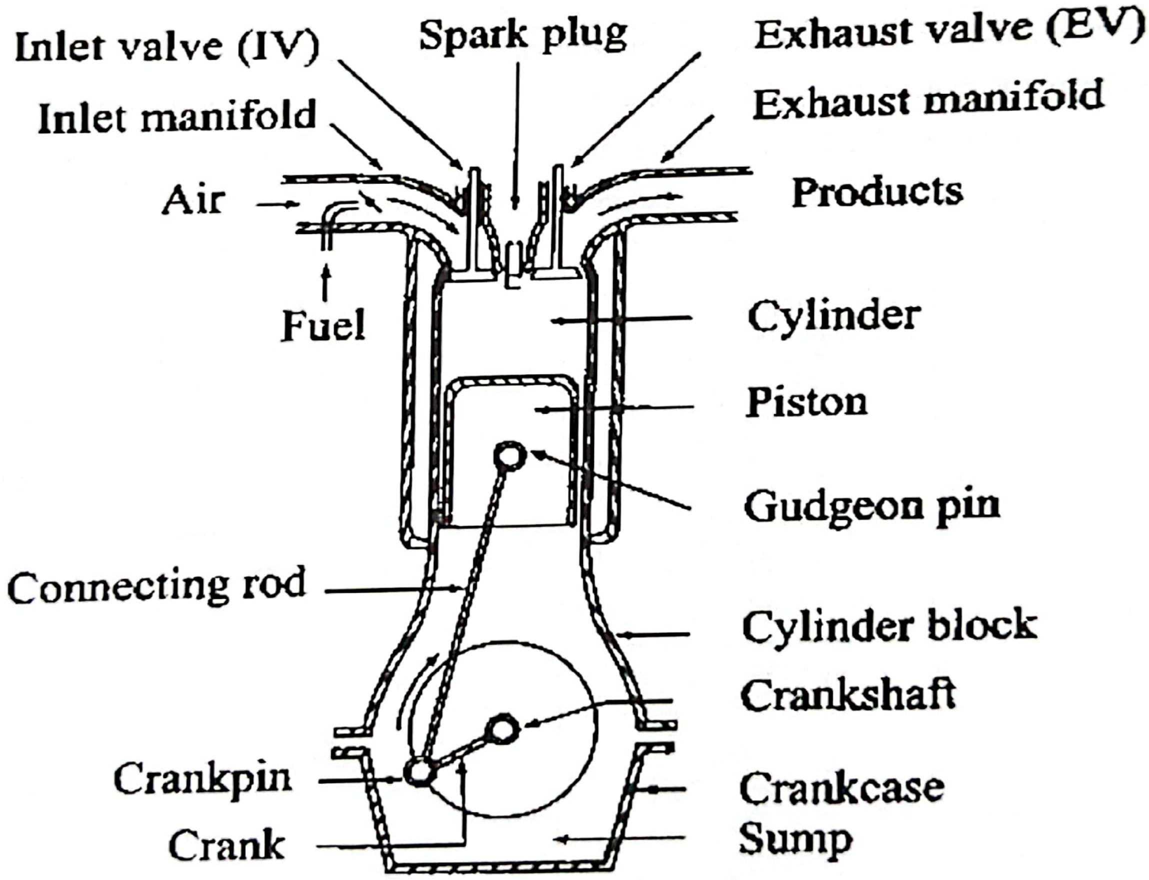
1. Cylinder, 2. Cylinder head, 3. Piston,
4. Piston rings, 5. Gudgeon pin, 6. Connecting rod,
7. Crankshaft, 8. Crank, 9. Engine bearing,
10. Crank case. 11. Flywheel, 12. Governor,
13. Valves and valve operating mechanism.

B. Parts for Petrol engines only:

1. Spark plug, 2. Carburettor, 3. Fuel pump.

C. Parts for Diesel engine only :

1. Fuel pump, 2. Injector.



Different engine components:

Cylinder block: The cylinder block is the foundation of the engine. Usually made of cast iron; contains coolant passages.

Cylinder Head: A detachable unit of an engine bolted to the top of the cylinder block.

Crankcase: Holds the cylinder and crankshaft of an IC engine. Made of cast iron. Also serves as a sump for the lubricating oil.

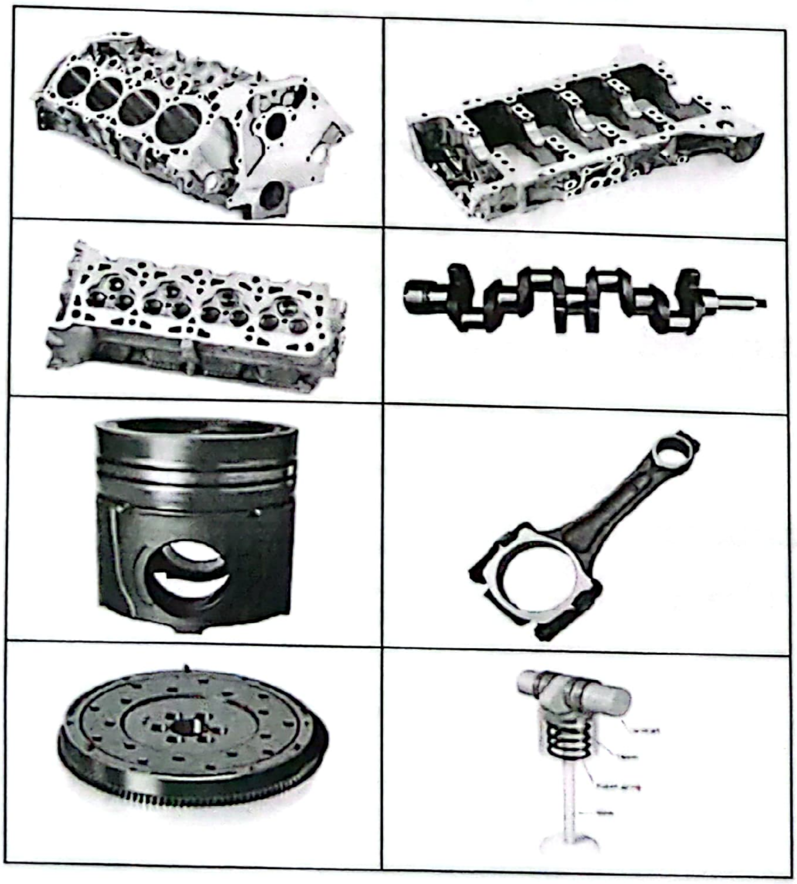
Connecting Rod: Connecting rod is used to transmit the motion from the piston to the crankshaft. Made of forged-steel or cast iron.

Crankshaft: It is considered as the backbone of an engine. Its function is to convert reciprocating motion of the piston into rotary motion with the help of connecting rod. Made of forged steel.

Piston: The piston is a cylindrical plug that moves up and down in the engine cylinder. Made of aluminum, cast steel or cast iron. It contains piston rings (oil & compression).

Flywheel: Mounted on the crankshaft. To maintain engine speed constant.

Intake and Exhaust Valve: Intake valve is usually made of a chromium-nickel alloy and slightly larger than exhaust valve for higher volumetric efficiency and also combustion. Exhaust valve is made of a silicon-chrome alloy since it operates at higher temperature.



Four Stroke Spark Ignition (SI) Engine

Stroke 1: Fuel-air mixture introduced into cylinder through intake valve
Stroke 2: Fuel-air mixture compressed
Stroke 3: Combustion occurs and product gases expand doing work
Stroke 4: Product gases pushed out of the cylinder through the exhaust valve

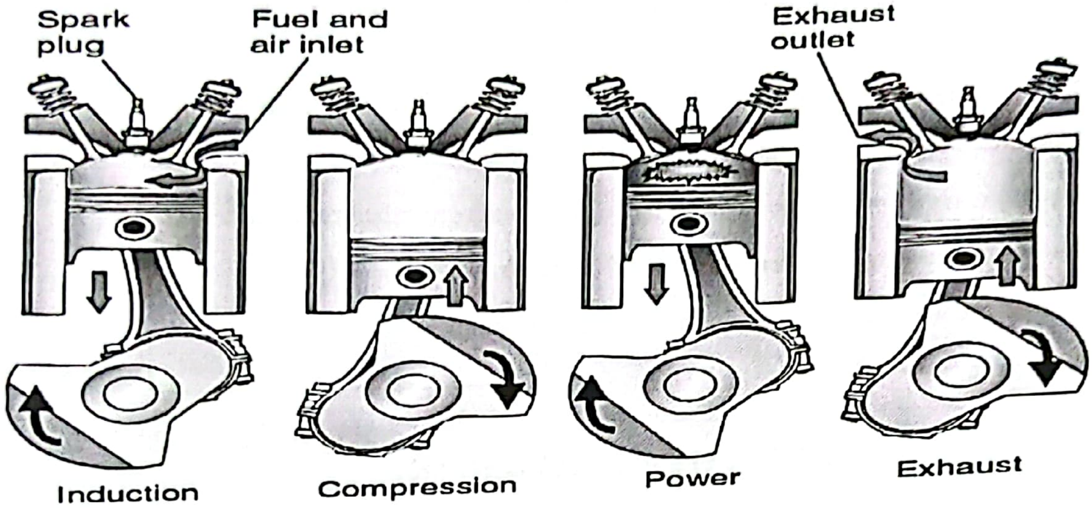


Figure: Different strokes of the SI Engine

Orientation with the following systems:

1. Fuel supply system
2. Lubricating oil system
3. Cooling water system
4. Air intake and exhaust system

Comparison of Petrol and Diesel Engines

SL No	Petrol (SI) Engine	Diesel (CI) Engine
1	A petrol engine draws a mixture of petrol and air during suction stroke.	A diesel engine draws only air during suction stroke.
2	The carburetor is employed to mix air and petrol in the required proportion and to supply it to the engine during suction stroke.	The injector or atomizer is employed to inject the fuel at the end of compression stroke.
3	Pressure at the end of compression is low.	Pressure at the end of compression is high.
4	The charge is ignited with the help of sparking plug.	The fuel is injected in the form of fine spray. The temperature of the compressed air is sufficiently high to ignite the fuel.

Assignment:

a) **List the advantages and disadvantages of a two stroke engine over a four stroke engine.**

b) **Describe the phenomenon of detonation in I.C. engines. On what factors does detonation depend?**

c) **Explain what do you understand by octane and cetane number rating of a fuel.**

d) **Discuss the cooling requirement of an I.C. engine.**

e) **Discuss the necessity of lubrication system in I.C. engine.**

EXPERIMENT NO – 10 (B)

Name of experiment: Study of Industrial Boiler

Objectives

1. Introduction of different components of steam power plant
2. To study the functions of boiler mountings and accessories.

Steam power plant

Generally, steam power plant is called as thermal power plant. The steam power plant can perform two purposes:

i. To generate electricity only and

ii. to generate electricity along with production of steam for process heating.

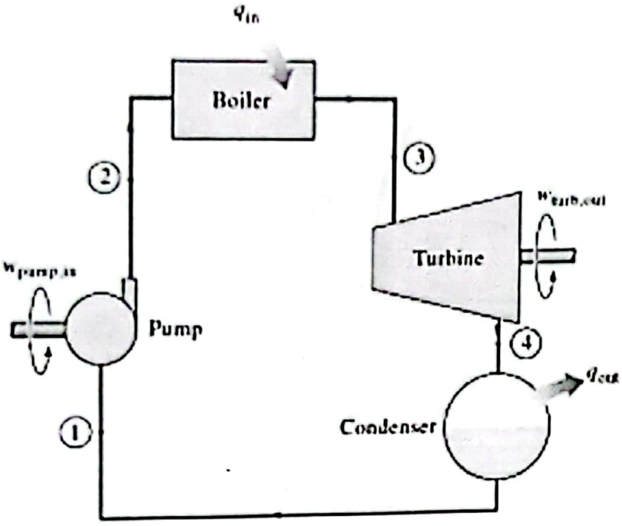
Steam power plant works on Rankine Cycle. Working fluid is steam and water.

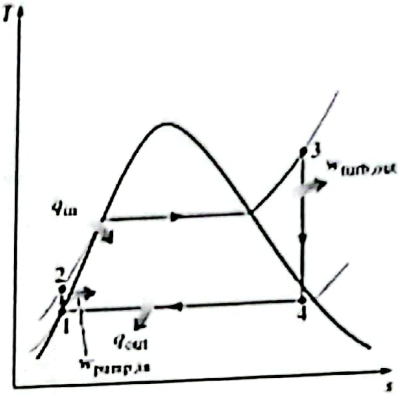
The main components of cycle are

1. **Boiler:** Boiler is used to produce steam. Heat energy produced by coal is used to produce steam. Water is allowed to heat until it goes into vapor state. Vapor is sent to the turbine.
2. **Turbine:** Turbine produces the work. Work produced is used to run the generator. The enthalpies at the enter and exit of the turbine are different. Then Vapor is sent into the

condenser.

3. **Condenser:** The vapor is condensed to water in the condenser and sent into the pump.
4. **Feed pump:** Pump send the water again into the Boiler and the cycle repeats again.





1-2 Isentropic compression in a pump
2-3 Constant pressure heat addition in a boiler
3-4 Isentropic expansion in a turbine
4-1 Constant pressure heat rejection in a condenser

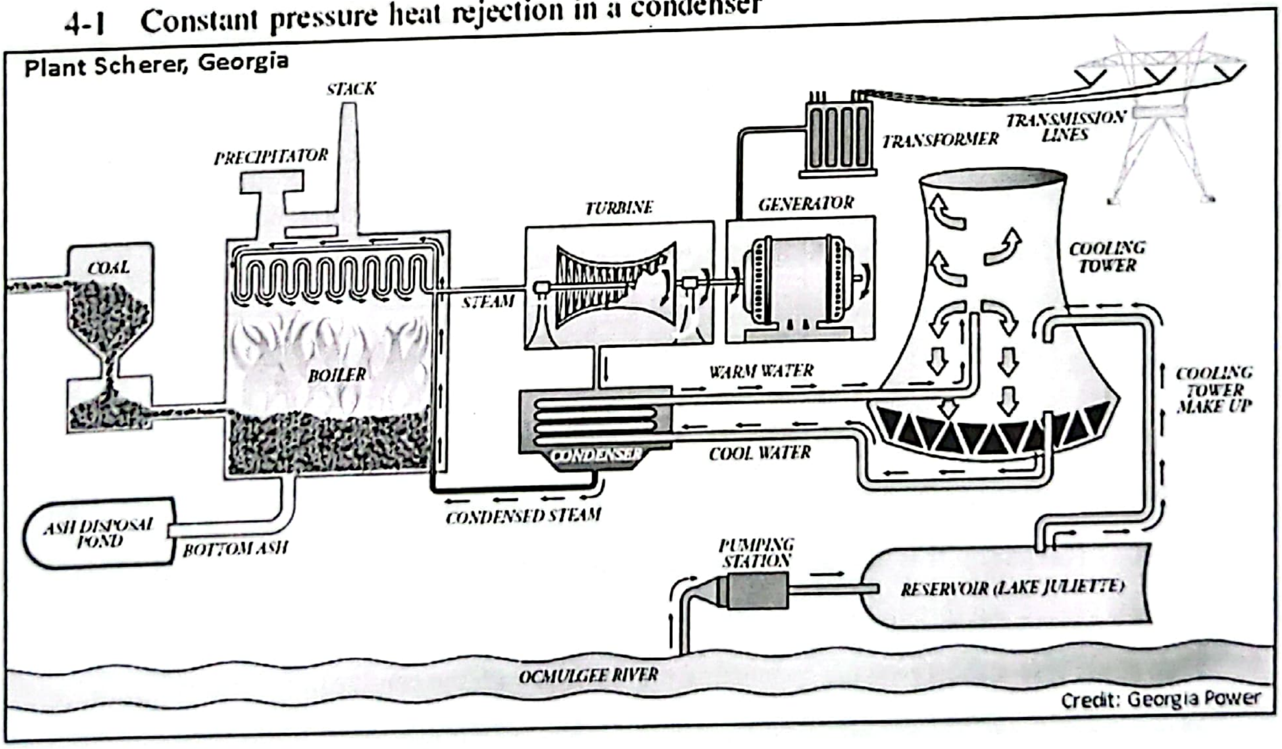


Figure: Layout of a steam power plant.

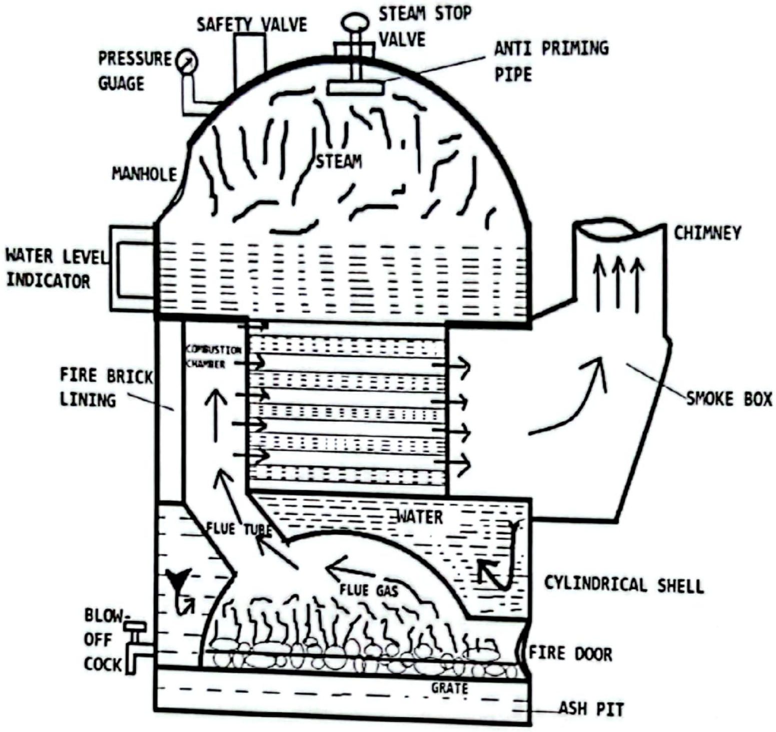


Figure: Cochran Boiler

Cochran Boiler

It is a multi-tubular vertical fire tube boiler having a number of horizontal fire tubes. It is the modification of a simple vertical boiler where the heating surface has been increased by means of a number of fire tubes.

It is consisted of:

Shell: It is hemispherical on the top, where space is provided for steam.

Grate: It is placed at the bottom of the furnace where coal is burnt.

Fire box (furnace): It is also dome-shaped like the shell so that the gases can be deflected back till they are passed out through the flue pipe to the combustion chamber.

Flue pipe: It is a short passage connecting the fire box with the combustion chamber.

Fire tubes: A number of horizontal fire tubes are provided, thereby the heating surface is increased.

Combustion chamber: It is lined with fire bricks on the side of the shell to prevent overheating of the boiler. Hot gases enter the fire tubes from the flue pipe through the combustion chamber.

Chimney: It is provided for the exit of the flue gases to the atmosphere from the smoke box.

Manhole: It is provided for inspection and repair of the interior of the boiler shell.

Boiler Mountings

Boiler mountings are the machine components that are mounted over the body of the boiler itself for the safety of the boiler and for complete control of the process of steam generation. Various boiler mountings are as under:

1. Pressure gauge
2. Water Level Indicator
3. Fusible plug
4. Safety Valve
5. Steam stop valve
6. Feed check valve
7. Blow-off cock
8. Man and Mud hole

Boiler Accessories

Boiler accessories are those components which are installed either inside or outside the boiler to increase the efficiency of the plant and to help in the proper working of the plant. Various boiler accessories are:

1. Air Preheater
2. Economizer
3. Super-heater
4. Feed Pump

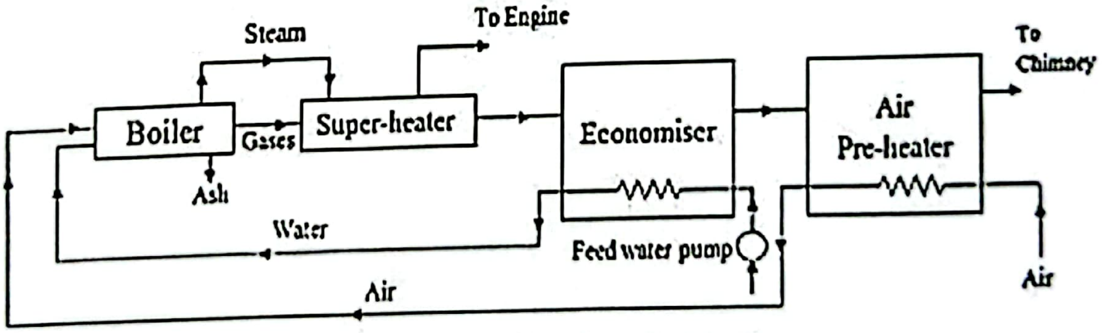
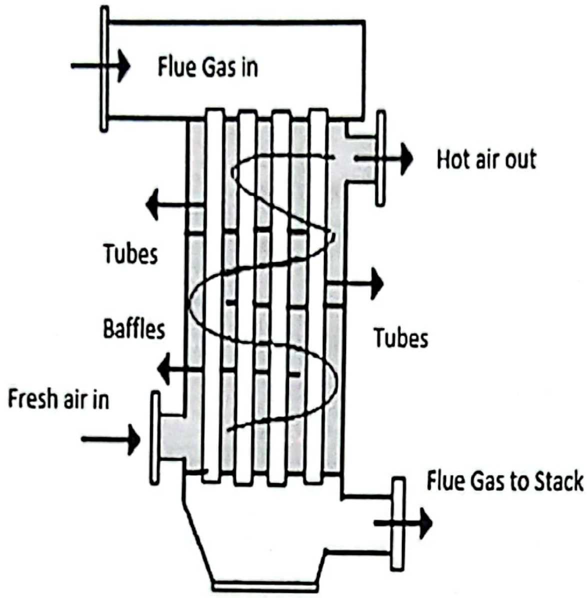


Fig- Schematic diagram of a boiler plant

Air Preheater

Air preheater is a waste heat recovery device. Air goes through it to the way of the furnace where it is heated utilizing the heat of exhaust gases. The function of air pre-heater is to increase the temperature of air before entering the furnace. It is generally placed after the economizer; so, the flue gases pass through the economizer and then to the air preheater. An air-preheater consists of plates or



Economizer

It is a device in which the waste heat of the flue gases is utilized for heating the feed water to recover some of the heat being carried over by exhaust gases. This heat is used to raise the temperature of feed water supplied to the boiler.

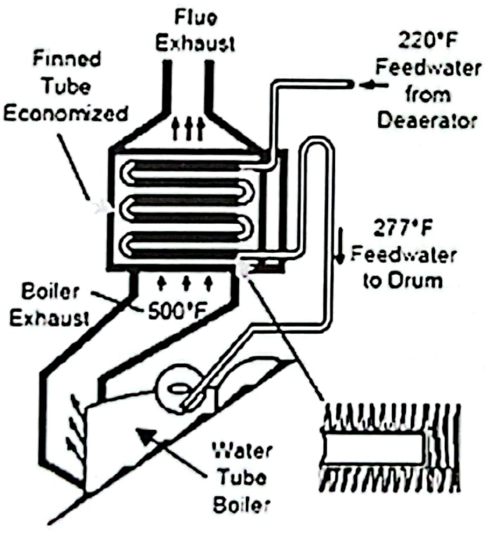


Fig: Economizer

Super heater

The function of super heater is to increase the temperature of the steam above its saturation point to superheat the steam generated by boiler. Super heaters are heat exchangers in which heat is transferred to the saturated steam to increase its temperature.

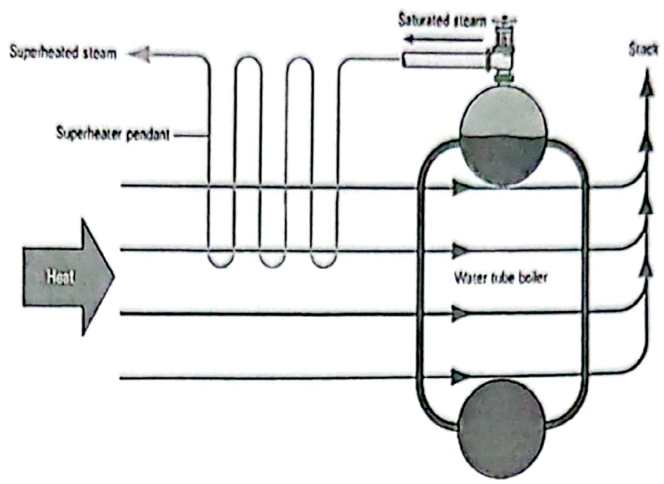


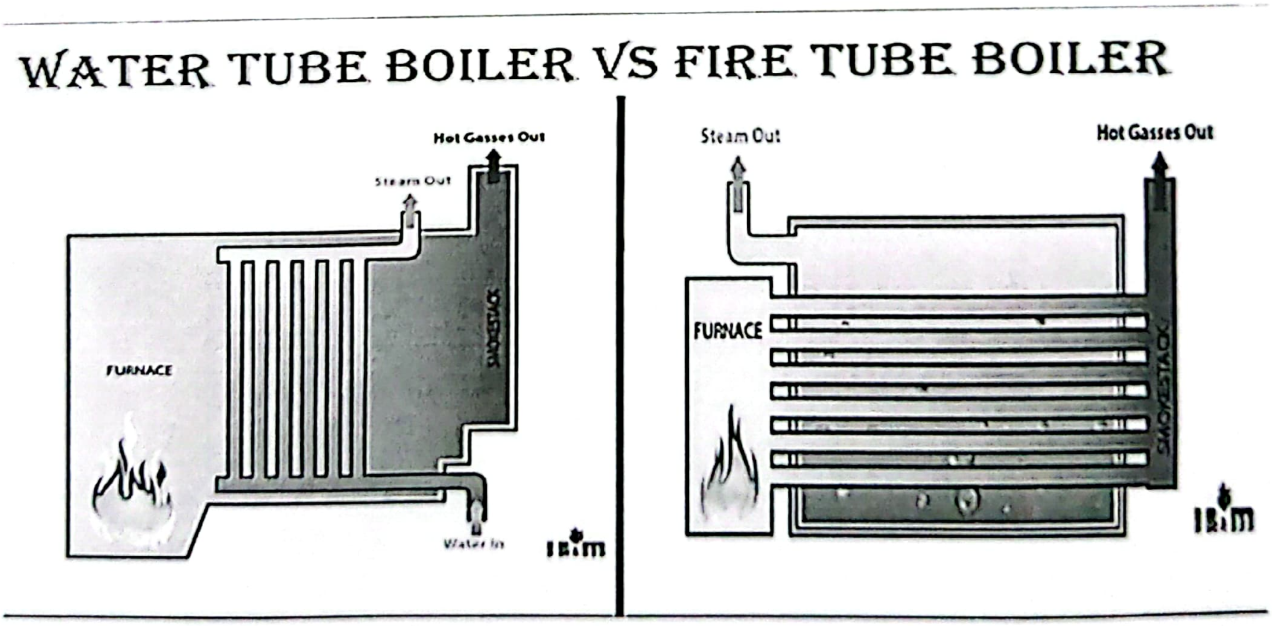
Fig: Super heater

Classification of boilers

According to contents in the tube:

a) **Fire tube boiler**: In fire tube boilers, the flue gases pass through the tube and water surround them. Vertical tubular, Lancashire, Cochran, Cornish, Locomotive fire box, Scotch marine etc. are some fire tube boilers.

b) **Water tube boiler**: In water tube boiler, water flows inside the tubes and the hot flue gases flow outside the tubes. Babcock and Wilcox boiler, Stirling boiler, La-mont boiler, Benson boiler, Loeffler boiler etc are some of water tube boilers.



Assignment:

a) What is steam boiler? How they are classified?

b) What are the differentiating features between a water tube and a fire tube boiler?

c) What is the purpose of a steam stop valve? Explain its working.

d) Explain why air preheaters are used in a high pressure boiler.

e) What is the difference between mountings and accessories?

f) What is the function of a superheater?