MODEL ANSWER

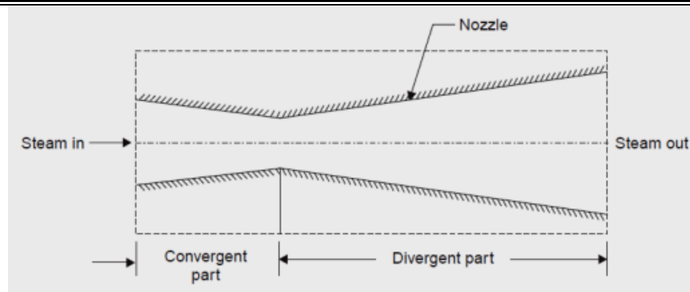
SUMMER– 17 EXAMINATION

Subject Title: Heat Engineering Subject Code: 17406

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1 a	I	**Biomass** Biomass is defined as the renewable organic materials, such as wood, agricultural crops or wastes, and municipal wastes, especially when used as a source of fuel or energy which can be burned directly or processed into biofuels such as ethanol and methane.	02
	Ii	**Steady Flow Energy Equation (SFEE)** The general form of steady flow energy equation is given below $\left(u_1 + p_1v_1 + Z_1g + \frac{C_1^2}{2}\right) + Q = \left(u_2 + p_2v_2 + Z_2g + \frac{C_2^2}{2}\right) + W$ Where u = Internal energy, p = pressure, v = volume , Z = datum height, C = velocity , Q = heat , W = work done This equation for Nozzle can be written as	01+01



Steam nozzle.

$$h_1 + \frac{C_1^2}{2} = h_2 + \frac{C_2^2}{2}$$

or $$\frac{C_2^2}{2} - \frac{C_1^2}{2} = h_1 - h_2 \quad \text{or} \quad C_2^2 - C_1^2 = 2(h_1 - h_2)$$

or $$C_2^2 = C_1^2 + 2(h_1 - h_2)$$

$$C_2 = \sqrt{C_1^2 + 2(h_1 - h_2)}$$

iii

The properties of an ideal gas are (any two points) 02

1. An ideal gas consists of a large number of identical molecules.
2. The volume occupied by the molecules themselves is negligible compared to the volume occupied by the gas.
3. The molecules obey Newton's laws of motion, and they move in random motion.
4. The molecules experience forces only during collisions; any collisions are completely elastic, and take a negligible amount of time.

iv

Boiler & Application of Cochran Boiler

Boiler is a closed vessel or arrangement of vessels and tubes, together with a furnace or other heat source, in which steam is generated from water to drive steam turbines or steam engines, supply heat, process certain materials, etc. 01+01

Application of Cochran Boiler:

The most common applications of Cochran boiler are

Steam roller

Pile drivers

Portable hoisting rigs

Steam shovels

v **Comparison between two –stroke & four stroke engines. (any four points – 2 marks)** ½ each

Four stroke engines	Two stroke engines
1) Cycle is completed in two revolution of crank shaft.	1) Cycle is completed in one revolutions of crank shaft.
2) One power stroke is obtained in every two revolution of crank shaft.	2) One power stroke is obtained in every revolution of crank shaft.
3) Because of one power stroke for two revolutions, power produced for same size engine is small or for same power engine is bulky.	3) Because of one power stroke for one revolution, power produced for same size engine is more. Theoretically twice but in actual practice 1.7 to 1.8 times or for same power, engine is light and compact.
4) Engine contains valves & valve mechanism.	4) Do not contain valves but only ports are present.
5)Heavier flywheel required	5) Lighter flywheel required.
6) Initial cost is high because of heavy weight and complicated valve mechanism.	6) Initial cost is low because of light weight and no valve mechanism.
7) Thermal efficiency is more.	7) Thermal efficiency is less.
8) Used where efficiency is important. e.g. bus , truck, tractor	8) Used where light and compact engine is required. e.g. scooters, lawn movers.

vi

FAD & Volumetric Efficiency

FAD (Free Air Delivery) is the actual quantity of compressed air converted back to the inlet conditions of the compressor. In other words, it is a standardized measure of the capacity of an air compressor. 01+01

Volumetric Efficiency

A compressor's volumetric efficiency is defined by the ratio of actual volume of air that it could suck if there is no clearance volume. It is the ratio of the actual volume of air drawn in each suction stroke to the stoke volume.

Volumetric efficiency = (Actual volume of air drawn in suction stroke) / (Stroke volume) vi Refrigerant used : The most popular hydro-fluorocarbon (HFC) refrigerants for new commercial air conditioning systems include R-410A (Genetron CH2F2), and R-134a (1,1,1,2-TETRAFLUOROETHANE C2H2F4).

viii **Clausius statement of second law of Thermodynamics:-** It states that it is impossible to construct a device working in a cyclic process whose sole effect is the transfer of energy in the form of heat from a body at a lower temperature (sink) to a body at a higher temperature (source). 02

Or

It is impossible for energy in the form of heat to flow a body at a lower temperature to a body at a higher temperature without the aid of external work.

1b i **Non-conventional Power generation system & its importance**

A Non-conventional Power Generation is an industrial facility used to generate electric power with the help of one or more non-traditional energies which converts different energy sources into electric power. These energies include sources like Wind, Solar, Geothermal, Ocean-thermal, Biomass, etc. 04

In general, power plants can be divided into two categories - conventional and non-conventional power plants.

Non-conventional power plants are:

Wind power plants: The kinetic energy of wind is used to create power.

Solar power plants: Generates power by collecting solar radiation.

Geothermal power plants: Uses the natural heat found in the deep levels of the earth to generate electricity.

Biomass power plants: Natural organic matter is burnt to produce electricity.

Importance: At present most power generation load is being taken by Thermal Power plants which requires very high amount of conventional form energy. As this source is limited, there is a need to tap new sources of energy like solar energy, geothermal energy, tidal energy, wind energy, etc.

The power generation is important because

i) This form of energy is a clean source
ii) It is renewable source 04
iii) It is available free of cost and in abundance
iv) This type power generation will reduce demand of conventional power
v) It will also reduce the environmental pollution by large quantity

The general form of SFEE is given by

ii

$$\left(u_1 + p_1v_1 + Z_1g + \frac{C_1^2}{2}\right) + Q = \left(u_2 + p_2v_2 + Z_2g + \frac{C_2^2}{2}\right) + W$$

This above equation can be reduced to different devices as below

For Turbine SFEE is

Applying energy equation to the system. 01

Here, $Z_1 = Z_2$ (*i.e.*, $\Delta Z = 0$)

$$h_1 + \frac{C_1^2}{2} - Q = h_2 + \frac{C_2^2}{2} + W$$

The sign of Q is *negative* because heat is *rejected* (or comes out of the boundary).
The sign of W is *positive* because work is done by the system

For Boiler SFEE is

For this system, $\Delta Z = 0$ and $\Delta\left(\frac{C_2^2}{2}\right) = 0$

$W = 0$ since neither any work is developed nor absorbed. 01

Applying energy equation to the system

$$h_1 + Q = h_2$$

For Compressor SFEE is

Applying energy equation to the system, we have :

$\Delta PE = 0$ and $\Delta KE = 0$ since these changes are negligible compared with other energies.

$\therefore$ $h_1 - Q = h_2 - W$ 01

For Condenser SFEE is

For this system :

$\Delta PE = 0$, $\Delta KE = 0$ (as their values are very small compared with enthalpies)

$W = 0$ (since neither any work is developed nor absorbed)

Using energy equation to steam flow

$$h_1 - Q = h_2$$

where Q = Heat lost by 1 kg of steam passing through the condenser. 01

Differentiate between reversible and irreversible process

iii

Sr No	Reversible process	Irreversible Process
1	A reversible process (also sometimes known as quasi-static process) is one which can be stopped at any stage and reversed so that the system and surroundings are exactly restored to their initial states.	An irreversible process is one in which heat is transferred through a finite temperature.
2	It must pass through the same states on the reversed path as were initially visited on the forward path.	It does not pass through same states
3	This process when undone will leave no history of events in the surroundings.	It always leaves some traces after the process
4	It must pass through a continuous series of equilibrium states.	It does not pass through equilibrium states
5	Some examples of nearly reversible processes are : (i) Frictionless relative motion. (ii) Expansion and compression of spring. (iii) Frictionless adiabatic expansion or compression of fluid. (iv) Polytropic expansion or compression of fluid. (v) Isothermal expansion or compression. (vi) Electrolysis.	Examples. i)Relative motion with friction (ii) Combustion (iii) Diffusion (iv) Free expansion (v) Throttling (vi) Electricity flow through a resistance (vii) Heat transfer (viii) Plastic deformation

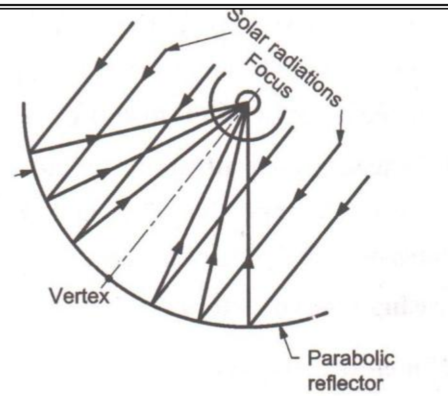
01 for each any four

2 a

Parabolic concentrating collector :

These concentrating collectors are used in which the absorber is placed along the focus axis. In this the collector pipe is used as an absorber with a selective coating.

Parabolic reflectors are usually made of highly polished or silvered glass or of a film of aluminized plastic on affirm base. Instead of the reflector having a continuous form the reflector may be made of a large number of flat mirror strips on the parabolic firm base. 02



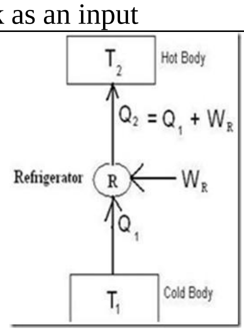
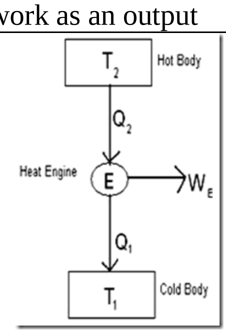
Parabolic concentrating solar collector

02

2 b

Differentiate

01 for each any four

Heat pump	Heat engine
it is a thermodynamic system which transfers heat from low temperature body and gives out the same to high temp body.	it is a thermodynamic system which transfers heat from high temperature body and gives out the same to low temp body.
it works between hot body temp and atmospheric temp	it works between hot body temp and reservoir temp.
$(COP)_{HP} = Q_1/Q_1-Q_2$	$(COP)_{HE} = Q_2/Q_1-Q_2$
COP of heat pump is greater than 1	COP of heat engine is always less than 1
in case of HP atmosphere acts as a cold body	in case of HE source acts as a hot body
it takes work as an input	it gives work as an output
	

c **Different processes** — 01 for each

n = ∞ infinity :The process is PV^{∞} i.e. V = Constant i.e. Isochoric Process

n = 0: The process is PV^{0} i.e. P = Constant i.e. Isobaric Process

n = 1: The process is PV^{1} i.e. PV = Constant i.e. Isothermal Process

n = γ: The process is PV^{γ} i.e. PV^{γ} = Constant i.e. Adiabatic Process

d **Classification of Steam Turbines** — 01 for each

i) Action of steam flowing over the blades

Impulse Turbine, Reaction Turbines & Combined Impulse and Reaction Turbines

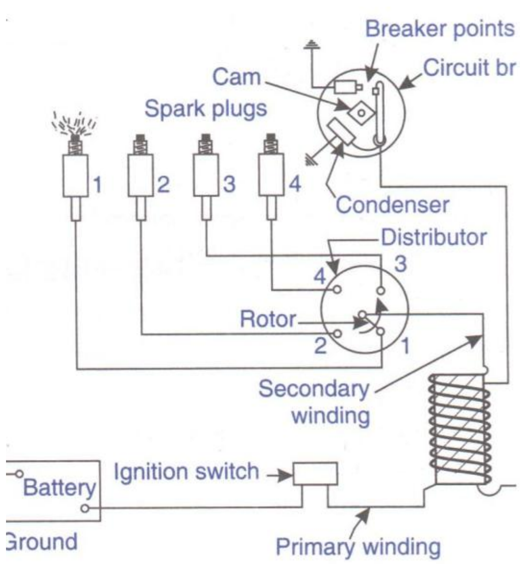
ii) Expansion stages: Single stage, Multistage Turbines

iii) Pressure of steam entering: Low pressure, Medium pressure, High Pressure, Very High pressure, Supercritical pressure Turbines

iv) Exhaust steam pressure : Low pressure or Positive pressure Turbines

e **Battery Ignition system** : It consists of a battery of 6 or 12 volts, ignition switch, induction coil, condenser, distributor and a circuit breaker. One terminal of battery is ground to the frame of the engine and other is connected through the ignition switch to one primary terminal of the ignition coil . The other terminal is connected to one end of contact points of the circuit breaker. — 02+02

To start with the ignition switch is made on and the engine is cranked. The contacts touch, the current flows from battery through the switch. A condenser connected across the terminals of the contact breaker points prevent the sparking at these points. The rotating cam breaks open the contacts immediately and breaking of this primary circuit brings about a change in the magnetic fields and voltage changes from 12 to 12000 V. due to the high voltage. The spark jumps across the gap in the spark plug and air fuel mixture is ignited in the cylinder



	f	**Advantages of two stage compression over single stage (any 4 points)** **Advantages are :** 1. Energy savings: When a two stage air compressor is operating at the low level, it uses less energy than the high level. Since it runs at the low level most of the time, it uses much less energy. 2. Better for air conditioner: Because it has longer cooling cycles, an air conditioner with a two stage air compressor does not shut on and off nearly as much as a unit with a standard air compressor. This puts less strain on your air conditioner and is also more energy efficient. 3. Greater control with respect to pressure and temperature 4. Greater humidity control when used in refrigeration systems 5. Higher efficiency	01 for each any four
3	a	**Advantages & Limitations of Wind Energy (any 2 + 2 points)** ADVANTAGES OF WIND ENERGY 1. **Wind energy is a clean fuel source.** Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. Wind turbines don't produce atmospheric emissions that increase health problems. 2. **Wind power does not use water, unlike conventional electricity sources.** Producing nuclear, coal, or gas-fired power uses water for cooling. Water is becoming a scarce resource all over the country. Wind power uses zero water in its energy generation. 3. **Wind is a free source of energy.** The nation's wind supply is abundant. Wind power is the largest source of annual new generating capacity. 4. **Wind power is inexhaustible.** Wind is actually a form of solar energy. Winds are caused by the heating of the atmosphere by the sun, the rotation of the Earth, and the Earth's surface irregularities. For as long as the sun shines and the wind blows, the energy produced can be harnessed. 5. **Wind power is cost-effective.** It is one of the lowest-cost renewable energy technologies available today. 6. **Wind turbines can be built on existing farms or ranches.** This greatly benefits the economy in rural areas, where most of the best wind sites are found. Farmers and ranchers can continue to work the land because the wind turbines use only a fraction of the acreage. 7. **Wind creates jobs.** The wind energy sector creates lot many jobs. **Limitations:** Some of the major Limitations of wind energy. 1. Noise Disturbances: Though wind energy is non-polluting, but the turbines may create a lot of noise. 2. Threat to Wildlife: Due to large scale construction of wind turbines on remote location, it	02 02

		could be a threat to wild life 3. Wind is unpredicted: This is another main disadvantage of wind energy is that winds can never be predicted. 4. Suited To Particular Region : Wind turbines are suited to the coastal regions which receive wind throughout the year to generate power. Therefore, countries that do not have any coastal or hilly areas may not be able to take any advantage of wind power. 5. **Safety Concerns:** In the action of tornadoes, hurricanes and cyclones have increased safety concerns.	
	b	Given data P_1 = 400 kP_a V_1 = 0.04 m^3 P_2 = 120 kP_a V_2 = 0.1 m^3 T_2 = 146 + 273 = 429 K C_P = 1.0216 kJ/kgK C_V = 0.7243 kJ/kgK We have, R = C_P - C_V = **0.2973 kJ/kgK** Applying the Gas Equation at final condition, we get $P_2 V_2 = m R T_2$ 120 x 0.1 = m x 0.2973 x T_2 $\therefore$ **m = 0.094 kg** Applying Gas Equation at Initial Condition, we get $P_1 V_1 = m R T_1$ 400 x 0.04 = 0.094 x 0.2973 x T_1 $\therefore$ **T_1 = 572.65 K** Now, Change in Internal Energy dU = m x C_p x dT = 0.094 x 0.7243 x (572.65 - 429) = **9.78 kJ**	01 for each
	c	**Gay-Lussac's Law**: This is also called as the Pressure Temperature Law. This law states that the pressure of a given amount of gas held at constant volume is directly proportional to the Kelvin temperature. As the pressure goes up, the temperature also goes up, and vice-versa.	02

Avagadro's Law- This law states that equal volumes of all gases at the same temperature and pressure contain the same number of molecules. In other words, it can be stated that the molecular weights of all the gases occupy the same volume at N.T.P. 02

d Differentiate between fire tube boilers and water tube boilers (Any four) 01 for each any four

Sr. No	Fire tube boilers	Water tube boilers
01	Hot flue gases flow in the tubes surrounded outside by the water	Water flows in the tubes surrounded outside hot gases
02	Slower in operation and have low evaporation rates	faster in operation and have low evaporation rates
03	Failure due to Temperature stress causing failure of feed water arrangement is minimum	Failure due to Temperature stress causing failure of feed water arrangement is more
04	It can work upto 20 bar pressure only	It can work upto 200 bar pressure
05	Simple and rigid construction	Complex construction
06	More maintenance and operation cost	less maintenance and operation cost
07	Smaller sizes and hence not suitable for large power houses	Bigger sizes and hence suitable for large power houses
08	Installation is difficult	Installation is easy
09	Requires less floor area	Requires more floor area

e **Methods of I C Engine cooling (any 2 + 2 points)**

I C Engine cooling achieved by following two methods

a) Air cooling system

b) Liquid cooling system

Merits & Demerits of liquid Cooling System

Merits :-

(a) Uniform cooling of cylinder, cylinder head and valves.

(b) Specific fuel consumption of engine improves by using water cooling system. 02

(c) If we employ water cooling system, then engine need not be provided at the front end of moving vehicle.

(d) Engine is less noisy as compared with air cooled engines, as it has water for damping noise.

Demerits:

(a) It depends upon the supply of water.

(b) The water pump which circulates water absorbs considerable power.
(c) If the water cooling system fails then it will result in severe damage of engine.
(d) The water cooling system is costlier as it has more number of parts.

Merits & Demerits of Air Cooling System

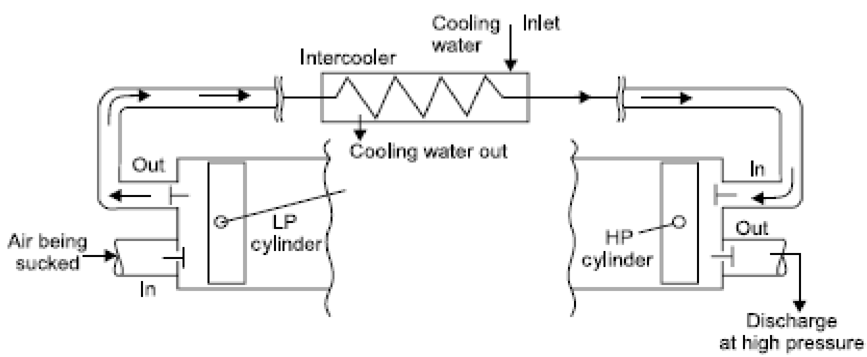
Merits:-
(a) Radiator/pump is absent hence the system is light.
(b) In case of water cooling system there are leakages, but in this case here are no leakages.
(c) Coolant and antifreeze solutions are not required.
(d) This system can be used in cold climates, where if water is used it may freeze.

02

Demerits:
(a) Comparatively it is less efficient.
(b) It is used in aero planes and motorcycle engines where the engines are exposed to air directly.

f

Two stage reciprocating air compressor :

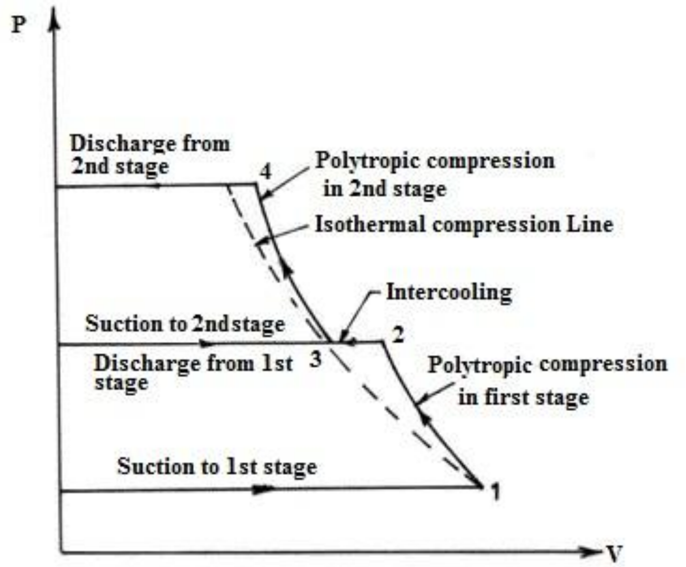


Two stage reciprocating compressor

Multistage compression refers to the compression process completed in more than one stage i.e. a part of compression occurs in one cylinder (L.P. cylinder) and subsequently compressed air is sent to subsequent cylinders (H.P. cylinder) for further compression.

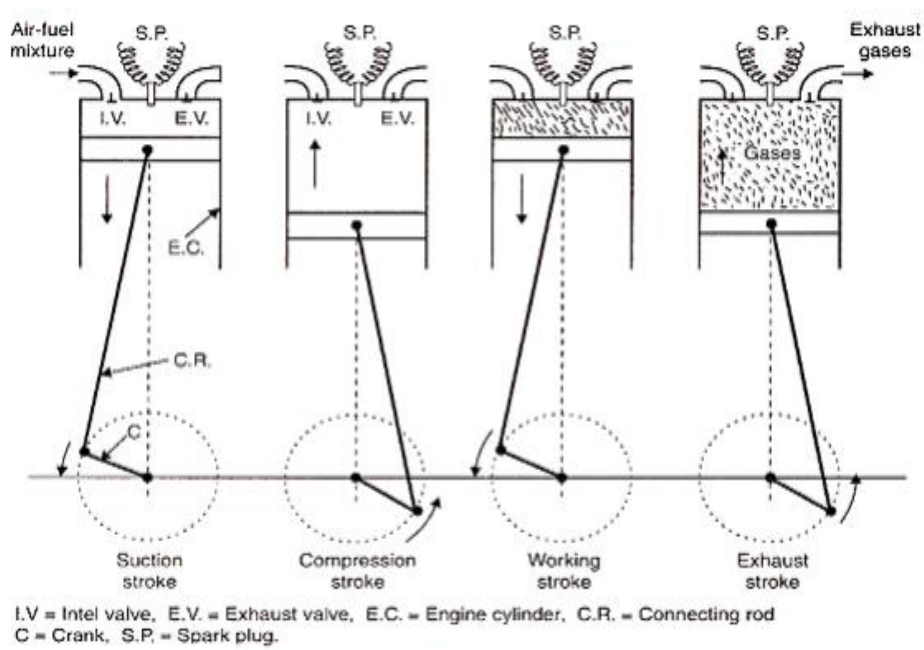
Figure shows the schematic of two stage compressor with intercooler between stages. The total work requirement for running this shall be algebraic summation of work required for low pressure (LP) and high pressure (HP) stages. The size of HP cylinder is smaller than LP cylinder as HP cylinder handles high pressure air having smaller specific volume.

PV DIAGRAMS



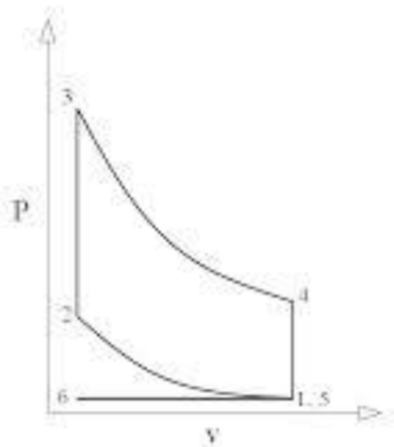
4	a	First Law of Thermodynamics: - It states that if a system executes a cycle , transferring work and heat through its boundary, the net heat transfer is equivalent to the net work transfer. or $\oint dQ = \oint dW$ where $\oint$ represents the sum for a complete cycle.	04
		Limitations of first law of thermodynamics 1. It is not clear about the direction of heat and work transfer 2. First law does not help whether or not system will undergo change. 3. No restriction on possibility of conversion energy from one form to another. 4. No clarity that how much percentage of one form of energy converted into another form of energy	04

	b	Given Data $V_1 = 0.028\ m^3$ $P_1 = 1.25$ bar $T_1 = 298$ K $V_2 = 0.0042\ m^3$ $p_1 v_1^{1.3} = p_2 v_2^{1.3}$ $1.25 \times (0.028)^{1.3} = P_2 \times (0.0042)^{1.3}$ $\therefore p_2 = 14.7$ bar Work done $= \frac{p_1 v_1 - p_2 v_2}{n - 1}$ $= \frac{(1.25 \times 0.028 \times 14.72 \times 0.0042)10^5}{1.3 - 1}$ $= -8.94$ kJ (work done on gas) $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$ $\frac{T_2}{298} = \left(\frac{14.72}{1.25}\right)^{0.3/1.3}$ $T_2 = 526.5$ K $T_3 = T_1 = 298$ K, $T_2 = 526.5$ K V_2 and $V_3 = 0.0042\ m^3$, $P_2 = 14.72$ bar $\frac{P_2}{T_2} = \frac{P_3}{T_3}$ $\frac{14.72}{526.5} = \frac{P_3}{298}$ $\therefore P_3 = 8.33$ bar	08

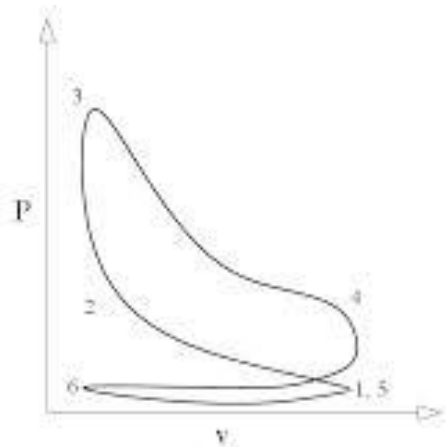
	c	**Locations & Functions of parts in RAC system** **i)** **Oil separator**: The oil separator is in the high side of the system i.e. after the compressor. Its function is to prevent oil particles going on to the evaporator. ii) **Receiver:** The Receiver is installed after the Condenser in order to collect the condensed refrigerant to allow a continuous liquid supply to the expansion device. **iii)** **Accumulator**: A suction-line accumulator is a safety device used on a refrigeration system to prevent liquid refrigerant from returning to the compressor. iv) **Drier cum filter:** Drier cum Filter placed just before the expansion valve to filter the refrigerant from impurities and removes any moisture present in the refrigerant.	02 for each
5	a	**Four stroke petrol engine**  	02
		1. Suction stroke: Suction stroke starts when piston is at top dead center and about to move downwards. During suction stroke inlet valve is open and exhaust valve is closed. Due to low pressure created by the motion of the piston towards bottom dead center, the charge consisting of fresh air mixed with the fuel is drawn into cylinder. At the end of suction stroke the inlet valve closes. The suction stroke is shown in fig 2. Compression stroke: During compression stroke, the compression of charge takes place by return stroke of piston, i.e. when piston moves from BDC to TDC. During this stroke both, inlet and exhaust valve remain closed. Charge which is occupied by the whole cylinder volume is compressed up to the clearance volume. Just before completion of compression stroke, a spark is produced by the spark plug and fuel is ignited. Combustion takes place when the piston is almost at TDC. The Compression stroke is	02

shown in fig

3. Expansion or power stroke: piston gets downward thrust by explosion of charge. Due to high pressure of burnt gases, piston moves downwards to the BDC. During expansion stroke both inlet and exhaust valves remains closed as shown in fig . Thus power is obtained by expansion of products of combustion. Therefore it is also called as 'power stroke'. Both pressure as well as temperature decreases during expansion stroke.
4. Exhaust stroke: At the end of expansion stroke the exhaust valve opens, the inlet valve remains closed and the piston moves from BDC to TDC as shown in fig. During exhaust stroke the burnt gases inside the cylinder are expelled out. The exhaust valve closes at the end of the exhaust stroke but still some residual gases remains in cylinder.



Actual P – V diagram

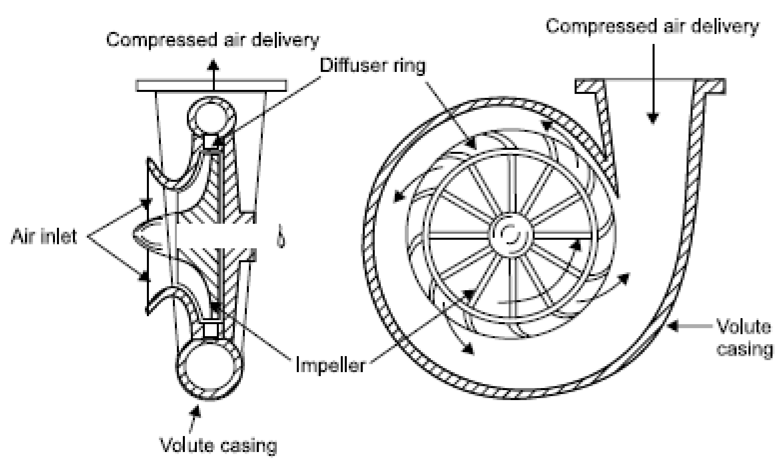


Theoretical P – V diagram

02+02

c

CENTRIFUGAL COMPRESSOR:



03

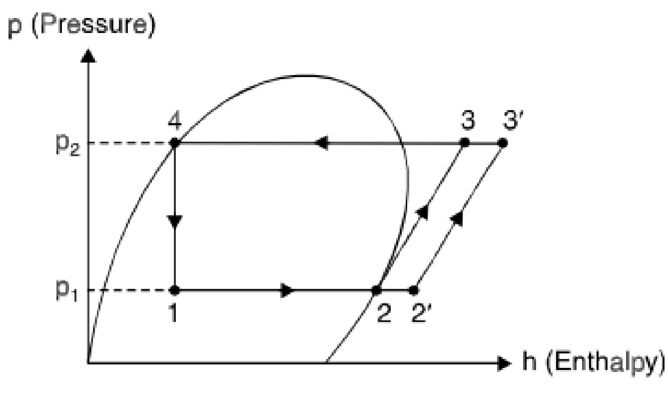
Centrifugal compressor is a radial flow machine compressing the fluid due to the dynamic action of impeller. Centrifugal compressors have impeller mounted on driving shaft, diffuser and volute casing. Centrifugal compressors have air inlet at the centre of impeller. The portion of impeller in front of inlet passage is called impeller eye. Impeller is a type of disc having radial blades mounted upon it. Compressor casing has a diffuser ring surrounding impeller and the air enters the impeller eye and leaves from impeller tip to enter diffuser ring. Volute casing surrounds the diffuser ring. Volute casing has cross section area increasing gradually up to the exit of compressor. These impellers of centrifugal compressors may also be of double sided type such that air can enter from two sides (both) of impeller.

Air enters the impeller eye axially and flows radially outwards after having entered compressor. Radial flow of air inside compressor is due to impeller (blades) rotating about its axis. These impeller blades impart momentum to the air entering, thereby rising its pressure and temperature. Subsequently the high pressure fluid leaving impeller enters the diffuser ring where the velocity of air is lowered with further increase in pressure of air. Thus in diffuser ring the kinetic energy of air is transformed into pressure head. High pressure air leaving diffuser is carried by volute casing to the exit of compressor. Due to increased cross section area of volute casing some velocity is further reduced causing rise in its pressure, although this is very small. Total pressure rise in compressor may be due to 'impeller action' and 'diffuser action' both. Generally, about half of total pressure rise is available in impeller and remaining half in diffuser. 03

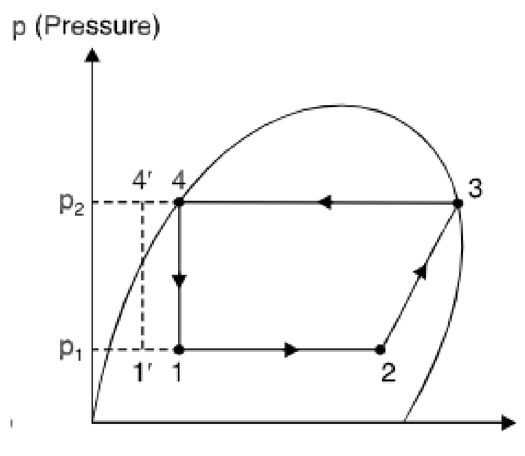
Applications : Centrifugal compressors are used in aircrafts, blowers, superchargers, etc. where large quantity of air is to be supplied at smaller pressure ratios. Generally, pressure ratio up to 4 is achieved in single stage centrifugal compressors while in multistage compressors the pressure ratio up to 12 can be achieved. These compressors run at speed of 20,000–30,000 rpm. 02

C i

Superheating & Under cooling on P-H Charts



Effect of superheating.



Effect of sub-cooling of liquid.

Effect of superheating. As may be seen from the Fig. the effect of superheating is to increase the refrigerating effect but this increase in refrigerating effect is at the cost of increase in amount of work spent to attain the upper pressure limit. Since the increase in work is more as compared to increase in refrigerating effect, therefore overall effect of superheating is to give a low value of C.O.P.

ii **Effect of under-cooling** of liquid. 'Under-cooling' is the process of cooling the liquid refrigerant below the condensing temperature for a given pressure. In Fig. the process of sub-cooling is shown. As is evident from the figure the effect of sub-cooling is to increase the refrigerating effect. Thus sub-cooling results in increase of C.O.P. provided that no further energy has to be spent to obtain the extra cold coolant required.

6 a

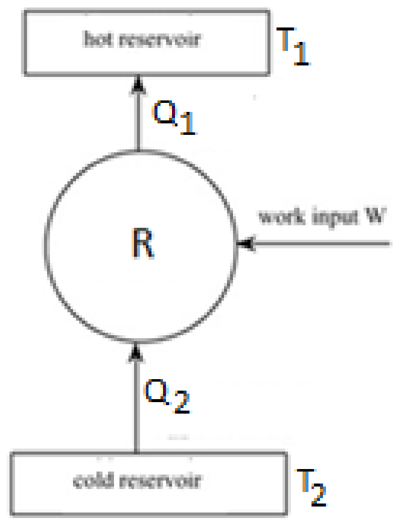
Given Data

Compressor work, W = 1.3 kW

Refrigeration Effect (RE) = 1 ToR

Q_2 = 3.517 kW

So, Coefficient of Performance of Carnot Refrigerator is



COP (Th) = R.E. / Work Done Required

= Q_2 / W

= 3.517 / 1.3 = **2.7**

04

Also, COP (Th) = T_2 / (T_1 - T_2)

2.7 = 247 / (T_1 - 247)

So, T_1 = 338.3 K

b **Specific Heats for Solids / Liquids & Gases and Reasoning**

In general specific heat(**C**) gives us an idea of the amount of energy (heat) we need to provide to a system in order to bring about a unit rise in the temperature of the system. It's value may vary depending on the process you are providing this energy. Hence we have two values of C namely Cv and Cp .

C_v for a gas is the change in internal energy (U) of a system with respect to change in temperature at a fixed volume of the system

04

i.e. $\mathbf{C_v = (\partial U/\partial T)_v}$

Now C_p for a gas is the change in the enthalpy (H) of the system with respect to change in temperature at a fixed pressure of the system

i.e **$C_p = (\partial H/\partial T)_p$**. So the enthalpy term is greater than the internal energy term because of the PΔV term i.e. in case of a constant pressure process more energy is needed, to be provided to the system as compared to that of a constant volume process to achieve the same temperature rise, as some energy is utilized in the expansion work of the system. And the relation that correlates these two is **$C_p = C_v + R$.**

In short any solid or a liquid when heated, does not undergo any change in the volume or pressure. But in case of a gas, both the pressure and volume change on heating. Therefore, specific heat of a gas is defined either at constant volume or at constant pressure and hence a gas has two specific heats. So, the values for Cp and Cv for the gas have significantly two different values.

But since liquids and solids can practically assumed to be incompressible, C_p and C_v for them have almost same values and hence only a single value of specific heat is used for them.

c

Difference between impulse and reaction turbine

Impulse turbine		Reaction turbine	
1.	Steam completely expand in nozzle & pressure remain constant during flow through the blade passage	1.	Steam expand partially in nozzle and further expansion take in rotor blade passage.
2.	Relative velocity of steam passing over blades of impulse turbine is constant.	2.	Relative velocity increases as steam passing over the blade expands.
3.	Blade is symmetrical profile	3.	Blade is aerofoil section.
4.	Pressure is same at inlet and outlet	4.	Pressure is different at inlet and outlet.
5.	Steam velocity is very high	5.	Steam velocity is not very high
6.	Lesser no of stages require	6.	More no. of stages requires
7.	Occupies less space per unit power	7.	Occupies more space per unit power
8.	Suitable for small power.	8.	Suitable & higher power.
9.	At low load the efficiency is low	9.	At low load, the efficiency is high

01 for each any four

Difference between Petrol & Diesel Engine

d

Basis	Petrol Engine	Diesel Engine
Sp. Fuel Consumption	**High**	**Low**
Thermal efficiency	**Low**	**High**
Fuel – air ratio	**F:A is less**	**F:A is More**
Compression ratio	**Low**	**High**

01 for each any four

e

Applications of Reciprocating Compressor (Any Four, each for ½ mark)

1. Fertilizer production
2. Food and beverage industry
3. Gas cylinder filling
4. Polyethylene production, low density
5. Polymer productions
6. Underground gas storage
7. Underground natural gas storage

02

Applications of Centrifugal Compressor (Any Four, each for ½ mark)

8. In gas turbines and auxiliary power units.
9. In automotive engine and diesel engine turbochargers and superchargers.
10. In pipeline compressors of natural gas to move the gas from the production site to the consumer.
11. In oil refineries, natural gas processing, petrochemical and chemical plants.
12. Air-conditioning and refrigeration and HVAC: Centrifugal compressors quite often supply the compression in water chillers cycles.
13. In air separation plants to manufacture purified end product gases.
14. In oil field re-injection of high pressure natural gas to improve oil recovery.

02

Properties of Ideal Refrigerant (any four)

Required Properties of Ideal Refrigerant:

	f	1) The refrigerant should have low boiling point and low freezing point. 2) It must have low specific heat and high latent heat. 3) The pressures required to be maintained in the evaporator and condenser should be low enough to reduce the material cost and must be positive to avoid leakage of air into the system. 4) It must have high critical pressure and temperature to avoid large power requirements. 5) It should have low specific volume to reduce the size of the compressor. 6) It must have high thermal conductivity to reduce the area of heat transfer in evaporator and condenser. 7) It should be non-flammable, non-explosive, non-toxic and non-corrosive. 8) It should not have any bad effects on the stored material or food, when any leak develops in the system. 9) It must have high miscibility with lubricating oil and it should not have reacting properly with lubricating oil in the temperature range of the system. 10) It should give high COP in the working temperature range. This is necessary to reduce the running cost of the system. 11) It must be readily available and it must be cheap also.	01 for each any four