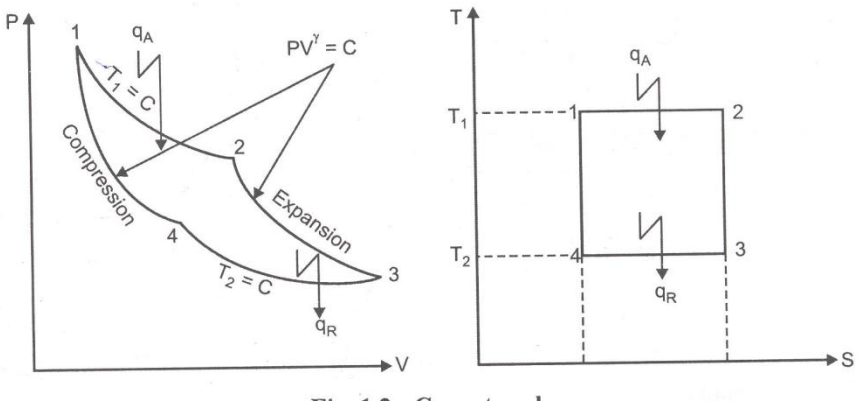
SUMMER – 13 EXAMINATION

Subject Code: **12155** **Model Answer**

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.

Q1 (a) Show Carnot heat engine cycle on PV & T-s diagram. Describe the processes involved.



(fig. -2, process-2marks)

Process 1-2: Reversible isothermal heat addition at const. temp T_1.

Process 2-3: Reversible adiabatic expansion from temp T_1 to temp T_2.

Process 3-4: Reversible isothermal heat rejection at const. temp T_2.

Process 4-1: Reversible adiabatic compression from temp T_2 to temp T_1.

(b) Define MPFI and explain its working. (Def. -1, working-3marks)

- MPFI means multi point fuel injection system.
- Each cylinder has no. of injectors to supply / spray fuel in cylinders.
-fuel injected into the individual cylinder after receiving command from the on board Engine management system computer or Engine Control Unit (ECU)
-System operates at a pressure upto 1500 bar & have upto 8 holes per injector.
-Mechanical pumps are used to create pressure but injection timing is computer controlled & deliver very precise amount of fuel.This makes possible to develop homogeneous charge having complete combustion reducing smoke &NOx.
-Upto 6 injectors are used per cylinder.

(C) Define stroke, piston speed, compression ratio & cut off ratio. ***(each def. – 1mark)***

Stroke – Distance travelled by piston from one dead centre to other dead centre.
Piston speed- Distance traveled by piston in one minute.(= 2LN m/min.)
compression ratio – Ratio of total cylinder vol. to the clearance vol.
cut off ratio – Ratio of vol. after heat addition to vol. before heat addition.

(d) List the pollutants in exhaust gases of diesel engines& describe their effects on environment.
(Pollutant – 1 , effect-3marks)

Pollutants : (1) Nitrogen oxides , (2)Hydrocarbons (3) Scoot or smoke (4)Diesel odour (5) Aldehydes.
Effects: -NOx causes respiratory irritation, headache, bronchitis, pulmonary emphysema, impairment of lungs, loss of appetite, and corrosion of teeth to human body.
-Hydrocarbon reduces visibility , eye irritation, peculiar odour . Some hydrocarbons induce cancer, affect DNA ,cell growth.
-Smoke spoils clothing, exterior finish of buildings. Increases chances of cancer.
-diesel exhaust fumes can cause eye irritation & sour eyes.
- aldehides causes irritation to eyes, skin &respiratory tract.

(e) Classify air compressor. (4 for four classifications)

- I. According to motion
(a) Reciprocating air compressor
(b) Reciprocating air compressor

(i) Positive displacement compressor

(ii) Non- Positive displacement compressor

II. According to number of stages

(i) Single stage compressor

(ii) Multistage compressor

III. According to working side of piston

(i) Single acting compressor

(ii) Double acting compressor

IV. According to pressure limit

(i) Low pressure compressor

(ii) High pressure compressor

V. According to pressure rise per stage

(i) Fan

(ii) Blower

(iii) compressor

VI. According to capacity of compressor

(i) Low capacity compressor

(ii) Medium capacity compressor

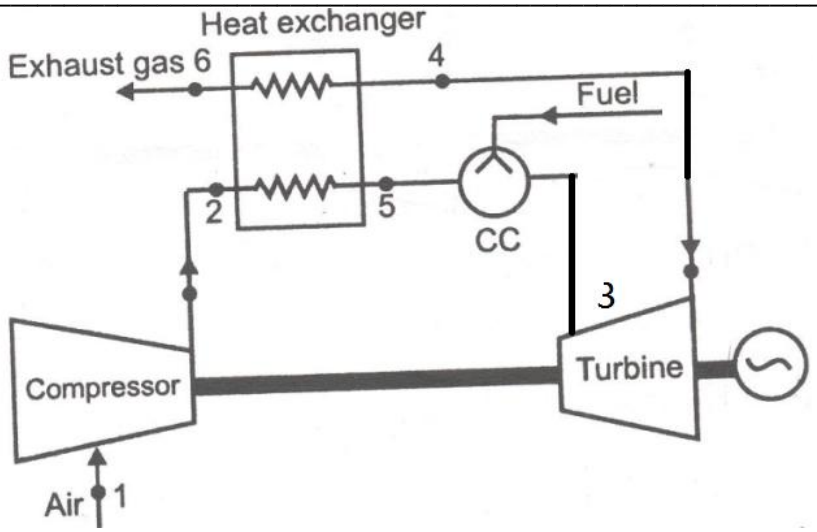
(iii) High capacity compressor

(f) Define regeneration and how it is accomplished in gas turbine. Draw block diagram.

-Air delivered by compressor passes through a heat exchanger to extract heat from exhaust gases known as "regenerator "

-Utilizing the waste heat from hot gases exhausted from the turbine. The heated air is passes into the combustion chamber & part of it is employed to burn the fuel.

-Some heat is added to the air in regenerator, hence thermal efficiency increases.



(marks 1+2+1)

(g) Write Application of refrigeration. (any four 4 marks)

1) Industrial application:- printing industries ,pharmaceutical industries ,rubber industries ,oil refineries,

2) Chemical industry:

In modern chemical industries

a) To control the rate of chemical reaction

b) To control the rate of fermentation

c) To liquidification of gas and vapor and solidification of liquid

d) To prevent loss of product

e) To petro- chemical industry

3) Preservation of goods:

a) Storage of blood in blood bank, medicines.

b) Storage and transportation of fruits, meat, poultry product, diary product.

4) Commercial purpose: for air conditioning, hospital, hotel, offices etc. for comfort, in ice factory in district milk dairy.

Q.2 Attempt any two: (

a) A test is carried out on 4 stroke 4 cylinder, S.I. Engine. B.P. when all cylinders firing was 20KW.

BP. Produced when cylinder No.1 is cut off=13.8KW

B.P. produced when cylinder No.2is cut off =13.5KW

B.P.produced when cylinder No.3 is cut off =14.oKW

B.P. produced when cylinder No.4is cut off=14.2KW

Find mech. Efficiency of the engine.

Ans: Total $(B.P.)_{engine}$ = 20KW

B.P. when 1st cylinder cut off = $(B.P.)_{234}$ =13.8 KW

B.P. when 2 nd cylinder cut off = $(B.P.)_{134}$ =13.5 KW

B.P. when 3rd cylinder cut off = $(B.P.)_{124}$ =14.0 KW

B.P. when 4th cylinder cut off = $(B.P.)_{123}$ =14.2 KW

I.P. of 1st cylinder = $I_1 = (B.P.)_{engine} - (B.P.)_{234}$ =20- 13.8 =6.2 Kw……(1 mark)

$I_2 = (B.P.)_{engine} - (B.P.)_{134}$ =20- 13.5 =6.5 Kw ……..(1 mark)

$I_3 = (B.P.)_{engine} - (B.P.)_{124}$ =20- 14 =6.0 Kw……(1 mark)

$I_4 = (B.P.)_{engine} - (B.P.)_{123}$ =20- 14.2 =5.8 Kw…….(1 mark)

Total I.P. = 6.2+6.5+6.0+5.8 = 24.5KW…… (2 marks)

Mech. Efficiency = (B.P./ I.P.)*100 = (20/24.5)*100 = 81.63 %.....(2 marks)

b) **Differentiate reciprocating and rotary compressors (12pts**). (8- marks)

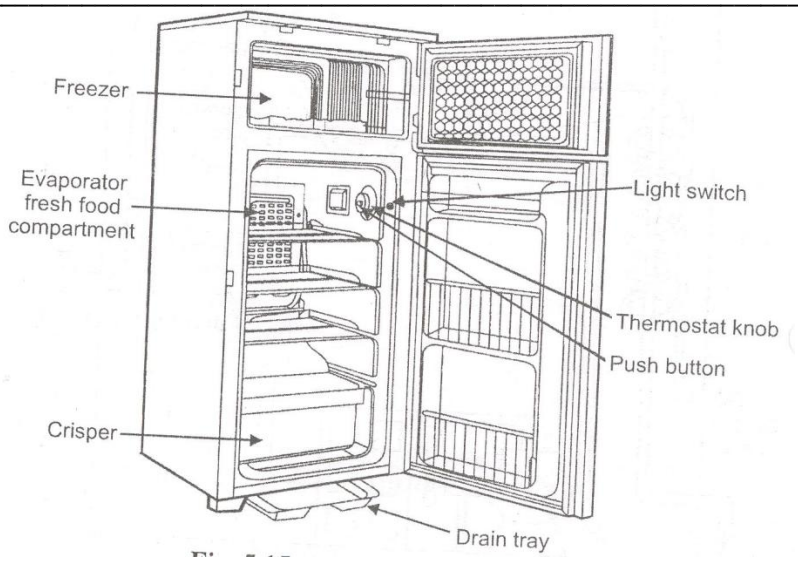
S.no.	Reciprocating compressors	Rotary compressors
1	Maximum delivery pressure may be as high as 1000 bar.	Maximum delivery pressure is 10 bar only.
2	Maximum free air discharge is @ 300 cu. m/min.	Maximum free air discharge is as high as 3000 cu. m/min.
3	Suitable for low discharge of air at very high pressure.	Suitable for large discharge of air at low pressure.
4	Speed of air compressor is low.	Speed of air compressor is high.
5	Air supply is intermittent.	Air supply is continuous.
6	Size of compressor is large for given discharge.	Size of compressor is small for the same discharge.
7	Balancing is major problem.	No balancing problem.
8	Lubricating system is complicated.	Lubricating system is simple.
9	Air delivered is less clean, as it comes in contact with the lubricating oil.	Air delivered is more clean, as it does not comes in contact with the lubricating oil.

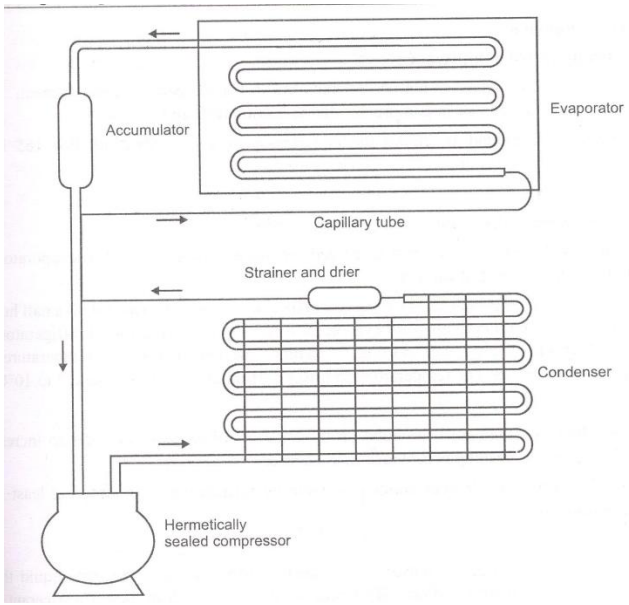
10	Isothermal eff. Is used for all sorts of calculations.	Isentropic eff. Is used for all sorts of calculations.
11	It has more number of moving parts.	It has more number of moving parts.
12	Due to low speed of rotation it cannot be directly coupled to prime mover but it requires reduction of speed.	It can be directly coupled to prime mover.

c) Draw a neat sketch of domestic refrigerator and describe it's working. Name the refrigerant used.

- Works on vapour compression cycle
- Hermatically sealed compressor is mounted on bottom part behind compartment.
- Cooling effect is produced in evaporator, mounted at uppermost part of cabinet; –ve temp is maintained to produce ice.
- Black coloured grill provided of air cooled condenser on backside of refrigerator. Wire meshing is provided to increase heat transfer area.
- Accumulator is the large cylindrical vessel designed to trap the refrigerant liquid that is not converted into vapour.
- Capillary tube is used as a expansion device, having sufficient length, having internal dia. 1/16 to 1/8 inch.
- Various controls – starting relay, overhead protector, thermostat, defrost system, light switch.
- Magnetic door, door with gasket is provided.
- R-12 - refrigerant used.

(3+4+1)





Q3. (a) Atmospheric air at 20^0C DBT & 60% RH is heated to 30^0DBT & 80% RH. Find WBT at initial and final condition.

- Using psychrometric chart WBT at initial condition is =15^0C…….. (2 marks)

WBT at final condition is =28^0C……(2 marks)

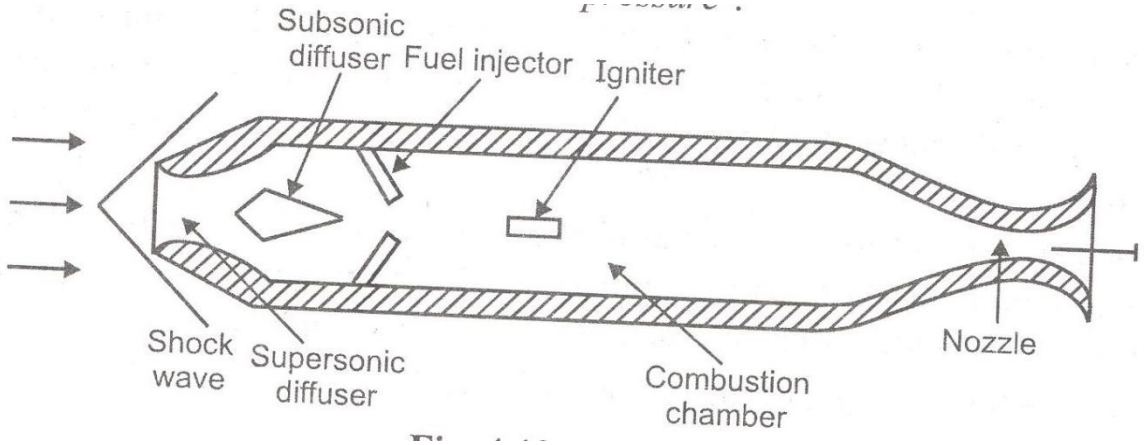
(b) Explain principal of ram jet with neat sketch. (2+2)

- Ramjet has no compressor,

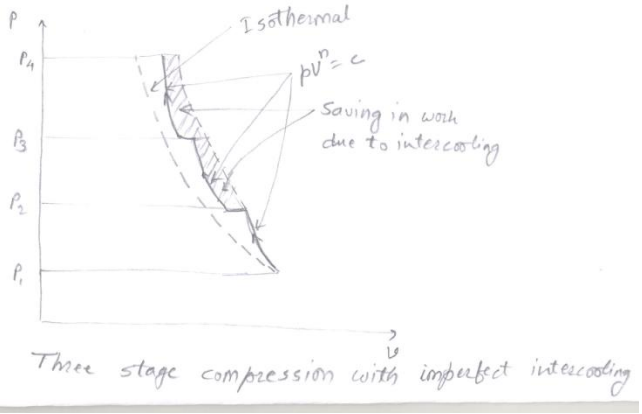
- Air entering into it with supersonic velocity is slowed down to sonic vel. In supersonic diffuser, increasing pressure.

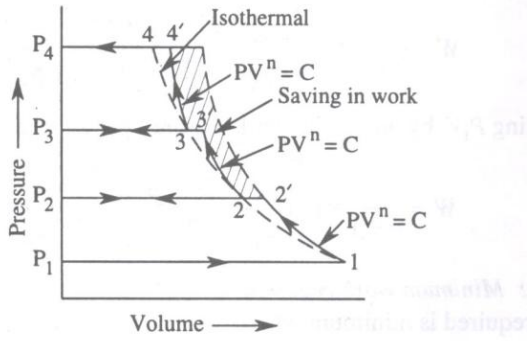
-subsonic diffuser increases further pressure & temp of air.

- fuel is injected into combustion chamber with flam stabilizer , high pressure & temp. gases passes through nozzle converting pressure energy into K.E.
- flight at supersonic speed.



(c) Show perfect & imperfect cooling of 3 stage reciprocating compressor on P-V diagram. (1+3)





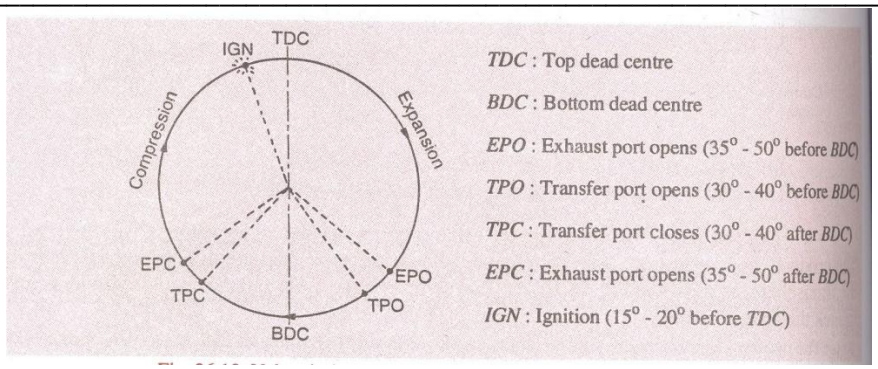
Three stage compression with perfect intercooling

(d) List desirable properties of lubricating additives and write their advantages. (2+2)

By adding lubricating additive lubricating oil gives –

- Proper viscosity, good cleaning ability, Anti corrosion property, anti- oxidation property , anti- rust , anti-foaming ability etc
- Advantages- act as acid neutralizer, reduce wear, reduce rusting, increase viscosity index, reduce pour point, reduce oil foaming and reduce oil oxidation.

(e) Draw valve timing diagram of 2 stroke S.I. engine & describe it.(2+2)



(f) Define preignition in S. I. engine. How it differ from autoignition? (Defination - 2marks, diff. -2 M)

- If combustion starts due to any other reason before production of spark , is known as preignition.
- In abnormal combustion sudden pressure rise is seen. Before the flame propagates to remote parts of cylinder, a charge present in that region reaches to critical temp. & pressure and starts autoignition. (i.e. ignition without assistance of propagating flame).

Q 4 Distinguish between supercharging and turbo charging.

	Supercharging	Turbo charging
1.	Increase the power output of the engine	Uses exhaust heat to run engine
2.	Increase air pressure with the help of compressor	It is a set of compressor and exhaust gas turbine
3.	To run compressor it uses the power from engine itself	To run compressor it uses some energy of exhaust gas turbine & use to drive the supercharger
4.	It requires less space because of only compressor	It requires more space due to supercharger and turbine

b) Heat supplied=5 x 42500 =**212500kJ/hr**

Heat carried away by cooling water = m_w x (C_{pw} x Δt_w)

= (11 x 60) x 4.187 x 23= **63558.6 KJ/hr…… (1 mark)**

Heat carried away from exhaust gases = m_g x (C_{pg} x Δt_g)

=(4.6 x 60) x 1 x 260 =**71760 KJ/hr……(1 mark)**

Brake power = 19 x 3600 = **11400 KJ/hr…… (1 mark)**

Heat accounted for due radiation = heat supplied- heat utilized in (B.P +cooling water+ exhaust gases)

= **65781.4 KJ/hr…….. (1 mark)**

Heat supplied	KJ/hr	Heat utilized	KJ/hr	% age
Heat supplied with fuel	212500	I) B.P	11400	5.364
		ii) Cooling water	63558.6	29.91
		iii) In exhaust gases	71760	33.77
		iv) Unaccounted for the losses in radiation	65781	30.96
TOTAL	212500		212500	100

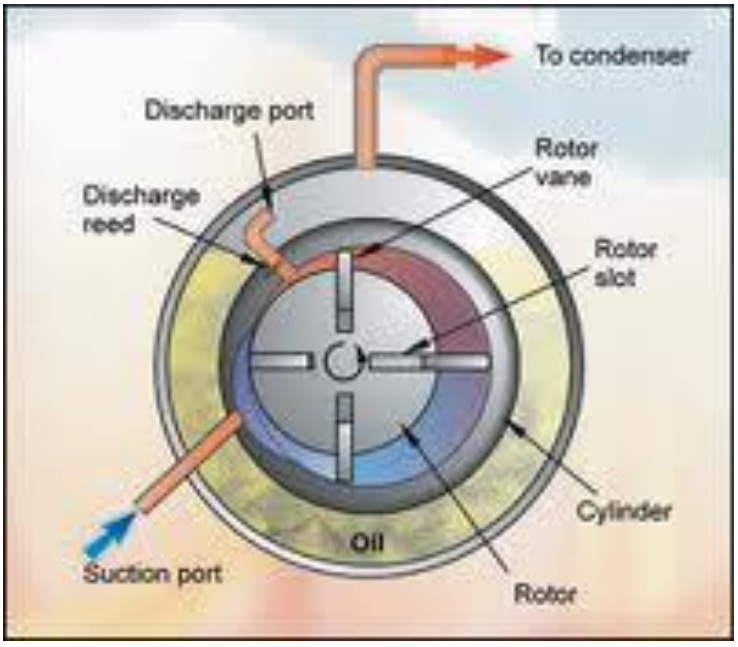
c) i) Function of catalytic converter: convert harmful pollutants into less harmful emissions before they leave the car exhaust system. (2 marks)

ii) Specifications of Bharat III norms (2marks)

	CO	HC	NOX
BS III (2005)	2.3	0.2	0.15

d)

(2 +2 marks)



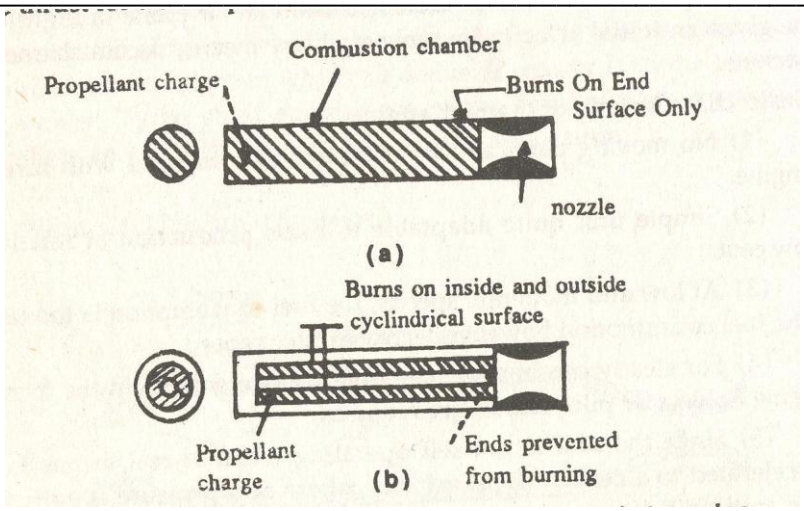
Vane compressor

e) **Solid propellent:** A rocket propellant in a solid form, usually containing a mixture or combination of fuel and oxidizer.

Working: Rocket consists of a seamless tube made up of steel, closed at one end and nozzle at the other open end. in solid propellant rockets, the fuel and the oxidizer are intimately mixed and formed into a solid grain which is placed in the combustor . Thus there is no fuel supply system.

In the restricted burning rocket engine, the burning of this propellant is restricted so that it burns in one direction only. The restricted burning also called the cigarette burning can be accomplished by pouring the charge when liquid so that on solidification it fits the chamber tight. Restricted burning rockets are preferred when the unit is required to deliver a small thrust for a relatively long duration. In the unrestricted burning, the engine charge is

free to burn on all surfaces at the same time such rockets are used where it is desirable to develop large thrust for a short duration i.e. in launching rockets boosters. The combustor of solid rocket has to be large enough to store the entire propellant and also strong enough to withstand the sufficiently high combustion pressures. Again the propellant being solid can't be used to cool the combustor and the nozzle and there is danger of overheating. As such these rockets are suitable for producing thrust only for short duration. Therefore, they are used extensively for missile and aircraft boosters, guided missiles and rocket projectiles.



e) (4 marks for 8 pts)

Vapor absorption refrigeration	Vapor compression refrigeration
1. Low grade energy supply	Mechanical high grade energy
2. Less wear and tear	More wear and tear
3. Can be used in remote places as it can work even with a simple kerosene lamp	Used where high grade mechanical energy is available
4. The system hasn't affected by variations of loads	Poor performance at part loads
5. Charging of refrigerant is difficult	Charging of refrigerant is simple
6. No chances of leakage of refrigerant	More chances
7. High energy supply	Lower energy supply
8. Liquid traces of refrigerant leads to evaporator damage	Liquid traces of refrigerant present in suction line may damage the compressor

Q.5 Attempt any two:

a) Heat abstracted/ kg of ice formed.

$=(t_{wo}-t_{w1}) C_{pw}$ + latent heat of ice + $(t_{ice\ initial}- t_{ice\ final}) CP_{ice}$ (02 Marks)

= [(20-0) x 4.187 +335 + (0-(-10)) x 2] x 1000

= 438370 KJ…… (02 Marks)

If assuming work supplied to be 1kWhr in 24 hrs then

COP= R.E./ Work Supplied …… (02 Marks)

=438370 /(3600 x 1)

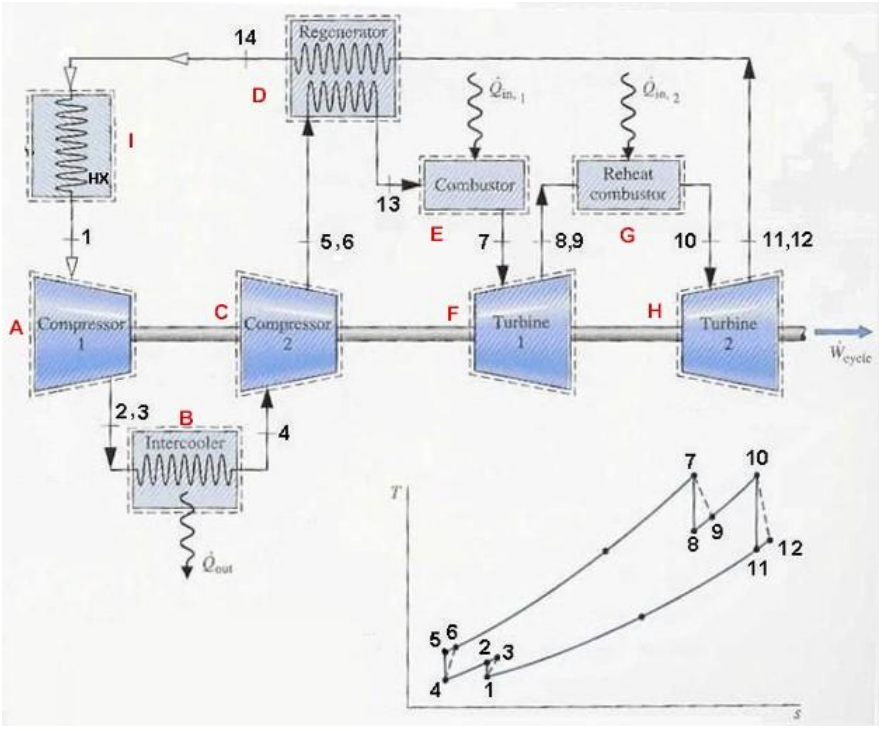
= 121.7

If assuming work supplied to be 1kW/hr for 24 hrs then

COP= `438370 /(3600 x 24)

= 5.073 …… (02 Marks)

b) Intercooling: air can be compressed in a compressor in two stages with cooler between two, called as intercooling (4+4 marks)



The basic advantage of improving efficiency of gas turbine can be obtained using intercooler. The figure shows a T-s diagram in which 4-3 is intercooling between 1-2 and 4-5.

Reheating: two turbines are used as shown in the figure. The air is getting heated and supplied to 1 St stage of the turbine then again it is heated and supplied to the second stage of turbine called as reheating.

c) Define : **(1mark each)**

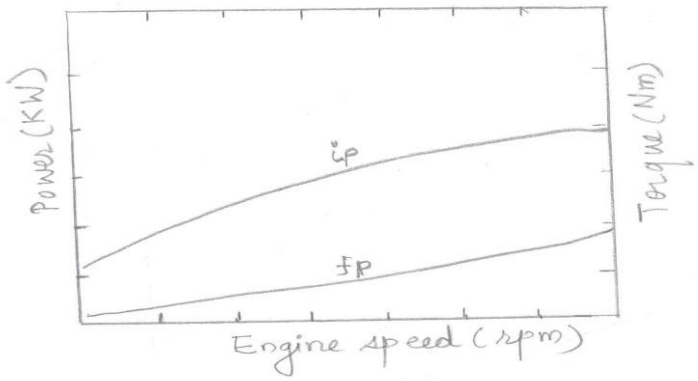
1) **Brake power:** useful energy available at the crankshaft.

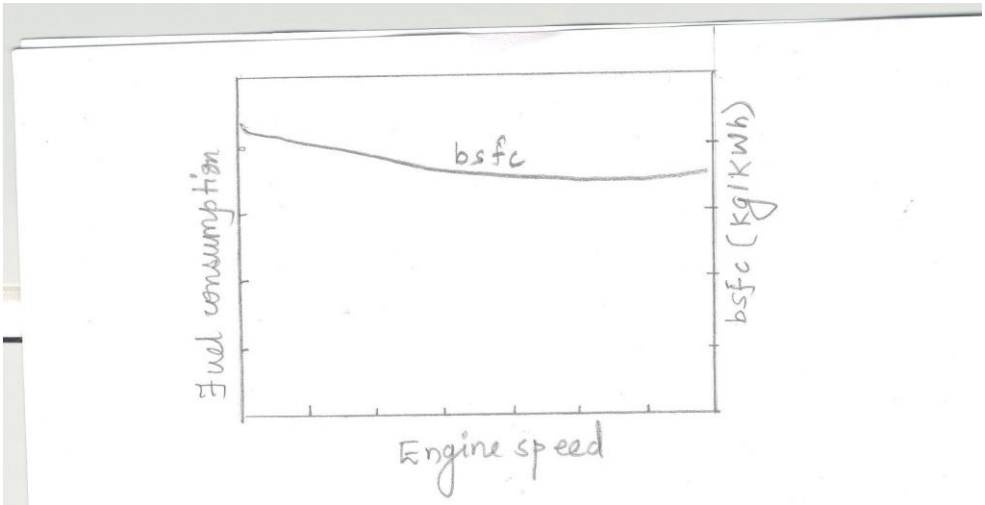
2) **Indicated power:** the power developed by the engine in the cylinder.

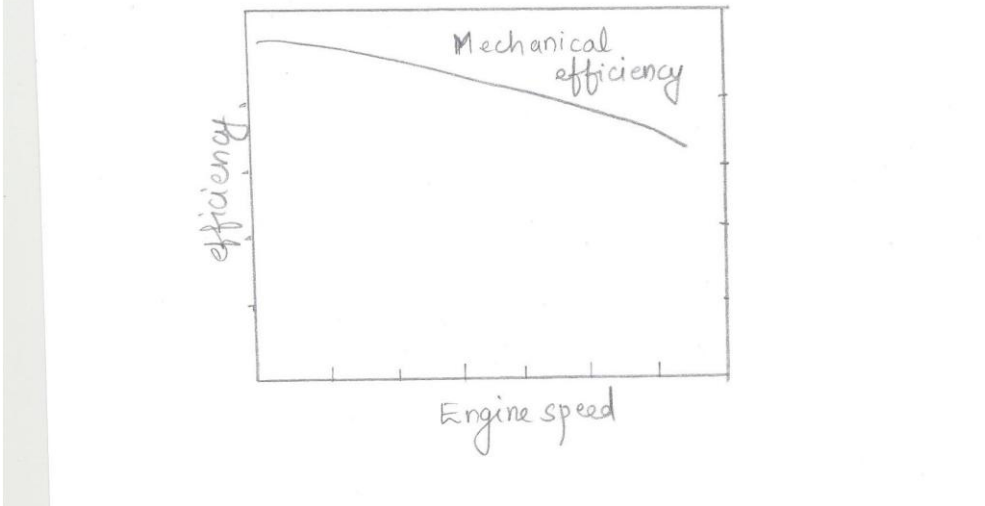
3) **Mechanical efficiency:** ability to transmit power developed in the engine cylinder to the crankshaft. It is the ratio of brake power and I.P.

4) **Brake Thermal efficiency:** the ratio of brake power output to power input

ii) (1 mark for each curve)







Q.6 Attempt any four:

i) Define Carburation: the process of producing a mixture of air and fuel in the correct proportion for engine combustion. (2 marks)

ii) Air conditioning: it is the science which deals with the supply and maintaining desirable internal atmospheric condition irrespective of external condition. (2 marks)

Or

i) Advantages of multistaging: (2 marks)

- High pressure can be produced.

- Increases volumetric efficiency.

- Reduces cost of compressor.

b) Morse test: it can used to calculate the indicated power or frictional power of a multicylinder internal combustion engine by cutting off each cylinder in turn.

Assumption: This method can be used only for multi – cylinder IC engines. The

The Morse test consists of obtaining indicated power of the engine without any elaborate equipment. The test consists of making, in turn, each cylinder of the engine inoperative and noting the reduction in brake power developed. In a petrol engine (gasoline engine), each cylinder is rendered inoperative by "shorting" the spark plug of the cylinder to be made inoperative. In a Diesel engine, a particular cylinder is made inoperative by cutting off the supply of fuel. It is assumed that pumping and friction is the same when the cylinder is inoperative as well as during firing.

In this test, the engine is first run at the required speed and the brake power is measured. Next, one cylinder is cut off by short circuiting the spark plug if it is a petrol engine or by cutting off the fuel supply if it is a diesel engine. From one of the cylinders is cut of from producing power, the speed of the engine will change. The engine speed is brought to its original value by reducing the load on the engine. This will ensure that the frictional power is the same.

If there are k cylinders, then

The total indicated power k

When all the cylinders are working = ip1 + ip2 + ip3 + …… ...+ ipk =$\sum$ ipj

j= 1k

We can write $\sum_{j=1}^{k} ipj = Bt + Ft$ …….. (1)

where ipj is the indicated power produced by j the cylinder, k is the number of cylinders,Bt is the total brake power when all the cylinders are producing power and Ft is the total frictional power for the entire engine.

If the first cylinder is cut – off, then it will not produce any power, but it will have

frictional losses. Then

we can write $\sum_{j=2}^{k} ipj = B1 - Ft$……..(2)

where B1 = total brake power when cylinder 1 is cut - off and

Ft = Total frictional power.

Subtracting Eq. (2) From Eq. (1) We have the indicated power of the cut off the cylinder. Thus

ip1 = Bt – B1 ……..(3).

Similarly we can find the indicated power of all the cylinders, viz., ip2, ip3, ….. ipk. Then the total indicated power is calculated as

$(ip)total = \sum_{j=1}^{k} ipj$ …….(4)

The frictional power of the engine is therefore given by

$F_t = (ip)\ total - B_t$ ……(5) (4 marks)

c) **Explain any one method of controlling pollutants in S.I engine. (4 marks)**

- Catalytic converters are devices which employ a catalyst to facilitate more complete chemical reaction at any condition.
- A catalyst is a substance that changes the rate of a chemical reaction, but whose own composition is unchanged by that reaction.
- For **air pollution control** purposes, such reactions involve the reduction of nitric oxide to molecular oxygen and **nitrogen** or oxidation of **hydrocarbons** and **carbon monoxide** to **carbon dioxide** and water.
- Using the catalyst, the activation energy of the desired chemical reaction is lowered.
- Therefore, the exothermic chemical conversion will be favored at a lower temperature.
- Traditional catalysts have normally been metallic, although nonmetallic materials, such as ceramics, have been coming into use in recent years.
- Metals used as catalysts may include noble metals, such as platinum, or **base** metals, including **nickel** and **copper**.
- Some catalysts are more effective in oxidation, others are more effective in reduction.
- Some metals are effective in both kinds of reactions.
- The catalyst material is normally coated on a porous, inert support structure of varying design.
- Examples include honeycomb ceramic structures with long channels and pellet beds.

d) **Given:** P_1=1 bar; P_4=16 bar; $PV^{1.2}$=C; V_1=2 m^3; Min power=? (4 marks)

Sol: $$I.P = 3n \frac{P_1V_1}{(n-1)} [(P_4/P_1)-1] = \mathbf{21.146KW}$$

e) **Uses of compressed air: (**4 marks)

1. Cleaning workshops and automobiles
2. Starting I.C engines
3. Spraying paint in paint industries
4. Cooling of large buildings
5. Supercharging I.C engines and working gas turbine plants
6. Construction of buildings, roads, dam, structural work, tunnels etc.
7. Spraying fuel in high speed diesel engines.

8. Operation of pneumatic drills,air motors, hammers etc.

f) (4 marks)

Closed cycle gas turbine	Open cycle gas turbine
1. Air is heated with an external source of fuel; amount of gas remains same.	1. External fuel is supplied to the combustion chamber, a product of combustion mixes with air.
2. Any fluid can be used for working	Only air is used for working
3. After turbine gas passes to cooler	After turbine gas goes to exhaust
4. High maintenance cost	Maintenance cost is low
