VETRI VINAYAHA COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING
ME6404 THERMAL ENGINEERING

UNIT I - GAS POWER CYCLES

1. What is a thermodynamic cycle?

Thermodynamic cycle is defined as the series of processes performed on the system, so that the system attains its original state.

2. What are the assumptions made for air standard cycle analysis?

(i)The working medium is a perfect gas thought i.e., It follows the law **pv =MRT**

(ii)The working medium does not undergo any chemical change throughout The Cycle.

(iii)The compression and expansion processes are reversible adiabatic i.e., There is no loss or gain of entropy.

(iv)The operation of the engine is frictionless.

3. Mention the various processes of dual cycle.

(i) Isentropic compression.
(ii) Constant pressure heat supplied.
(iii) Isentropic expansion, and
(iv) Constant pressure heat rejection.

4. Define air standard cycle efficiency.

Air standard efficiency is defined as the ratio of work done by the cycle to heat supplied to the cycle.

5. Define mean effective pressure as applied to gas power cycles.

Mean effective pressure is defined as the constant pressure acting on the piston during the working stroking. It is also defined as the ratio of work done to the stroke volume or piston displacement volume.

6. Define the following terms (i) Compression ratio (ii) Cut off ratio and (iii) Expansion ratio?

(i) Compression ratio is defined as the ratio between total cylinder volumes to clearance volume.

(ii) Cut off ratio is defined as the ratio of volume after the heat addition to volume before the heat addition.

(iii) Expansion ratio is the ratio of volume after the expansion to the volume before expansion

7. Which cycle is more efficient with respect to the same compression ratio?

For the same compression ratio, Otto cycle is more efficient than diesel cycle.

8. For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, diesel and dual cycle.

η Otto > η Dual > η Diesel

9. Name the factors that affect air standard efficiency of Diesel cycle.

Compression ratio and cut-off ratio.

10. What is the effect cut-off ratio on the efficiency of diesel cycle when the compression ratio is kept constant?

When cut-off ratio of diesel cycle increases, the efficiency of cycle is decreased when compression ratio is kept constant and vice versa.

11. Write any four major differences between Otto and diesel cycle.

Sl.No.	**Otto cycle**	**Diesel cycle**
1	It consists of two isentropic and two constant volume processes.	It consists of two isentropic, one constant volume and one constant pressure processes.
2	Heat addition takes place of constant volume.	Heat addition takes place of constant pressure.
3	Compression ratio is equal to expansion ratio.	Compression ratio is greater than expansion ratio.
4	Efficiency is more than diesel cycle for the same compression ratio and heat input.	Efficiency is less.

UNIT II –INTERNAL COMBUSTION ENGINES

1. List the various components of engine.

(i)Cylinder block
(ii)Cylinder head
(iii)Crankcase
(iv) Cylinder liners
(v) Piston& piston rings

2. Name the basic thermodynamic cycles of the two types of internal combustion reciprocating engines.

Otto cycle in S.I engines and diesel cycle in C.I engines.

3. Define compression ratio of an IC engine?

It is the ratio of volume when the piston is at BDC to the volume when the piston is at TDC.

4. Define the terms Mean effective pressure?

It is defined as the algebraic sum of the mean pressure acting on the during one complete cycle.

5. What is meant by highest useful compression ratio?

The compression ratio which gives maximum efficiency is known as highest useful compression ratio.

6. Why compression ratio of petrol engines is low while diesel engines have high compression ratio?

Since fire point of petrol is less as compared to diesel, petrol engine has low compression ratio.

7. Compare the thermal efficiency of petrol engines with diesel engines. Give reasons.

Thermal efficiency of diesel engine is greater than petrol engine this is due to high compression ratio.

8. What do you mean by scavenging in I.C. Engines?

The process of removing the burnt gases from the combustion chamber of engine cylinder by using fresh air fuel mixture is known as Scavenging.

9. Define Cetane number?

The property that quantities the ignition delay is called as Cetane number.

10. Which is better efficient two stroke or four stroke engines?

Two-stroke engine give always lesser efficiency than four-stroke engine due to incomplete combustion and poor scavenging.

11. Why a choke is used in carburetor and what is meant by automatic chocking?

Initially, more fuel is required to reduce high starting torque which is done by using supply unit will be cut off by a choke called automatic choking.

12. What are the important requirements of fuel injection system?

* The beginning as well as end of injection should take place sharply
* Inject the fuel at correct time in the cycle throughout the speed range of the engine.
* The injection of fuel should occur at the correct rate and in correct quantity as required by the varying engine load.
* Atomize the fuel to the required degree.
* Distribute the fuel throughout the combustion chamber for better mixing.

13. Mention different types of fuel injection systems in C. I engines.

a) Air injection system
b) Airless or Solid injection
(i) Common rail system
(ii) Individual pump system.

14. Define delay period with respect to a CI engine.

The physical delay period is the time between the beginning of injection and the attainment of chemical reaction reaction conditions. During this period fuel is atomized, mixed with air and raised to its self-ignition temperature.

During the chemical delay reactions start slowly ad then accelerate until ignition takes place.

15. What is the purpose of providing spark plug in SI engine?

The function of a spark plug is to produce an electric spark for the ignition of compressed air-fuel mixture inside the engine cylinder.

16. What is the purpose of a thermostat in an engine cooling system?

A Thermostat valve is used in the water-cooling system to regulate the circulation of water in system to maintain the normal working temperature of the engine parts during the different operating conditions.

17. State any three functions of lubrication?

a) It reduces friction between moving parts.
b) It reduces wear and tear of the moving parts. c)
It minimizes power boss due to friction.

UNIT III -STEAM NOZZLES AND TURBINES

1. What are the various types of nozzles and their functions?

Nozzle is a duct of varying cross-sectional area in which the velocity increases with the corresponding drop in pressure.

2. What are the effects of friction on the flow through a steam nozzle?

1. The final fraction of the steam is increased as the part of the kinetic energy gets converted into heat due to friction and absorbed by steam with n increase in enthalpy.

2. The expansion is no more isentropic and enthalpy drop is reduced thereby resulting in lower exit velocity.

3. The specific volume of steam is increased as the steam becomes drier due to this frictional reheating.

3. Define nozzle efficiency and critical pressure ratio.

Nozzle efficiency: It is defined as the ratio of actual enthalpy drop to the isentropic enthalpy drop

Nozzle efficiency = Actual enthalpy drop / Isentropic enthalpy drop

Critical pressure ratio: There is only one value of the ratio (P2/P1) which produces maximum discharge from the nozzle. The ratio is called critical pressure ratio.

$$\text{Critical pressure ratio } P_2/P_1 = (2/n+1)^{n/n+1}$$

Where,

P_1 = Initial pressure

P_2 = Throat pressure.

4. **Explain the phenomenon of super saturated expansion in steam nozzle.**

When the supersaturated steam is expanded in the nozzle, the condensation should occur in the nozzle. Since the steam has a great velocity, the condensation does not take place at the expected rate. So the equilibrium between the liquid and vapour phase is delayed and the steam continues to expand in a dry state.

The steam in such set of condition is said to be supersaturated or meta stable flow.

5. What are the conditions that produce super saturation of steam in nozzles?

When the superheated steam expands in the nozzle, the condensation will occur in the nozzle. Since, the steam has more velocity, the condensation will not take place at the expected rate. So, the equilibrium between the liquid and vapour phase is delayed and the steam continues to expand in a dry state.

The steam in such set of condition is said to be supersaturated or meta stable flow.

6. What are the effects of super saturation in a steam nozzle?

The following effects in a nozzle on steam, in which super saturation occurs, may be summarized as follows.

1. The dryness fraction of the steam is increased.
2. Entropy and specific volume of the steam are increased.
3. Exit velocity of the steam is reduced.
4. Mass of stream discharged is increased.

7. What are the differences between supersaturated flow and isentropic flow through steam nozzles?

Supersaturated flow	Isentropic flow
1. Entropy is not constant	Entropy is constant
2. Reduce in enthalpy drop .	No reduce in enthalpy drop
3. We cannot use mollier diagram to solve problems	We can use mollier diagram to solve problems.

8. The critical pressure ratio initially dry saturated steam is.

$P_2 / P_1 = 0.577$

9. The critical pressure ratio for initially super heated steam is _____ as compared to initially dry saturated steam.

Less.

10. When the backpressure of a nozzle is below the designed value of pressure at exit of nozzle, the nozzle is said to be _____

Under damping.

11. What is a steam turbine?

Steam turbine is a device which is used to convert kinetic energy of steam into mechanical energy.

12. What is the fundamental difference between the operation of impulse and reaction steam turbines?

Impulse Turbine	Reaction turbine
1. It consists of nozzles and moving blades.	It consists of fixed blades and moving blades.
2. Pressure drop occurs only in nozzles not in moving blades.	Pressure drop occurs in fixed as well as moving blades.
3. Steam strikes the blades with kinetic energy.	Steam passes over the moving blades with pressure and kinetic energy.
4. It has constant blade channels area.	It has varying blade channels area.

13. Explain the need of compounding in steam turbines. (Or)

Explain the purpose of compounding in steam turbines.

In simple impulse turbine, the expansion of steam from the boiler pressure to condenser pressure takes place in a single stage turbine. The velocity of steam at the exit of turbine is very high. Hence, there is a considerable loss of kinetic energy (i.e. about 10to 12%). Also the speed of the rotor is very high (i.e. up to 30000rpm). There are several methods of reducing this speed to lower value. Compounding is a method of absorbing the jet velocity in stages when the steam flows over moving blades.

14. What are the different methods of compounding?

1. Velocity compounding

2. Pressure compounding

3. Pressure-velocity compounding

15. What is meant by carry over loss?

The velocity of steam at exit is sufficiently high thereby resulting in a kinetic energy loss called "Carry over loss" or "Leading velocity loss".

UNIT IV - AIR COMPRESSOR

(1) Classify the various types of air compressors.

1. According to the and principle of operation
a)Reciprocating compressors
b) Rotary compressors.
2) According to the action
a) Single acting compressors b)
Double acting compressors
3) According to the number of stages a)
Single stage compressors
b) Multistage compressors
4) According to the pressure limit
a)Low pressure compressors
b)Medium pressure compressors
c) High pressure compressors
5) According to the capacity
a)Low capacity compressors
b) Medium capacity compressors c)
High capacity compressors

(2) What is meant by single acting compressors?

In single acting reciprocating compressor, the suction, compression and delivery of air takes place on both sides of the piston

(3)What is meant by single stage compressor?

In single stage compressor, the compression of air from the initial pressure to the final .pressure is carried out in one cylinder only.

(4)What is meant by double acting compressor?

In double acting reciprocating compressor, the suction, compression and delivery of air takes place on both sides of the piston.

(5) Indicate the application of reciprocating compressors in industry?

The applications of compressed air as follows:
1) Pneumatic brakes
2) Pneumatic jakes.
3) Pneumatic drills.
4) Pneumatic lifts.
5) Spray painting.
6) Shop cleaning.
7) Injecting fuel in diesel engines.
8) Supercharging internal combustion engines.
9) Refrigeration, and air conditioning systems.

(6) What are the advantages of multi stage compression with internal cooling over single stage compression for the same pressure ratio?

1. It improves the volumetric efficiency for the given pressure ratio.

2It reduces the leakage loss considerably.

3. It gives more uniform torque and hence a smaller size flywheel is required.

4. It reduces the cost of the compressor.

(7) Define the terms as applied to air compressors: Volumetric efficiency and isothermal compression efficiency.

(or)

Define the mechanical efficiency and isothermal efficiency of a reciprocating air compressor.

Volumetric efficiency:

Volumetric efficiency is defined as the ratio of volume of free air sucked into the compressor per cycle to the stroke volume of the cylinder.

Volumetric efficiency: Volume of free air taken per cycle/Stroke volume of the cylinder.

Isothermal compression efficiency:

Isothermal efficiency is defined as the ratio between isothermal work to the actual work of the compressor.

$$\text{Isothermal efficiency} = \frac{\text{brake power}}{\text{Indicated power}}$$

(8) Define clearance ratio?

Clearance ratio is defined as the ratio of clearance volume to swept volume (or) stroke volume.

$$C = \frac{Vc}{Vs}$$

Vc=Clearance volume

Vs=Swept volume

9) Discuss the effect of clearance upon the performance of an air compressor.

The volumetric efficiency of air compressor increases with decrease in clearance of the compressor.

(10) Give two merits of rotary compressor over reciprocating compressor.

1. Rotary compressor gives uniform delivery of air where compared to reciprocating compressor.

2. Rotary compressors are small in size for the same discharge as compared with reciprocating compressors.

3. Lubricating system is more complicated in reciprocating compressor where as it is very simple in rotary compressor.

(11) Name the methods adopted for increasing isothermal efficiency of reciprocating air compressor.

Isothermal efficiency is increased by perfect inter cooling.

(12) Why clearance is necessary and what is its effect on the performance of reciprocating compressor?

When the piston reaches top dead center in the cylinder, there is a dead space between piston top and cylinder head. This space is known as clearance space and the volume occupied by this space is known as clearance volume.

(13) What is meant by inter cooler?

An inter cooler is a simple heat exchanger. It exchanges the heat of compressed air from the low-pressure compressor to the circulating.

(14) What are the factors that affect the volumetric efficiency of a reciprocating compressor?

1. Clearance volume.

2. Compression ratio.

(15) What is compression ratio?

Compression ratio is defined as the ratio between total volume and clearance volume.

$$\text{Compression ratio} = \frac{\text{Total volume.}}{\text{Clearance volume.}}$$

UNIT V- REFRIGERATION AND AIR–CONDITIONING

1. Define tonne of refrigeration.

A tonne of refrigeration is defined as the quantity of heat required to be removed from one tonne of water (1000kg) at 0 C to convert that into ice at 0 C in 24 hours. In actual practice,

1 tonne of refrigeration= 210kJ/min=3.5kW

2. Define tonne of refrigeration. Heat is removed from a space at a rate of 42,000kJ/h. Express this heat removal rate in tons.

A tonne of refrigeration is defined as the quantity of heat required to be removed from one tonne of water (1000kg) to convert that into ice at 0° C 24 hours.

3. The vapour compression refrigerator employs the ---- cycle.

Reversed Carnot.

4. The door of a running refrigerator inside a room was left open. What will happen?

The room will be gradually warmed up.

5. In a vapor compression refrigeration system, where the lowest temperature will occur?

At inlet of evaporator

6. How does the actual vapour compression cycle differ from that of the ideal cycle?

1. In actual cycles, pressure losses occur in both condenser and evaporator.

2. Friction losses occur in compressor.

7. Name four important properties of a good refrigerant.

1. Low boiling point.

2. High critical temperature and pressure.

3. Low specific heat of liquid.

8. What is the difference between air conditioning and refrigeration?

Refrigeration is the process of providing and maintaining the temperature in space below atmospheric temperature.

Air conditioning is the process of supplying sufficient volume of clean air containing a specific amount of water vapour and maintaining the predetermined atmospheric condition with in a selected enclosure.

9. What is the function of the throttling valve in vapour compression refrigeration system?

The function of throttling valve is to allow the liquid refrigerant under high pressure and temperature to pass to controlled rate after reducing its pressure and temperature.

10. In a vapour compression refrigeration system, where the highest temperature will occur?

After compression.

11. The vapour absorption system can use low-grade heat energy in the generator. Is true or false?

True.

12. Name any four commonly used refrigerants.

1. Ammonia (NH3)
2. Carbon dioxide (CO2).

13. Explain unit of Refrigeration.

Unit of refrigeration is expressed in terms of tonne of refrigeration.

A tonne of refrigeration is defined as the quantity of heat required to be removed from one tonne of water (1000kg) to convert that into ice at 0° C in 24 hours.

14. Why throttle valve is used in place of expansion cylinder for vapour compression refrigerant machine.

In throttling process, enthalpy remains constant and pressure is reduced so throttle valve is used.

15. What are the effect pf superheat and sub cooling on the vapour compression cycle?

Superheating increases the refrigeration effect and COP may be increased or decreased. But sub cooling always increase the COP of the refrigeration and also decrease the mass flow rate of refrigerant.

16. What are the properties of good refrigerant?

An ideal refrigerant should possess the following desirable properties.

1. The refrigerant should have low freezing point.
2. It must have high critical pressure and temperature to avoid large

power requirements.

3. It should have low-specific volume to reduce the size of the compressor.
4. It should be nonflammable, non-explosive, non-toxic and noncorrosive.

17. What is net refrigerating effect of the refrigerant?

Refrigerating effect is the total heat removed from the refrigerant in the evaporator.

$$\text{COP} = \frac{\text{Refrigeration effect}}{\text{Work done}}$$

Refrigeration effect= COP * Work done.

18. Name the various components used in simple vapour absorption system.

1. Absorber
2. Pump
3. Generator
4. Condenser.
5. Throttle valve.
6. Evaporator.

19. Define refrigerant.

Any substance capable of absorbing heat from another required substance can be used as refrigerant.

20. How does humidity affect human comfort?

If the humidity is above a certain level, water vapour from human body moisture cannot be absorbed by the atmospheric air. It results in discomfort because of sweating.

UNIT-1 GASPOWER CYCLES **PART-B**

Otto Cycle:

1. (a) Derive an expression for air standard efficiency of an Otto cycle. Obtain an expression for

Mean effective pressure of an Otto cycle.

(b) An engine works on Otto Cycle. The initial pressure and temperature of the air is 1 bar and 40˚C. 825 KJ of heat is supplied per Kg of air at the end of the compression. Find the temperature and pressure at the salient points if the compression ratio is 6. Also find the efficiency and mean effective pressure for the cycle. Assume air is used as working fluid and take all ideal conditions.

2. In an engine working on constant volume cycle, the pressure, temperature and volume at the beginning of the cycle are 1.2 bar, 35˚C and 0.5 m^3 respectively. At the end of compression stroke, the pressure is 12 bars. 315 KJ of heat is added per kg of gas during constant volume heating process. Calculate the pressure, temperature and volume at all points. Also find the air standard efficiency of the cycle.
3. A six cylinder petrol engine has a compression ratio of 5:1. The clearance volume of each cylinder is 110 CC. It operates on the four stroke constant volume cycle and the indicated efficiency ratio referred to air standard efficiency is 0.56. At the speed of 2400 rpm, it consumes 10 Kg of fuel per hour. The calorific value of fuel is 44000 KJ/Kg. Determine the average indicated mean effective pressure.

Diesel Cycle:

4. Derive an expression for mean effective pressure of a Diesel cycle in terms of pressure ratio, cut off ratio and compression ratio.
5. An air standard Diesel cycle has a compression ratio of 12 and cutoff takes place at 6 % of the stroke. Calculate the air standard efficiency of the cycle.
6. 1kg of air is taken through a diesel cycle. Initially the air is at 25˚C and 1 bar. The compression ratio is 14 and the heat added is 1850 KJ. Calculate the ideal cycle efficiency and the mean effective pressure.

Dual Cycle:

7. In a dual cycle the air is compressed isentropically to $1/14^{th}$ of its initial volume. At the end of compression heat is added at constant volume till its pressure increases to twice the pressure at the end of compression. Then heat is added at constant pressure till its volume increases to twice the volume after compression. Find the efficiency of the cycle.
8. In engine working on Dual cycle, the temperature and pressure at the beginning of cycle are 90˚C and one bar. The compression ratio is 9. The maximum pressure is limited to 68 bar

and total heat supplied per kg of air is 1750 KJ. Determine air standard efficiency and mean effective pressure.

Brayton Cycle:

9. (a) Derive an expression for air standard efficiency of a Brayton cycle in terms of pressure ratio and compression ratio. Also prove that the pressure ratio for maximum work is a function of limiting temperature ratio.

(b) A gas turbine works on an air standard Brayton cycle. The initial condition of the air is 25˚C and 1 bar. The maximum pressure and temperature are limited to 3 bars and 650˚C. Determine the following (i) Cycle efficiency (ii) Heat supplied and rejected per kg of air. (iii) Work output (iv) Exhaust temperature.

10. The extreme of pressure and temperature in an open circuit constant pressure gas turbine plant are 1 bar, 5.25 bar and 25˚C and 560˚C respectively. The isentropic efficiency of the turbine is 88 % and that of the compressor is 84 %. Determine the efficiency of the plant

UNIT-2 INTERNAL COMBUSTION ENGINES **PART-B**

1. (a) Explain the working principle of diesel injector with a neat sketch.

(b) Calculate the diameter and length of the stroke of a diesel engine working on four stroke constant pressure cycle from the following data. Indicated power = 18.75 KW, rotation per minute = 220, Compression ratio = 14, Fuel cut off = $1/20^{th}$ of the stroke, Index of expansion = 1.3, Index of compression = 1.35, Length/diameter = 1.5, Assume the pressure and temperature of the air at the inlet are 1 bar and 40˚C respectively.

2. (a) Explain any four types of classification of Internal Combustion engines.

(b) With a neat sketch explain any one type of ignition system.

3. Explain the working of 4-stroke cycle Diesel engine. Draw theoretical and actual valve-timing diagram for the engine. Explain the reasons for the difference.

4. Explain why cooling is necessary in I.C. engine. With neat sketches describe the working of water cooling system used for multi-cylinder engine. Why should a pump and thermostat be provided in the cooling system of an engine?

5. Explain with neat sketches the method of lubrication of the following parts of the I.C. Engines. (i) Piston and cylinder (ii) Crank-pin and Gudgeon pin (iii) Cam-shaft.

6. (i) Explain with neat sketch Air Cooling of Engines.

(ii) Explain any one lubrication system adopted in multi cylinder SI engines.

7. Explain the principle of Magneto ignition system. Enumerate its advantages and disadvantages?

8. (a) What are the various factors influencing the flame speed in SI Engines?

(b) Explain the combustion phenomenon in SI Engines.

9. (a) What is the purpose of cooling an I.C. Engine?

(b) What are the ill effects of improper cooling?

(c) With neat sketches, describe how a fuel injection pump supplies fuel to a diesel engine for different load conditions.

(d) Explain the normal combustion and knocking in a diesel engine with pressure-crank angle diagram

10. (i) Explain the function of a fuel injection pump with a simple sketch.

(ii) What are the advantages and disadvantages of Magneto ignition system over Batter ignition system?

UNIT-3 STEAM NOZZLES AND TURBINES **PART-B**

1. (a) Steam at a pressure of 15 bar saturated is discharged through a convergent-divergent nozzle to a back pressure of 0.2 bar. The mass flow rate is 9 kg/kW-hr, if the power developed is 220 kW, determine number nozzles required if each nozzle has a throat of rectangular cross section of 4mm x 8mm. If 12% of overall isentropic enthalpy drop occurs in the divergent portion due to friction, find the cross section of the exit rectangle?
   (b) Explain the supersaturated expansion of steam in a nozzle.
2. (a) Derive the expression for critical pressure ratio in terms of index of expansion.
   (b) A convergent divergent adiabatic steam nozzle is supplied with steam at 10 bars and 250˚C. The discharge pressure is 1.2bar. Assuming the nozzle efficiency as 100% and initial velocity of steam is 50 m/s, find the discharge velocity.
3. (a) Derive an expression for the critical pressure ratio in terms of the index of expansion.
   (b) Dry saturated steam enters a steam nozzle at a pressure of 15 bar and is discharged at a pressure of 2 bar. If the dryness fraction of discharge steam is 0.96, what will be the final velocity of steam? Neglect initial velocity of steam. If 10% of heat drop is lost in friction, find the percentage reduction in the final velocity.
4. (a) Steam at a pressure of 15 bars with 50°C of superheat is allowed to expand through a convergent-divergent nozzle. The exit pressure is 1 bar. If the nozzle is required to supply 2 kg/sec. of steam to the turbine, then calculate
   (i) The velocities at throat and exit.
   (ii) Areas at throat and exit Assume 10% frictional loss in divergent part only and percentage taken as % of, total heat drop.
   (b) Explain the pressure and velocity compounding diagram of multi stage turbine with neat a sketch.

5. The blade speed of a single ring of an impulse turbine is 300 m/s and the nozzle angle is 20°C. The isentropic heat drop is 473 KJ/Kg and the nozzle efficiency is 0.85. Given that the blade velocity coefficient is 0.7 and the blades are symmetrical, draw the velocity diagrams and calculate for a mass flow of 1 kg/s:
   (i) Axial thrust on the blading.
   (ii) Steam consumption per B.P. hour if the mechanical efficiency is 90 per cent.
   (iii) Blade efficiency and stage efficiency
6. In a 50 percent reaction turbine stage running at 50 revolutions per second, the exit angles are 30°C and the inlet angles are 50°C. The mean diameter is 1m. The steam flow rate is 10000 kg/mm and the stage efficiency is 85%. Determine
   (i) The power output of the stage
   (ii) The specific enthalpy drop in the stage and
   (iii) The percentage increase in the relative velocity of steam when it flows over the moving blades.
7. A 50 % reaction turbine running at 400 rpm has the exit angle of the blades as 20° C and the velocity of steam relative to the blades at the exit is 1.35 times the mean speed of the blade. The steam flow rate is 8.33 Kg/s and at a particular stage the specific volume is

1.381 m^3/Kg. Calculate for this stage. (i) A suitable blade height, assuming the rotor mean diameter 12 times the blade height, and (ii) The diagram work

8. (a) Define the following terms for reaction turbines: (i) Diagram efficiency and (ii) Stage efficiency.
   (b) Determine the condition for maximum efficiency of a 50 % reaction turbine and show that the maximum efficiency for such a turbine is [2cos2 α1/(1+cos2α1)],where αl is the angle at which the steam enters the blades.
9. A single row impulse turbine develops 132.4 kW at a blade speed of 175 m/s, using 2 kg of steam per sec. Steam leaves the nozzle at 400 m/s. Velocity coefficient of the blades is 0.9. Steam leaves the turbine blades axially. Determine nozzle angle, blade angles at entry and exit, assuming no shock.
10. A single-stage impulse turbine is supplied steam at 4 bar and 160°C and it is exhausted at a condenser pressure of 0. 1 bar at the rate (if 60 kg/mm. The steam expands in a nozzle with an efficiency of 90°C. The blade speed is 250 m/s and nozzle are inclined at 20°C to the plane of the wheel. The blade angle at the exit of the moving blade is 30°C. Neglecting friction losses in the moving blade, determine (i) Steam Jet Velocity (ii) Power developed (iii) Blade efficiency (iv) Stage efficiency.

UNIT-4 AIR COMPRESSOR **PART-B**

1. A multi stage air compressor is to be designed to evaluate the pressure from 1 bar to 120 bars. Such that the single stage pressure ratio not to exceed 4. Find (i) Number of stages (ii) exact stage pressure ratio (iii) Inter stage pressure.
2. Consider a single acting two stage reciprocating air compressor running at 300 rpm. Air is compressed at a rate of 4.5Kg/min from 1.013 bar and 288 K through a pressure ratio of 9 to 1. Both the stages have same pressure ratio and the index of expansion in both stages is 1.3. Assume a complete inter-cooling, find the indicated power and the cylinder swept volume required. Assume that the clearance volumes of both stages are 5% of their respective swept volumes.
3. A two stage air compressor compresses air from 1 bar and 20°C to 42 bar. If the law of compression is $pv^{1.3}$ = constant and the inter cooling is perfect. Find per kg of air
   (i) The work done in compression
   (ii) The mass of cooling water necessary for abstracting the heat in the intercooler, if the temperature rise of the cooling water is 25°C.
4. (i) With a neat sketch describe any one type of rotary compressor.
   (ii) A single stage single acting reciprocating air compressor delivers 14 m3 of free air per minute from 1 bar to 7 bars. The speed of compressor is 310 rpm. Assuming that compression and expansion follow the law $pv^{1.35}$ = constant and clearance is 5 % of the swept volume, find the diameter and stroke of the compressor. Take stroke length is 1.5 times the bore diameter.
5. (i) Explain with suitable sketches the working of two stage air compressor with actual p-v Diagram.
   (ii) A single acting single stage compressor is belt driven from an electric motor at 400 rpm. The cylinder diameter is 15 cm and the stroke is 17.5 cm. The air is compressed from 1 bar to 7 bar and the law of compression $PV^{1.3}$ = constant. Find the power of the motor, if transmission efficiency is 97 % and the mechanical efficiency of the compressor is 90%. Neglect clearance effects.
6. A three-stage air-compressor delivers 5.2 m3 of free air per minute. The suction pressure and temperature are 1 bar and 30°C. The ambient pressure and temperature are 1.03 bar and 20°C. The air is cooled to 30°C after each stage of compression. The delivery pressure of the compressor is 150 bar. The RPM of the compressor is 300. The clearances of LP, I.P and H.P cylinders are 5% of the respective strokes. The index of compression and re expansion in all stages is 1.35. Neglecting pressure losses, find the B.P of the motor required to run the compressor if the mechanical efficiency is 80%.
7. (a) Derive the expression for volumetric efficiency of a reciprocating air compressor and explain why it is less than unity.

(b) Determine the size of the cylinder of a double acting air compressor of 32 KW I.P, in which air is drawn in at 1 bar and compressed to 16 bar according to the law $pv^{1.25}$ = constant. R.P.M. 300, Piston speed = 180 m/min, Volumetric efficiency = 0.8.

8. A two-stage double acting air compressor, operating at 200 r.p.m, takes in air at 1.013 bar and 27° C. The size of the L.P. cylinder is 350 x 380 mm, the stroke of H.P. cylinder is the same as that of the L.P. cylinder and the clearance of both the cylinders is 4%. The L.P. cylinder discharges the air at a pressure of 4.052 bar. The air passes through the inter-cooler so that it enters the H.P. cylinder at 27° C and 3.850 bar, finally it is discharged from the compressor at

9.(a) Explain the construction and working of Multi stage compressor and discuss the perfect and imperfect inter cooling with neat a sketch.

(b) 4 bars the value of n is both cylinders is 1.3. Cp = 1.0035 kJ/kg-K and R = 0.287 kJ/kg-K. Calculate: (i) The heat rejected in the inter-cooler. (ii) The diameter of H.P. cylinder and (iii) the power required to drive H.P. cylinder.

10. (a) What are the advantages of multistage compression? (4)

(b) A single stage single acting reciprocating air compressor takes in 17 m^3/min at suction conditions of 100 kPa and 25°C. The delivery pressure is 700 kPa. The clearance volume is 6% of swept volume. The compression and expansion follows the law pV1.3 = Constant. The speed of the compressor is 600 rpm. Stroke to bore ratio is 1. Find the power required to drive the compressor and Cylinder dimensions.

UNIT-5 REFRIGERATION AND AIR CONDITIONING <u>PART-B</u>

1. (i) Explain the construction and working of vapour absorption refrigeration system. (ii) With a neat sketch, explain a vapour compression refrigeration system.

2. A refrigeration system of 10.5 tones capacity at an evaporator temperature of 12°C and a condenser temperature of 27°C is needed in a food storage locker. The refrigerant ammonia is sub cooled by 6°C before entering the expansion valve. The vapour is 0.95 dry as it leaves the evaporator coil. The compression in the compressor is of adiabatic type. Find (i) Condition of vapour at the outlet of the compressor (ii) Condition of vapour at the entrance of the evaporator (iii) COP and (v) The power required. Neglect valve throttling and clearance effect.

3. (i) A Freon-12 refrigerator producing a cooling effect of 20 kJ/s operates on a simple vapour compression cycle with pressure limits of 1.509 bar and 9.607 bar. The vapour leaves the evaporator dry saturated and there is no under cooling. Determine the power required by the machine.

(ii) If the compressor operates at 300 r.p.m. and has a clearance volume of 3% of stroke volume, determine the piston displacement of the compressor. For compressor assume that the expansion following the law $pv^{1.3}$ = constant.

4. A simple saturation refrigeration cycle developing 15 tons of refrigeration using R12 operates with a condensing temperature of 35°C and an evaporator temperature of -6°C. Calculate: (i) The refrigerating effect, (ii) Refrigerant flow rate, (iii) The power required to drive the compressor, (iv) COP.

5. Explain with a neat sketch the summer Air - Conditioning suitable for Chennai weather Conditions. OR Explain the summer Air Conditioning system suitable for hot and humid weather.

6. (i) Exp1ain summer Air Conditioning with a neat layout.
(ii) Sketch various processes of summer Air Conditioning in a Psychometric chart

7. (a) A sling psychrometer reads 40OC DBT and 36OC WBT. Find the humidity ratio, relative humidity, DPT, specific volume of air, density of air, density of water vapour and enthalpy

(b) Saturated air at 21˚C is passed through a drier so that the final relative humidity is 20%.

The air is then passed through a cooler until its final temperature is 21˚C without a change in specific humidity. Find (i) The temperature of air after drying process, (ii) the heat rejected in cooling process, (iii) the dew point temperature at the end of drying process.

8. 40 m^3 of air per minute at 31˚C DBT and 18.5˚C WBT is passed over the cooling coil whose surface temperature is 4.4˚C. The coil cooling capacity is 3.56 tons of refrigeration under the given condition of air. Determine DBT and WBT of the air leaving the cooling coil.

9. A sling psychrometer in a laboratory test recorded the following readings. Dry bulb temperature = 35°C, Wet bulb temperature = 25°C Calculate the following

(i) Specific humidity

(ii) Relative humidity

(iii) Vapour density in air

(iv) Dew point temperature and

(v) Enthalpy of mixture per kg of dry air

Take atmospheric pressure = 1.0132 bar.

10. (a) An office is to be air-conditioned for 50 staff when the outdoor conditions are 30°C DBT and 75% RH if the quantity of air supplied is 0.4m^3/min/person, find the following:

(i) Capacity of the cooling coil in tones of refrigeration

(ii) Capacity of the heating coil in kW.

(iii) Amount of water vapour removed per hour. Assume that required air inlet conditions are

20°C DBT and 60% RH, Air is conditioned first by cooling and dehumidifying and then by heating. (iv) If the heating coil surface temperature is 25°C, find the by-pass factor of the heating coil?

(b) Explain the desirable thermodynamic properties and environmental safety aspects of alternative refrigerants.