THERMODYNAMICS & HEAT POWER ENGINEERING

1. Write the classification of I.C engines

Ans: i) **Based on working Cycle**: Four-stroke, Two-stroke.

ii) **Based on fuel Used**: Gasoline, Diesel, Gas, Alcohol, Dual-Fuel.

iii) **Based on Ignition System**: Spark Ignition (SI), Compression Ignition (CI).

iv) **Based on engine Configuration**: Single-cylinder, Multi-cylinder (In-line, V, Flat, Radial).

v) **Based on cooling Method**: Air-cooled, Water-cooled.

vi) **Based on engine Stroke**: Two-stroke, Four-stroke.

vii) **Based on revolutions**: High-speed, Low-speed.

viii) **Based on Purpose/Application**: Automobile, Marine, Aircraft, Stationary, Locomotive.

ix) **Based on Valve Mechanism**: OHV, OHC, Pushrod.

2. Differentiate between thermodynamic intensive and extensive properties

Ans: Intensive Properties: Intensive properties are properties that do not depend on the amount or size of the material in the system. They are independent of the system's mass or volume

Ex: Temperature, Pressure, Density, Boiling point, Refractive index etc

Extensive Properties: Extensive properties are properties that depend on the amount or size of the material in the system. These properties change when the quantity of material changes

Ex: Mass, Volume, Energy, Entropy etc

3. State the advantages and limitations of 2-stroke engine over 4-stroke engine

Ans:

Advantages of 2-Stroke Engine	Limitations of 2-Stroke Engine
Higher power output per unit displacement	Lower fuel efficiency
Simpler design with fewer components	Higher emissions
More compact & lightweight	Lower durability and more frequent wear
Higher RPM capability	More frequent maintenance
No need for valve mechanisms	Noisy operation
Higher torque at lower RPMs	Inefficient lubrication

4. What are the various chemicals used in pipettes for absorbing CO_2, O_2 and CO in Orsat apparatus

Ans: i) KOH (Potassium Hydroxide) or NaOH (Sodium Hydroxide) solution is commonly used to absorb carbon dioxide (CO_2)

ii) Pyrogallic acid ($C_6H_6O_3$) is used to absorb oxygen (O_2)

iii) Calcium chloride ($CaCl_2$) solution is used to absorb carbon monoxide (CO)

5. Explain the function of inter-cooler in a multi-stage air compressor

Ans: The **intercooler** in a multi-stage air compressor is essential for reducing the temperature of the air between compression stages, leading to improved efficiency, reduced energy consumption, and protection of the compressor. It enables the compressor to operate at higher pressures without excessive temperature rise, ensuring optimal performance and longevity of the equipment

6. Write steady flow energy equation?

Ans: The steady flow energy equation (SFEE) is an application of the First Law of Thermodynamics for a control volume through which fluid flows in a steady state (i.e., the properties of the fluid at any given point in the control volume do not change over time). The equation accounts for the energy changes due to heat, work, mass flow, and changes in internal, kinetic, and potential energy

$$Q-W=m\left(h_2-h_1+\frac{V_2^2-V_1^2}{2}+g(z_2-z_1)\right)$$

Where:

m = mass flow rate (kg/s)

h_1 & h_2 = specific enthalpy at the inlet and exit

v_1 & v_2 = velocity at the inlet and exit

z_1 & z_2 = height at the inlet and exit

7. What is the function of diffuser in Ramjet engine.

Ans: The diffuser in a ramjet engine helps by converting the kinetic energy of the incoming air (high speed) into pressure and temperature increases, preparing the air for combustion, and ensuring a smooth flow of air into the combustion chamber

8. Define specific heats C_p and C_v

Ans: Specific Heat at Constant Pressure (C_p):

The specific heat at constant pressure, denoted as Cp. It is the amount of heat required to raise the temperature of a unit mass of a substance by 1°C (or 1 K) while keeping the pressure constant

$$C_p=\left(\frac{\partial Q}{\partial T}\right)_P=\frac{dQ}{m\,dT}\quad \text{(at constant pressure)}$$

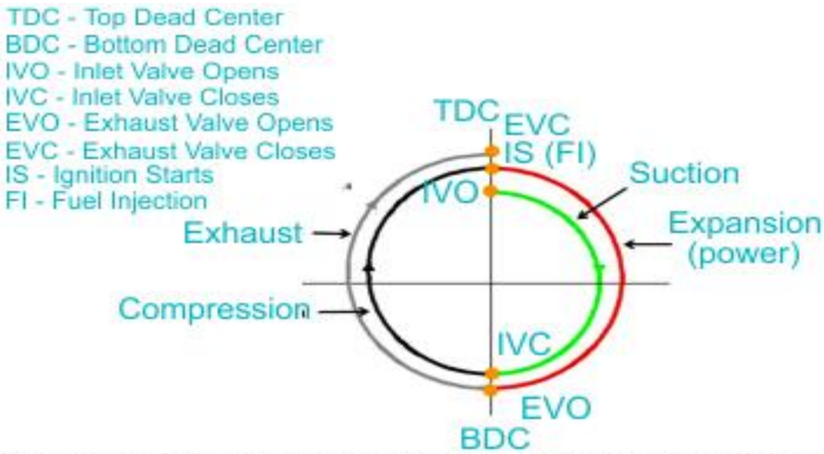
Specific Heat at Constant Volume (C_v):

The specific heat at constant volume, denoted as Cv. It is the amount of heat required to raise the temperature of a unit mass of a substance by 1°C (or 1 K) while keeping the volume constant

$$C_v=\left(\frac{\partial Q}{\partial T}\right)_V=\frac{dQ}{m\,dT}\quad \text{(at constant volume)}$$

9. Draw theoretical valve timing diagram of a 4-stroke petrol engine

Ans:



Theoretical Valve Timing Diagram of 4 Stroke Engine

10. Define First Law of thermodynamics & give the expression.

Ans: The First Law of Thermodynamics is a statement of the principle of conservation of energy. It asserts that energy cannot be created or destroyed, but only converted from one form to another. For a thermodynamic system, the first law describes how the internal energy of a system changes as a result of heat added to the system, work done by the system, and changes in other forms of energy

The mathematical expression of the First Law of Thermodynamics is:

$$\Delta U = Q - W$$

Where:

ΔU = change in internal energy of the system

Q = heat added to the system (positive if heat is added, negative if heat is removed)

W = work done by the system (positive if the system does work on the surroundings, negative if work is done on the system)

11. What is mean by knocking in I.C engine.

Ans: Knocking in an internal combustion (I.C.) engine refers to an undesirable and potentially damaging phenomenon where the air-fuel mixture in the engine's cylinder ignites prematurely or unevenly. This causes a sudden, sharp increase in pressure and temperature, resulting in a characteristic knocking or pinging sound. This sound is caused by the rapid combustion of the air-fuel mixture in areas away from the spark plug, as opposed to the normal, controlled combustion process that happens in a smooth manner

Causes of knocking:

Premature Ignition: This occurs when the air-fuel mixture ignites before the spark plug fires, often due to high temperature and pressure in the cylinder

Auto-Ignition: Under certain conditions, such as high engine load, low-octane fuel, or improper timing, the fuel-air mixture may self-ignite due to compression before the spark is initiated by the spark plug

Poor Fuel Quality (Low Octane): Fuels with low octane ratings are more prone to knocking because they resist compression ignition less effectively. Higher octane fuels can withstand greater compression without auto-igniting

Excessive Compression: When the compression ratio of the engine is too high for the type of fuel used, the mixture may ignite prematurely due to excessive heat and pressure

Overheating of the Engine: If the engine gets too hot, it may increase the chances of knocking because the air-fuel mixture will reach the point where it spontaneously ignites

Incorrect Spark Timing: If the spark plug fires too early or too late, the mixture may ignite prematurely, leading to knocking

12. What are the limitations of a simple carburetor?

Ans: While simple carburettors were effective for older vehicles and small engines, their limitations such as inefficiency, poor fuel management, difficulty in emissions control, and lack of precision make them unsuitable for modern vehicles. Fuel injection systems have largely replaced carburettors because of their superior ability to control the air-fuel mixture, improve fuel efficiency, reduce emissions, and integrate with modern engine control systems

13. In I.C engines define the terms: Indicated power, Brake power and Friction power.

Ans: Indicated Power (IP): Indicated power is the total power developed by the combustion of fuel in the engine cylinders before any losses due to friction or other external factors. It is the power calculated from the pressure within the engine's cylinders during the power stroke

Brake Power (BP): Brake power is the actual usable power output of the engine that is available at the crankshaft or flywheel, measured after accounting for frictional losses in the engine. It represents the power that can be harnessed to perform work (such as driving a vehicle, running a machine, etc.)

Friction Power (FP): Friction power is the portion of the total power (indicated power) that is lost due to internal friction within the engine components such as the piston, crankshaft, valves, and bearings. It is the power required to overcome the friction between moving parts and is subtracted from the indicated power to obtain the brake power

14. Which I.C engine as a more valve overlap and why?

Ans: Valve overlap refers to the period in a four-stroke internal combustion (I.C.) engine when both the intake and exhaust valves are open simultaneously. This typically occurs near the end of the exhaust stroke and the beginning of the intake stroke. During this time, exhaust gases are exiting the cylinder, and fresh air/fuel mixture is starting to enter.

Engines with more valve overlap typically include high-performance engines, particularly high-performance racing engines or engines designed for high RPM (revolutions per minute)

Reasons for More Valve Overlap:

i) Improved Volumetric Efficiency
ii) Enhanced High-RPM Performance
iii) Increased Power at Higher RPMs
iv) Turbocharging or Forced Induction

15. Why Carnot cycle treated as ideal cycle?
Ans: The Carnot cycle is treated as the ideal thermodynamic cycle because it represents the maximum possible efficiency that a heat engine can achieve when operating between two thermal reservoirs. This is due to several key reasons:

Reversible Process: The Carnot cycle consists entirely of reversible processes (isothermal and adiabatic). In a real engine, irreversibilities such as friction, heat loss, and non-idealities occur, which reduce the overall efficiency. The Carnot cycle, by being reversible, avoids these inefficiencies, making it an idealized benchmark.

Maximum Efficiency: The efficiency of the Carnot cycle depends only on the temperatures of the hot and cold reservoirs and is given by the equation:

$$\eta = 1 - T_h / T_c$$

where T_h is the temperature of the hot reservoir and Tc is the temperature of the cold reservoir. This shows that the efficiency depends specific details of the cycle. No real engine can exceed this efficiency

No Entropy Generation: In the Carnot cycle, there is no net entropy generation within the system, as the processes are reversible. Real cycles, in contrast, involve some degree of entropy generation, which leads to a reduction in efficiency

Idealized Assumptions: The Carnot cycle assumes that the working substance behaves ideally (often assumed to be an ideal gas), the heat exchanges happen infinitesimally slowly (infinite time), and no friction or other dissipative forces are present

16. Explain the Clausius statement?
Ans: The Clausius statement is one of the two fundamental formulations of the second law of thermodynamics. It can be stated as:
It is impossible for a heat engine to transfer heat from a colder body to a hotter body without the input of external work

17. Define thermodynamic State, path and process.
Ans: State: The condition of a system defined by its properties (e.g., temperature, pressure, volume)
Path: The sequence of states the system passes through during a change
Process: The transformation or change of the system from one state to another, typically characterized by changes in properties like pressure, temperature, and volume

18. List out the methods of ignition system generally used in SI engines.
Ans: Distributor-less Ignition System (DIS): Eliminates the distributor and uses multiple ignition coils
Capacitor Discharge Ignition (CDI): Uses capacitors to store and rapidly discharge energy for stronger sparks
Inductive Ignition System: Common in large engines, uses inductance to generate the spark
Dual Ignition System: Provides redundancy with two spark plugs per cylinder for reliability
High Energy Ignition (HEI): Provides a high-energy spark for improved ignition in performance engines

Each method has its specific advantages, and the choice of ignition system depends on factors such as engine type, size, performance requirements, and cost

19. What are fuels used in Jet propulsion.

Ans: Jet-A/Jet-A1: Kerosene-based, used in commercial and military aviation.
Jet B: Blend of kerosene and gasoline, used in cold climates
RP-1: Highly refined kerosene, used in rockets and missiles
Hydrogen: High energy content, used in rockets and experimental aircraft
Biofuels: Renewable fuels blended with traditional jet fuels
SPK (Synthetic Paraffinic Kerosene): Synthetic fuels made from various feed stocks
LOX/RP-1: Combination of liquid oxygen and RP-1 for rocket propulsion

Each of these fuels has specific applications depending on the requirements of the engine, the environment (e.g., temperature conditions), and the desired performance characteristics (e.g., energy density, storage stability)

20. What is the necessity of governing in a turbine?

Ans: i) **Stable operation** by maintaining constant speed despite load fluctuations.
ii) **Protection** against over-speeding and mechanical damage
iii) **Efficiency** by optimizing fuel or steam usage
iv) **Safe start-up and shut-down** operations
v) **Synchronization** with generators in power plants

Governing is vital for the smooth, safe, and efficient operation of turbines across a variety of applications, especially in power generation, where stability and safety are crucial