AKTU

B. Tech I-Year

Gateway Classes

Semester -I & II

Common to All Branches

Fundamentals of Mech. Engg.(BME101/201)

UNIT-2 : IC Engines & Electric Vehicles

Hand Written Notes

Gateway Series for Engineering

- Topic Wise Entire Syllabus
- Long - Short Questions Covered
- AKTU PYQs Covered
- DPP
- Result Oriented Content

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B. Tech I-Year

Gateway Classes

Fundamentals of Mech. Engg.(BME101/201)

Hand Written Notes

Unit-2

Introduction to IC Engines and Electric Vehicles

Syallbus

IC Engine: Basic definition of engine and Components, Construction and Working of Two stroke and four stroke SI & CI engine, merits and demerits, scavenging process; difference between two-stroke and four stroke IC engines and SI and CI Engines.

Electric vehicles and hybrid vehicles: Components of an EV, EV batteries, chargers, drives, transmission and power devices. Advantages and disadvantages of EVs. Hybrid electric vehicles, HEV drive train components, advantages of HV.

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Gateway Classes

Fundamentals of Mech. Engg. **By M. S. Tomer Sir**

Topic: I.C. Engine

Lecture - 1

Today's Target

→ Definition: IC Engine
→ Differences b/w EC Engine & IC Engine
→ Classification of IC Engine
→ PYQs

Engine: Definition

* It is a device which converts one form of energy into another form of useful energy.

$$\text{Chem. Energy} \xrightarrow[\text{Burning}]{\text{Fuel}} \text{Thermal Energy} \xrightarrow{\text{Engine}} \text{Mech. Energy}$$

Based on combustion engines are classified into

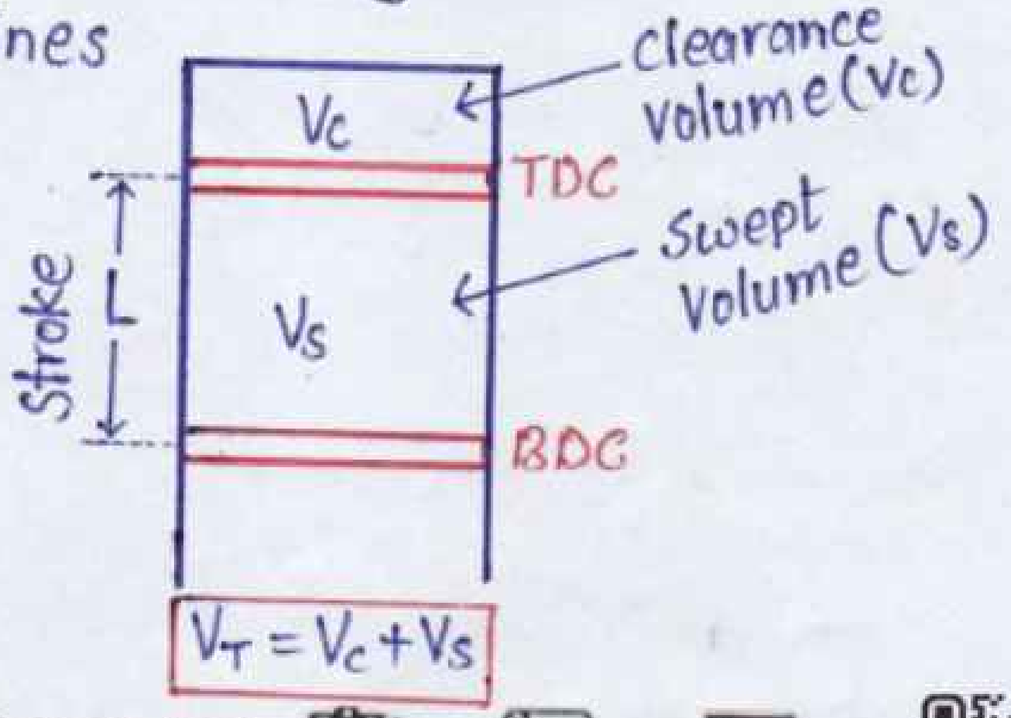
- Internal Combustion Engine (I.C. Engine)
- External Combustion Engine (E.C. Engine)

Internal Combustion Engine [AKTU 2020-21]

* In internal combustion engine the burning or combustion of the fuel take place inside the cylinder.

Example - Automobile Engines

- Petrol Engine
- Diesel Engine



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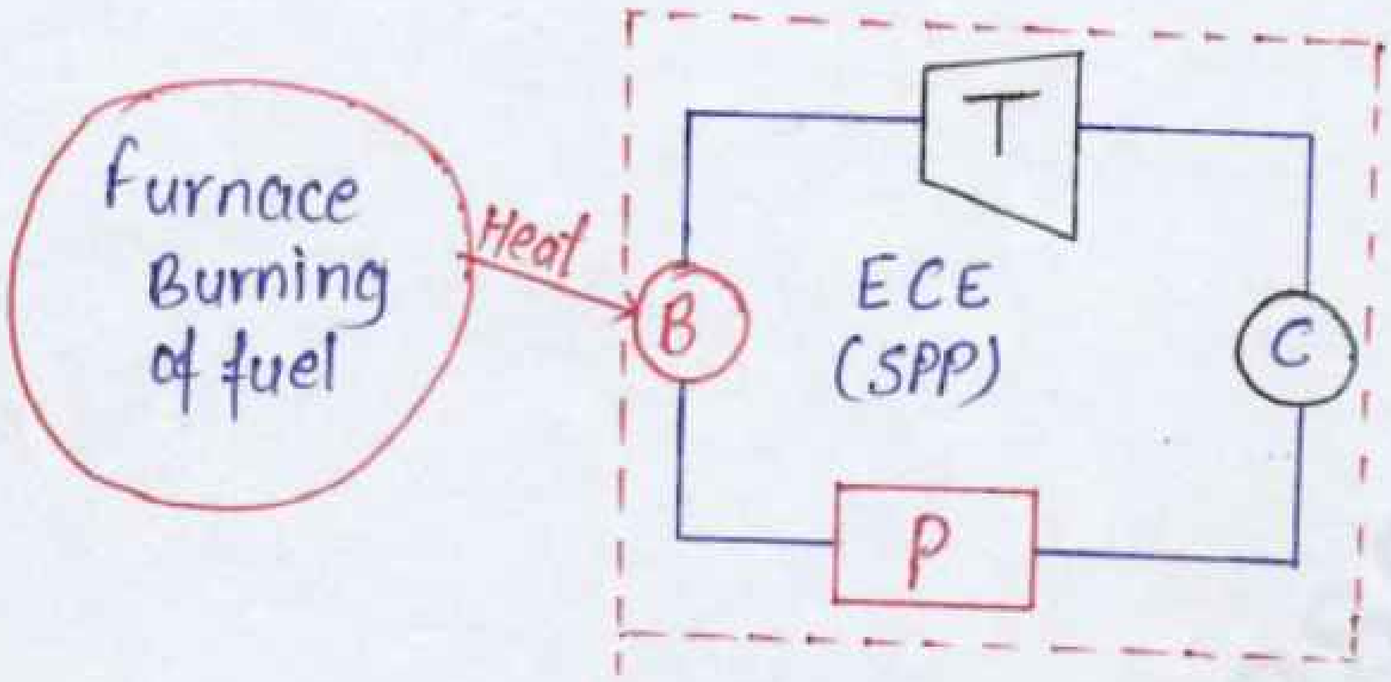
External Combustion Engine

* In external combustion engine the combustion of the fuel takes place outside the engine.

Example- Steam Engine, Closed gas turbine etc.



Differences between ICE and ECE

S.No	EC Engine	IC Engine
1.	Combustion of fuel is outside the engine	Combustion of fuel is inside the engine
2.	Bulky due to presence of auxiliary apparatus like boiler and condenser	It is light and compact
3.	High ratio of weight to power output	Low ratio of weight to power output
4.	It can use cheaper fuels including solid fuels.	High grade fuels are used with proper filteration
5.	Higher requirement of water for dissipation of heat	Lesser requirement of water
6.	Lower efficiency	Higher efficiency
7.	Silent operation due to outside combustion.	Very noisy operated engine

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Advantages of an I.C. Engine

These are the following advantages of an I.C. Engine

1. Mechanical Simplicity
2. Low initial cost due to absence of boiler, turbine condenser etc.
3. High efficiency than external combustion engine
4. Power to weight ratio is high
5. Very suitable for small power requirement applications
6. Starting time is very less
7. Requires less maintenance.

Dis-advantages of an I.C. Engine

These are the following disadvantages of an I.C. Engine

1. Variety of fuels that can be used is limited to very fine quality gaseous and liquid fuel.
2. Fuel used is very costly like gasoline or diesel.
3. Engine emissions are generally high compared to external combustion engine.
4. Not suitable of large scale power generation.
5. In case of reciprocating internal combustion noise is generated due to detonation.

Classification of an I.C. Engine

1. On the basis of strokes used
   - Two stroke cycle Engines
   - Four stroke cycle Engines

2. On the basis of Cycle used
- Otto Cycle Engines
- Diesel Cycle Engines
- Dual Cycle Engines

3. On the basis of types of fuel used
- Petrol Engines
- Diesel Engines
- Gas Engines

4. On the basis of types of Ignition Method:
- Spark Ignition (SI)
- Compression Ignition (CI)

5. On the basis of types of cooling system used:
- Air cooled engines
- Water cooled engines

6. Classify the IC engine on the basis of l/d ratio. [AKTU 2022-23]
- **Long-stroke engines**
  - These engines have a relatively long stroke compared to the bore diameter.
  - Have an l/d ratio greater than 1.
- Square engines
  - Square engines have l/d ratio close to 1, which means the stroke length is roughly equal to the bore diameter.

➤ Short-stroke engines

- These engines have a shorter stroke compared to the bore diamter.
- Have an l/d ratio less than 1.

7. On the basis of types of different position of cylinder:

➤ Horizontal cylineder engines
➤ Vertical cylinder engines
➤ Inclined cylinder engines

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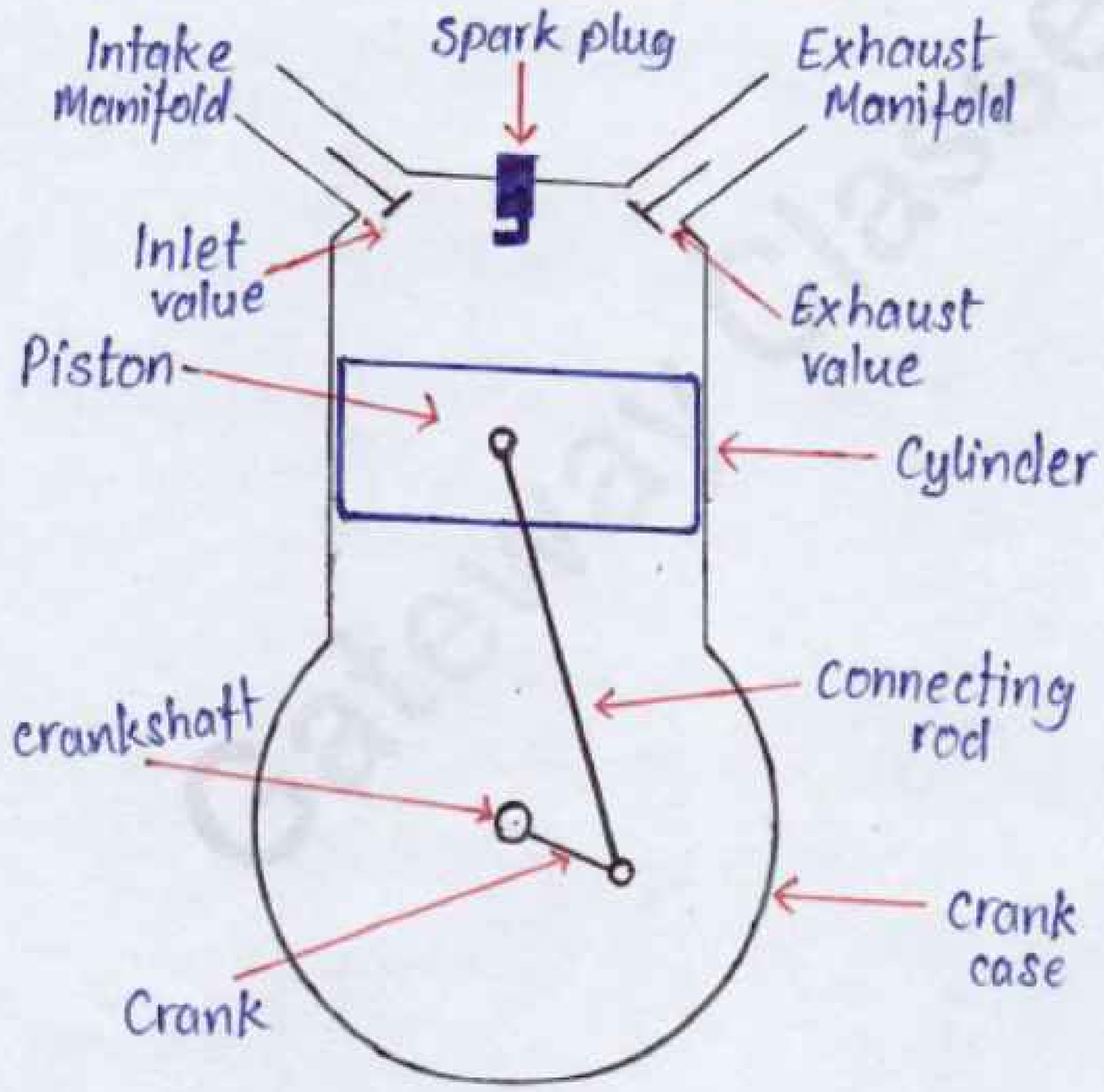
Fundamentals of Mech. Engg. **By M. S. Tomer Sir**

Topic: IC Engine

Lecture:- 2

Today's Target
→ Components of IC Engine
→ IC Engine Terminology
→ PYQs

Main Components of an I.C.E [AKTU 2022-23]



Cylinder Block: The foundation of the engine, housing the cylinders where the combustion process occurs.
It is made of cast iron or aluminium.

Cylinders: These are cylinder chambers where the combustion of fuel and air takes place. It is made of cast iroon or aluminium.

Pistons: Pistons are cylindrical components that move up and down inside each cylinder. The pressure created by the combustion process forces the pistons down, converting the pressure into mechanical motion. It is made of aluminium alloy, sometimes with steel reinforcement.

Crankshaft: The crankshaft is a rotating shaft connected to the pistons through connecting rods. It converts the linear motion of the pistons into rotational motion, which is then used to drive the wheels of the vehicle. It is made of forged steel or nodular cast iron.

Camshaft(s): The camshaft controls the opening and closing of intake and exhaust values. It is made of steel or cast iron. It is synchronized with the crankshaft and is responsible for timing the engine's valve operation.

Valves: Valves are responsible for allowing the intake of air and fuel into the combustion chamber (intake valve) and expelling the exhaust gases (exhaust valve) after.combustion. These are made of stainless steel.

Combustion Chamber: The area inside the cylinder where the air and fuel mixture is ignited by a spark plug (in petrol engines) or by compression (in diesel engines).

Spark Plugs: In gasoline engines, spark plugs are used to ignite the air-fuel mixture in the combustion chamber, creating the controlled explosion that drives the piston down. It is made of ceramic insulator with metal electrodes.

Intake and Exhaust Manifolds: These are pathways that direct the intake air and fuel mixture into the cylinders and expel the exhaust gases out of the engine, respectively.

Fuel Injection/Carburetor system: The system responsible for mixing air and fuel in the right proportion before it enters the combustion chamber. Older engines use carburetors, while modern ones use fuel injection systems.

IC Engine Terminology [AKTU]

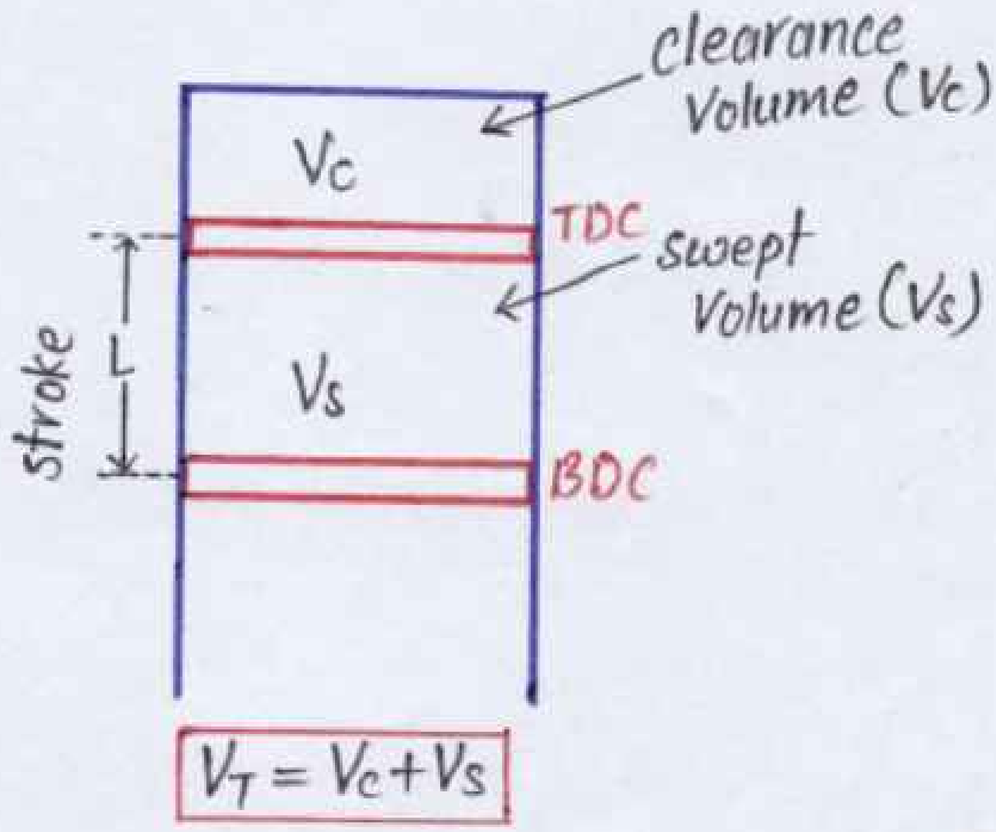
Top-Dead-Center (TDC): It is position of the piston when it is farthest from the crank shaft.

Bottom-Dead-Center (BDC): It is the position of the piston when if is nearest to the crankshaft.

Stroke: When piston moves from TDC to BDC or BDC to TDC is known as stroke.

Stroke Length (L): It is the distance between TDC and BDC.

Bore (D): Inner diameter of the cylinder or diameter of the piston face.



$$V_T = V_c + V_s$$

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Swept Volume (V_s): Volume displaced by the piston as it travels through one stroke.

$$V_s = \frac{\pi}{4} D^2 L$$

Total swept $V_s = K \frac{\pi}{4} D^2 L$

where K = no. of cylinders

Clearance Volume (V_c): It is the volume of the cylinder when piston is at TDC, therefore it is minimum volume.

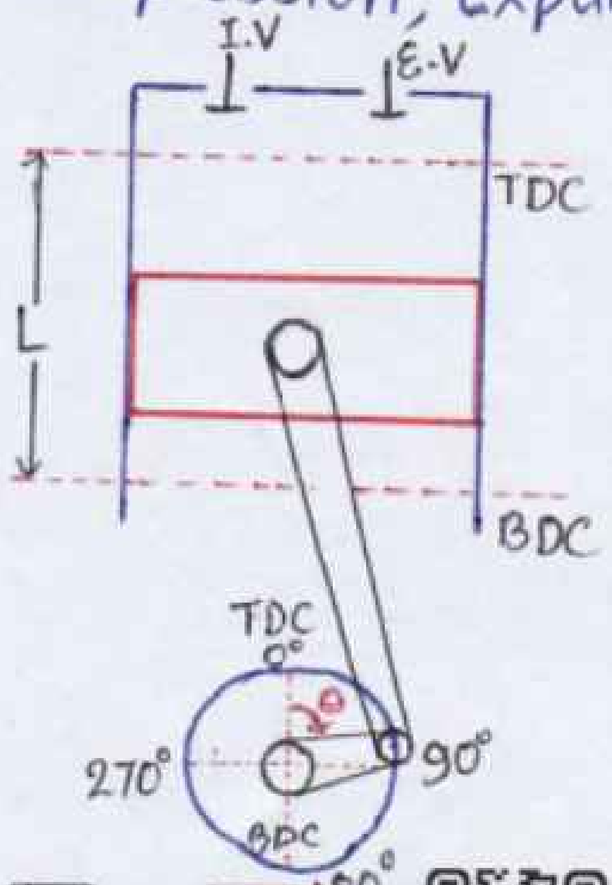
Compression ratio (r): It is defined as the ratio of volume before compression to the volume of after compression.

Volume before compression = $V_c + V_s$

Volume after compression = V_c

Four Stroke Engines

* If a cycle of an engine is completed in Four strokes of the piston or Two revolution (720°) of the crank is known as four stroke engine.
* Cycle consists of processes i.e. Intake, compression, Expansion and Exhaust.
* Four Stroke Engines may be SI or CI.
* SI engines work on Otto cycle.
* CI engines work on Diesel cycle



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Topic: I.C. Engine

Lecture - 3

Today's Target
→ Four Stroke Engines
→ Working of Four Stroke SI Engines
→ Working of Four Stroke CI Engines
→ Differences between SI and CI Engines
→ PYQs

Four Stroke Engines

* If a cycle of an engine is completed in four strokes of the piston or Two revolution (720°) of the crank is known as four stroke engine.
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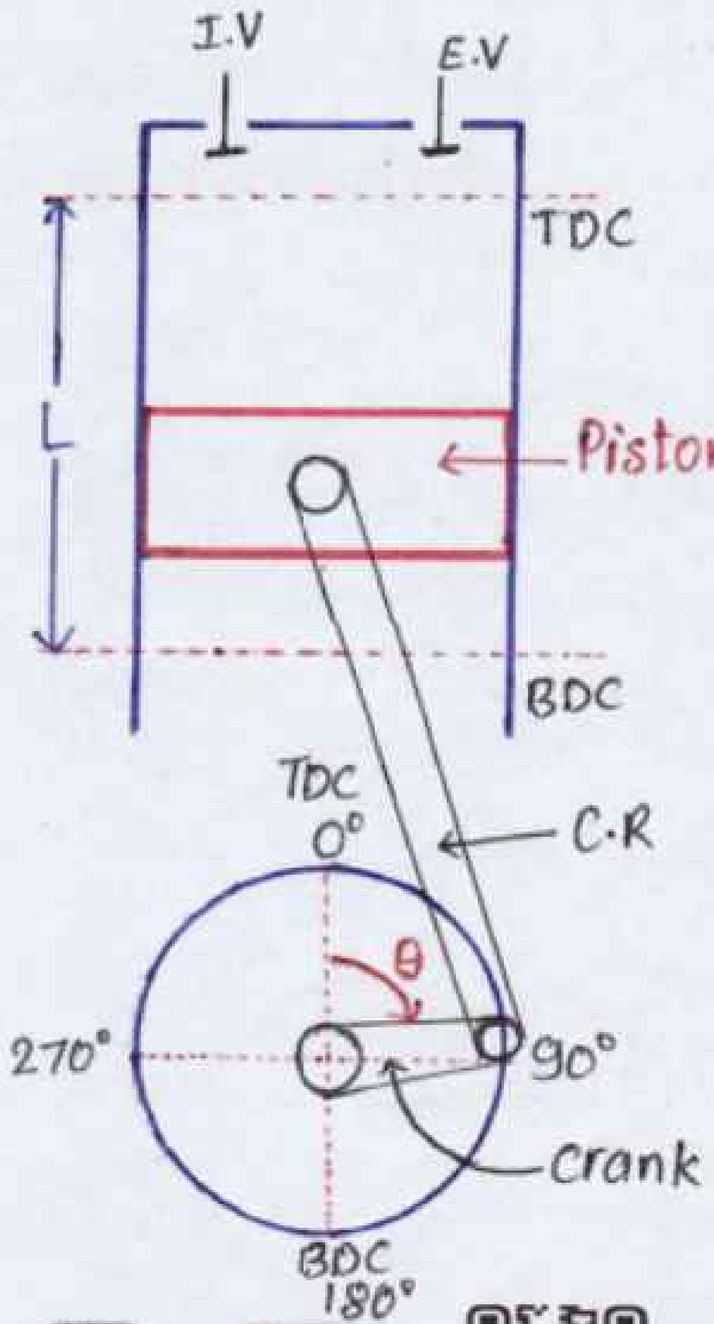

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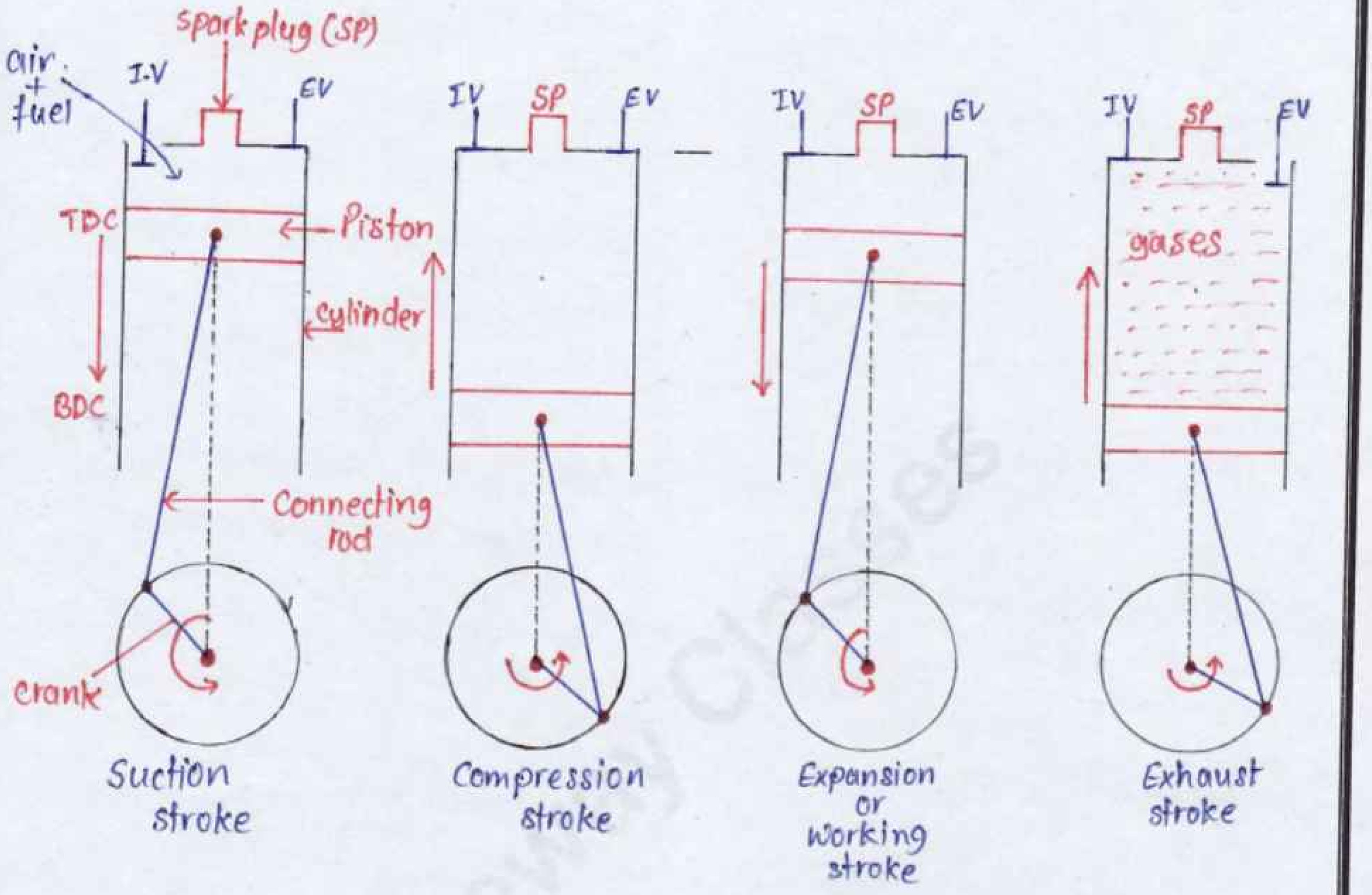
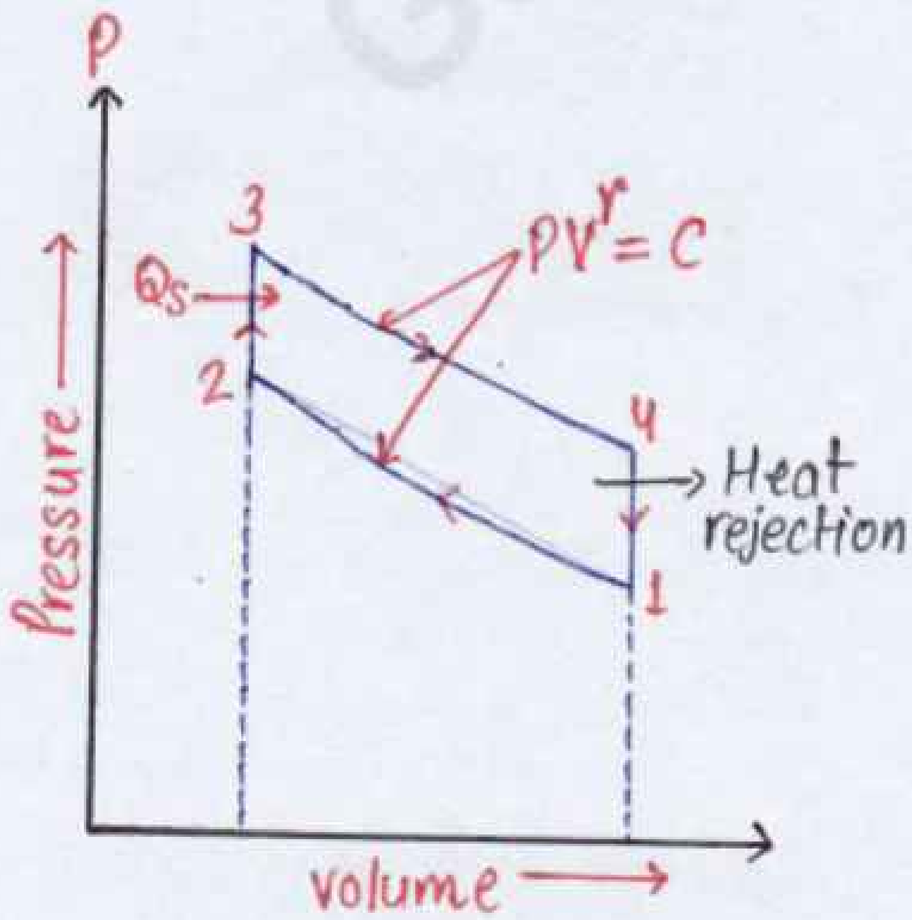
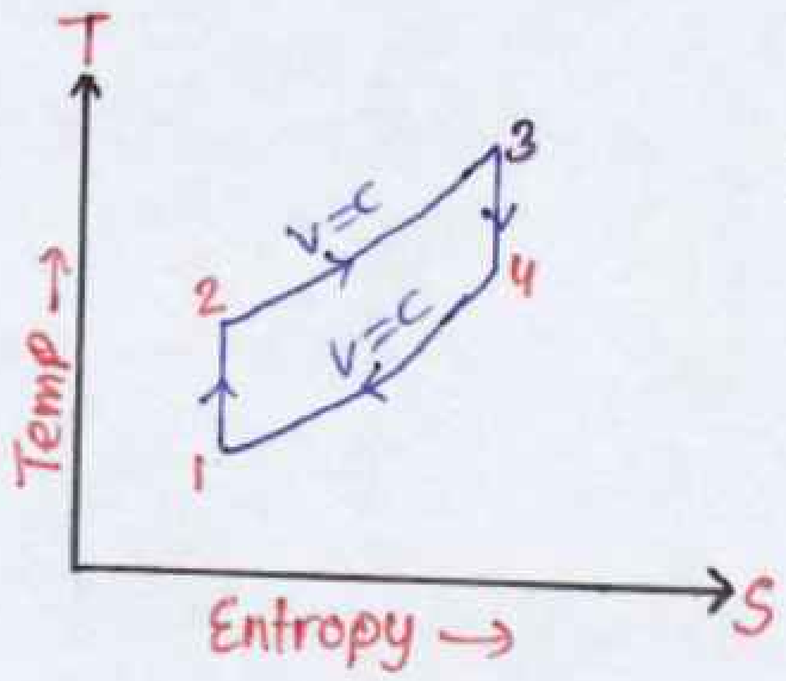
Working of Four Stroke SI Engines (Petrol Engine) [AKTU 2022-23]



P-V and T-s diagrams for Otto Cycle : SI Engine





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Working of Four Stroke SI Engines

The working of a four-stroke spark-ignition (SI) engine involves four strokes:

1. Intake
2. Compression
3. Power
4. Exhaust

These strokes are repeated in a continuos cycle to produce power

1. Intake Stroke (Suction)

- Piston moves downward from TDC to BDC.
- Inlet valve is opened and the exhaust valve is closed.
- Pressure inside the cylinder is reduced below the atmospheric pressure.
- The mixture of air-fuel is sucked into the cylinder through the inlet valve.
- The timing of the intake valve is controlled by the camshaft, which is synchronized with the engine's rotation.

2. Compression Stroke:

- Piston moves up from BDC to TDC.
- Both inlet and exhaust valves are closed.
- Temperature and pressure increased due to compression of air.
- fuel mixture in the cylinder.
- At the end of compression combustion starts with spark plug.

3. Power Stroke (Expansion):

- The burning gases expand rapidly.

- Gases exert an impulse (thrust or force) on the piston.
- The piston is pushed from TDC to BDC.
- This linear motion of the piston is converted into rotary motion of the crankshaft through connecting rod.
- Both inlet and exhaust valves are closed.

4. Exhaust Stroke:

- Piston moves upward from BDC to TDC.
- Exhaust valve is opened and the inlet valve is closed.
- The burnt gases are forced out to the atmosphere through the exhaust valve.
- The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh charge to start a new cycle.

After the exhaust stroke, the cycle repeats, and the engine continues to operates as long as there is a supply of air-fuel mixture and a spark to ignite it.

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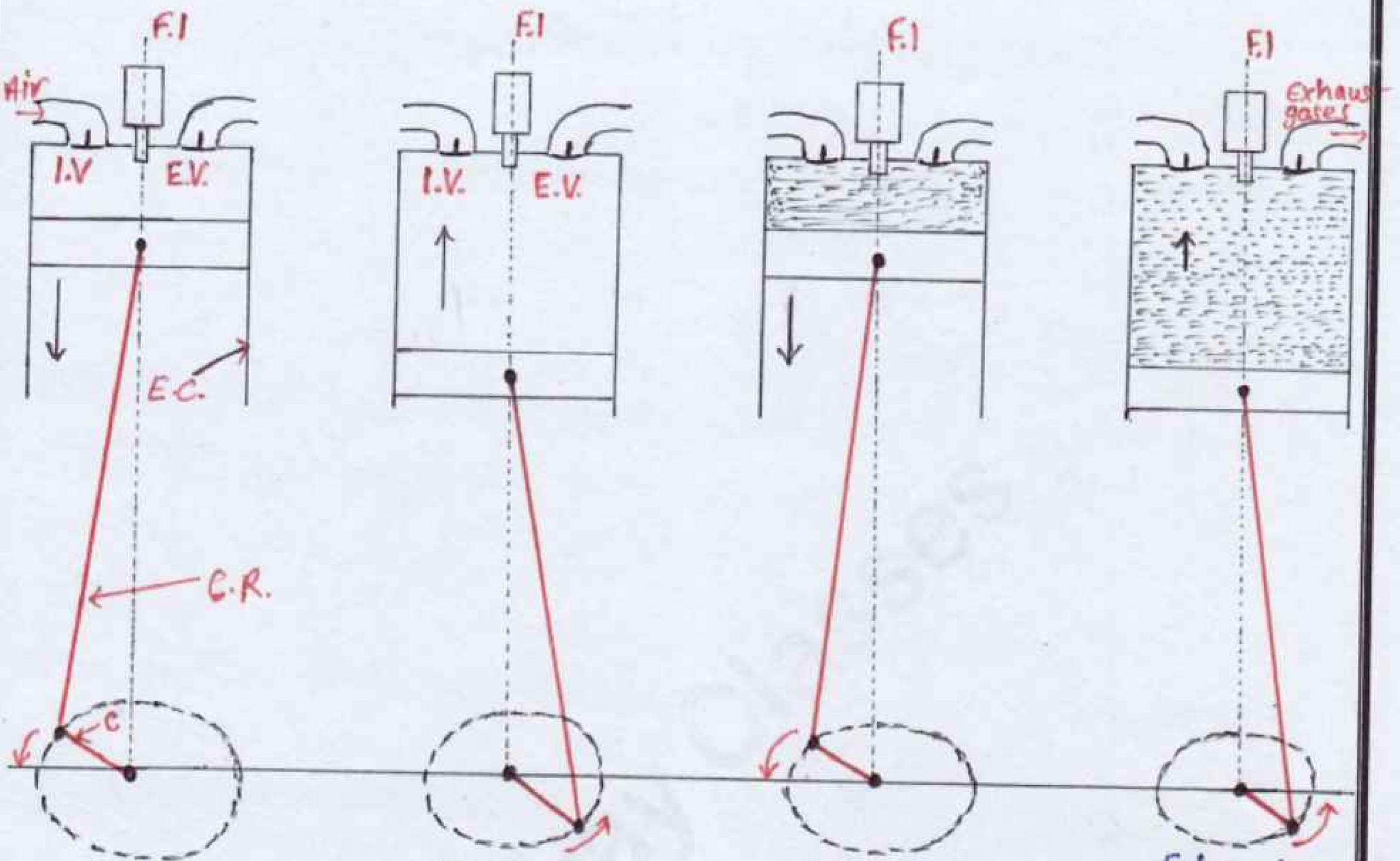
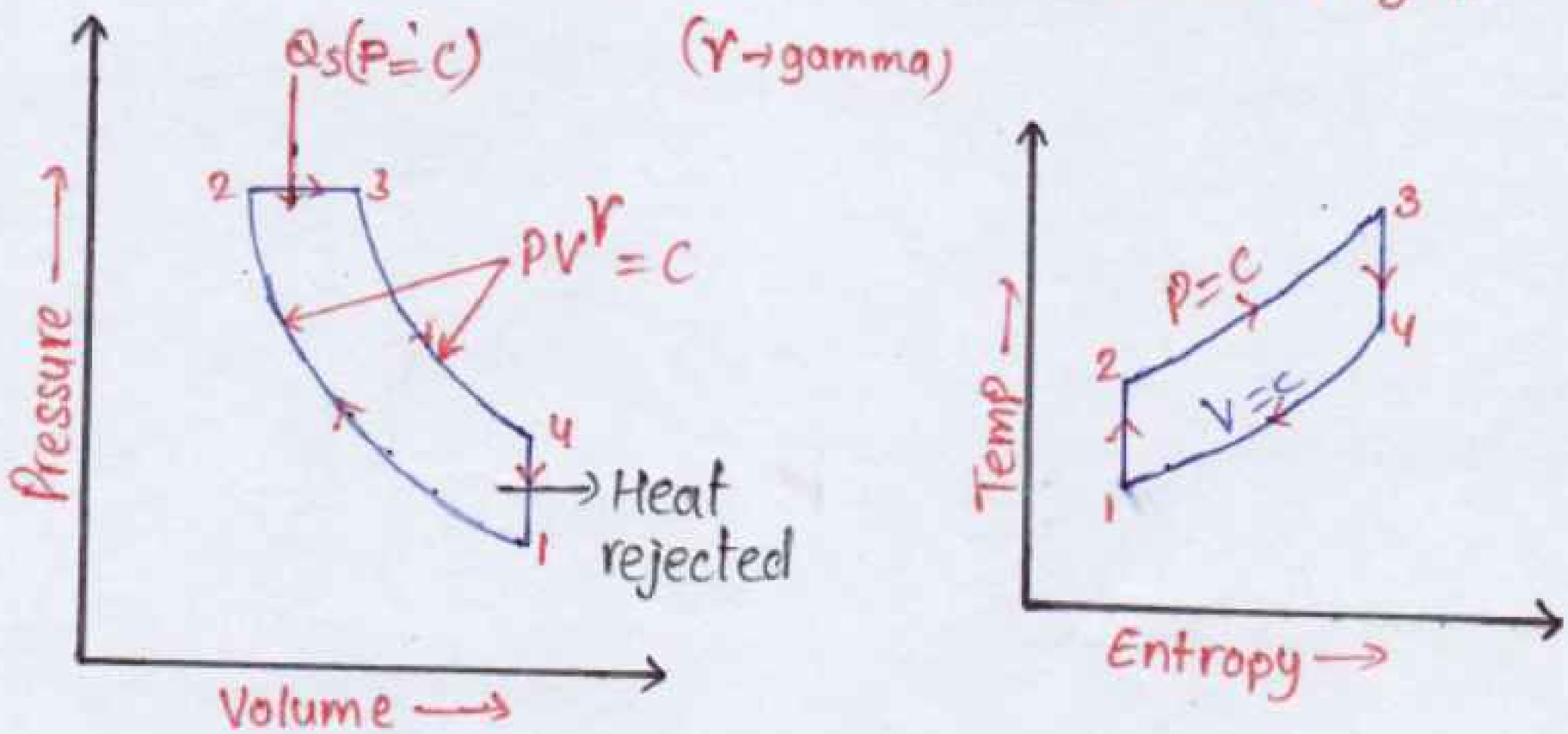
Working of Four Stroke CI Engines (Diesel Engine) [AKTU 2022-23]



P-V and T-s diagrams for Diesel Cycle: CI Engine



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Working of Four stroke CI Engines

The working of a four-stroke spark-ignition (SI) engine involves four strokes:

1. Intake
2. Compression
3. Power
4. Exhaust.

These strokes are repeated in a continuous cycle to produce power.

1. Intake Stroke (suction):

- Piston moves from TDC to BDC.
- Inlet valve is opened and the exhaust valve is closed.
- When piston moves from TDC to BDC, the pressure inside the cylinder is reduced below the atmospheric pressure.
- Fresh air from the atmosphere is sucked into the engine cylinder through air cleaner and inlet valve.

2. Compression stroke:

- Piston moves from BDC to TDC.
- Both inlet and exhaust valves are closed.
- The only air is drawn during suction stroke is compressed to a high pressure and temperature.

3. Power Stroke (Expansion):

- Fuel (diesel) is injected inside the cylinder with the help of fuel injector.
- The burning gases expand rapidly and push the piston from TDC to BDC. crank shaft through connecting rod.
- Both inlet and exhaust valves are closed.

4. Exhaust Stroke:

- Piston moves from BDC to TDC.
- Exhaust valve is opened the inlet valve is closed.
- The burnt gases are forced out to the atmosphere through the exhaust valve.
- The inlet valve opens slightly before TDC and thy cylinder is ready to receive fresh air to start a new cycle.

After the exhaust stroke, the cycle repeats, and the engine continues to operate as long as there is a supply of air-fuel mixture and a spark to ignite it.

Differences between SI and CI Engines [AKTU 2023-24]

S.No.	SI Engine	CI Engine
1.	It works on OTTO cycle or constant volume heat addition.	It works on a Diesel cycle or constant pressure heat addition.
2.	During the intake or suction process, air and fuel are used. The fuel used Petrol which is highly volatile.	During the intake or suction process, only air is used. The fuel used Diesel which is low volatile.
3.	Self-ignition temperature is high.	Self-ignition temperature is low.
4.	The fuel is supplied by Carburetor.	The fuel is supplied by Injector.
5.	The maintenance cost is low.	The maintenance cost is high.
6.	It is used in small Vehicles.	It is used in Heavy vehicles.
7.	The compression ratio is 6 to 10.	The compression ratio is 16 to 22.
8.	The starting of this engine is easy.	Starting is a little difficult comparatively SI engine.
9.	It produces less noice	It produces high noise.
10.	Lower thermal efficiency because of the low compression ratio.	High thermal efficiency because of the high compression ratio.

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Fundamentals of Mech. Engg. **By M. S. Tomer Sir**

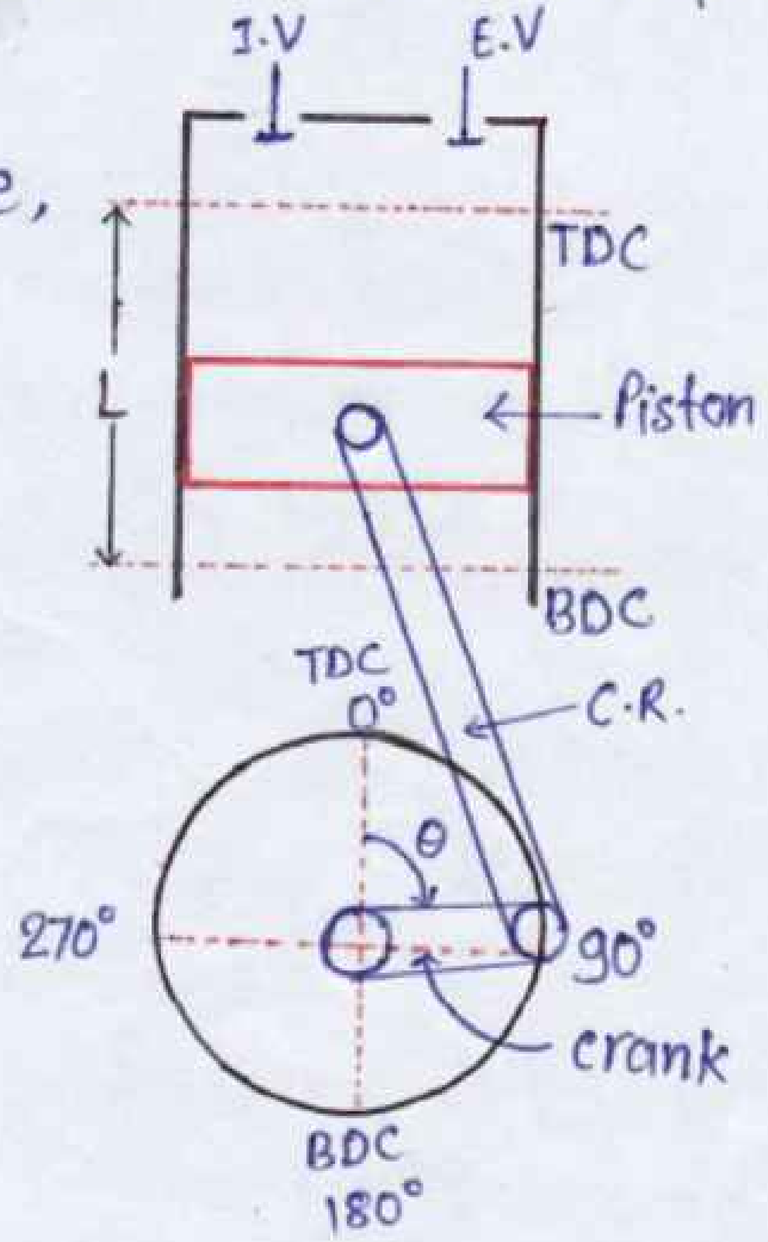
Topic : I.C. Engine

Lecture - 4

Today's Target
→ Two Stroke Engines
→ Working of Two-Stroke SI Engines
→ Working of Two-Stroke CI Engines
→ Differences between 2-stroke and 4-stroke Engines

Two strokes Engines

* If a cycle of an engine is completed in Two strokes of the piston or ONE revolution (360°) of the crank is known as four stroke engine.
* Cycle consists of processes i.e. Intake, Compression, Expansion and Exhaust.
* Two stroke Engines may be SI or CI.
* SI Engines work on Otto cycle
* CI engines work on Diesel cycle



Working of Two-stroke SI Engine

Working [AKTU 2023-24]

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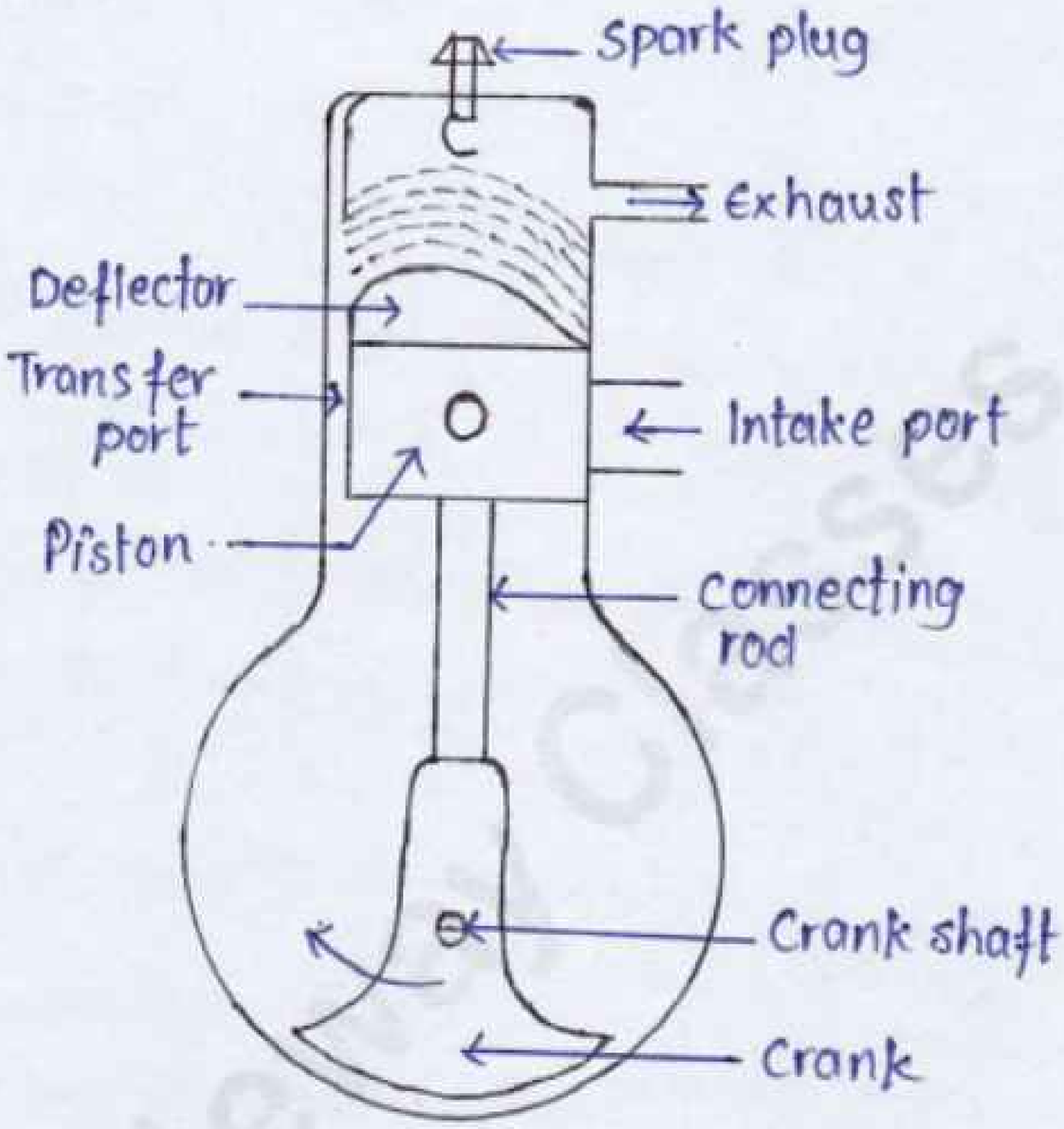
- The working of a two-stroke spark-ignition (SI) engine involves a simpler cycle compared to a four-stroke engine.
- It completes one power cycle in just two strokes of the piston.
- These engines are commonly used in small applications like motor-cycles, scooters etc.



1. Intake and Compression:

- The piston moves from (BDC) to (TDC).
- Both transfer and exhaust ports are covered by the piston.
- Air fuel mixture which is already transferred into the cylinder is compressed by moving piston.
- The pressure and temperature increases at the end of compression.
- As piston almost reaches the top dead center. The air fuel mixture inside the cylinder is ignited by means of an electric spark produced by a spark plug.

- At the same time, the inlet port is uncovered by the piston. Fresh air fuel mixture enters the crankcase through the inlet port.

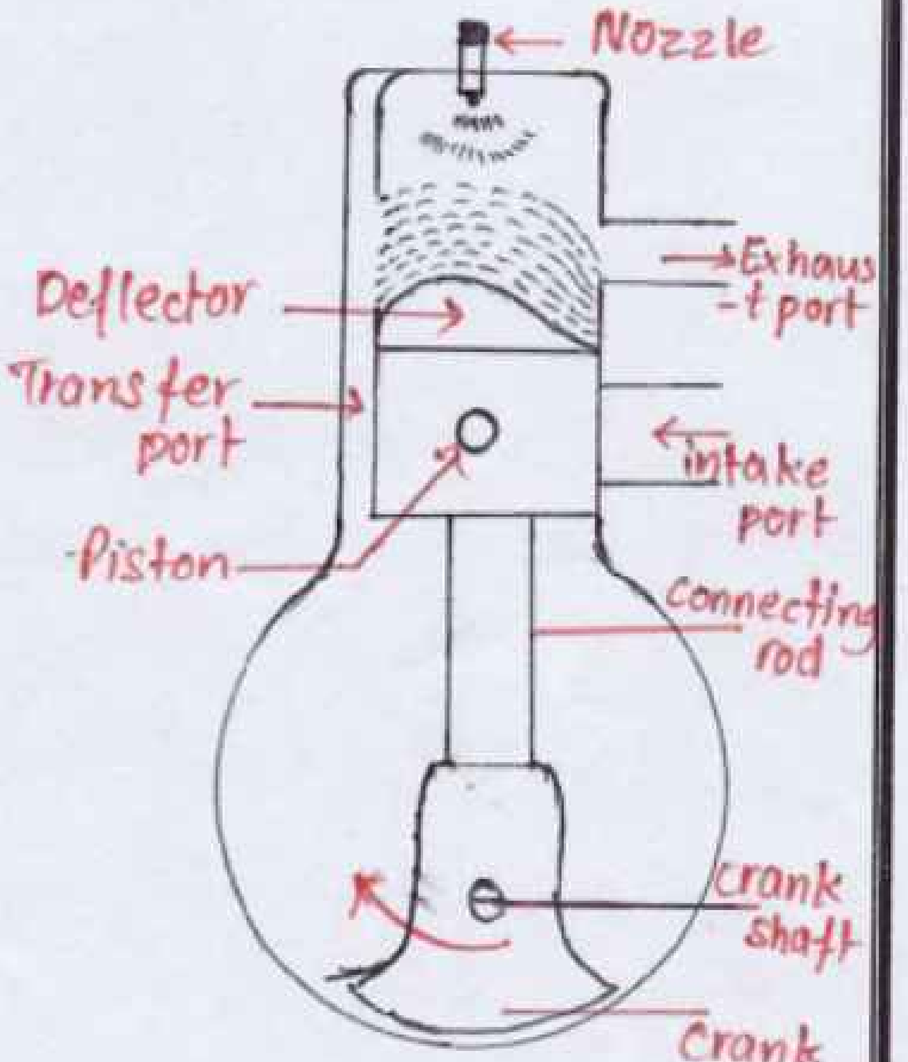
2. Power and Exhaust:

- The burning gases expand in the cylinder. The burning gases force the piston to move down. Thus useful work is obtained.
- When the piston moves down, the air fuel mixture in the crankcase is partially compressed.
- This compression is known as crank case compression.
- At the end of expansion, exhaust port is uncovered, Burnt gases escape to the atmosphere. Transfer port is also opened.

Working of Two Stroke CI Engines

Working:

- The working of a two-stroke compression-ignition (CI) engine involves a simpler cycle compared to a four-stroke engine.
- It completes one power cycle in just two strokes of the piston.
- These engines are commonly used in small applications like motorcycles, scooters etc.



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Working of Two Stroke CI Engines [Sem exam]

1. Intake and Compression:

- The piston moves from (BDC) to (TDC)
- Both transfer and exhaust port are covered by the piston.
- Air which is already transferred into the cylinder is compressed by moving piston.
- The pressure and temperature increases at the end of compression.
- Piston almost reaches the top dead center. The fuel is injected into the hot compressed air inside the cylinder.
- The fuel mixed with hot air and burns.
- The admission of fresh air into the crankcase continues till the piston reaches the top dead center.

2. Power and Exhaust:

- The burning gases expand in the cylinder.
- Burning gases force the piston to move down. Thus useful work is obtained.
- At the same time, the air in the crankcase is compressed partially by the movement of the piston from TDC to BDC.
- At the end of expansion, the exhaust port is uncovered.
- The burnt gases escape to the atmosphere through the exhaust port.

Scavenging process [AKTU 2022-23 Even Sem]

Scavenging:

- Scavenging is a process of pushing exhaust gases out of the cylinder.

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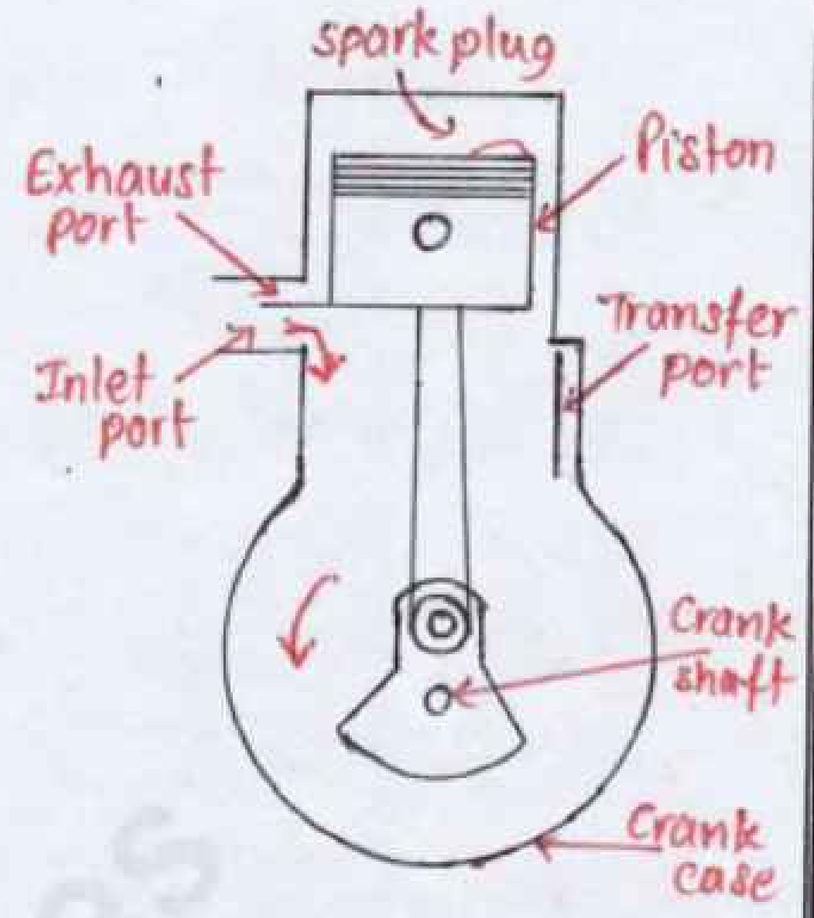
- One of the critical aspects of two-stroke engine design is scavenging, which involves replacing the exhaust gases with fresh air-fuel mixture to optimize combustion efficiency.
- The charge (air fuel mixture or air) enters the engine cylinder from the crank case at a pressure higher than the exhaust gases.



Differences between 4 strokes and 2 strokes engines [Univ Exam]

S. No.	4-Stroke Engine	2-Stroke Engine
1.	Four stroke of the piston and two revolution of crankshaft.	Two stroke of the piston and one revolution of crankshaft
2.	One power stroke in every two revolution of crankshaft	One power stroke in each revolution of crankshaft
3.	Heavier flywheel due to non-uniform turning movement	Lighter flywheel due to more uniform turning movement
4.	Lesser cooling and lubrication requirements	Greater cooling and lubrication requirements
5.	Power produce is less	Theoretically twice power
6.	Contains valve and valve mechanism	Contains ports arrangement
7.	Volumetric efficiency and Thermal efficiency are high but mechanical efficiency is low	Volumetric efficiency and Thermal efficiency are low but mechanical efficiency is high
8.	Heavy and bulky	Light and compact

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Fundamentals of Mech. Engg. **By M. S. Tomer Sir**

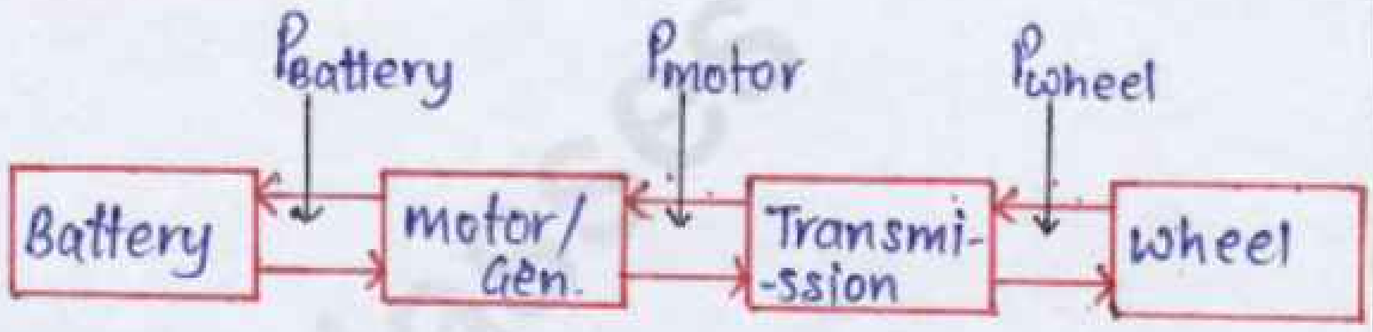
Topic : Electric vehicle (EVs)

Lecture:- 5

Today's Target
→ Electric vehicle (EVs)
→ Hybrid Electric Vehicles (HEVs)
→ PYQs

Electric Vehicle [AKTU 2022-23]

- An electric vehicle (EV) is a vehicle that uses one or more electric motor for propulsion.
- The electric motors are the replacement of ICE.



Main components of electric vehicle are:
- Battery
- Electric motor
- Battery charger
- Power electric converter

Electric vehicles (EVs) have gained popularity in recent years due to their potential to reduce greenhouse gas emissions and dependence on fossil fuels.

Advantages and dis-advantages of an Electric vehicle

Advantages: [AKTU 2023-24]

- Environmental Benefits: EVs produce zero emissions, which helps reduce air pollution and greenhouse gas emissions, leading to improved air quality and a healthy environment.

- Energy Efficiency: Electric vehicles are more energy-efficient than internal combustion engine vehicles. They convert a higher percentage of energy from the electricity grid into usable power for driving, reducing energy waste.
- Lower Operating Costs: EVs have lower Operating costs compared to traditional gas-powered vehicles. Electricity is generally cheaper than gasoline, and EVs require less maintenance due to less moving parts.
- Reduced Noise Pollution: Electric vehicles are quieter than internal combustion engine vehicles, reducing noise pollution in urban areas and creating a quieter driving experience.
- Government Incentives: Many governments offers incentives and subsidies to encourages the adoption of electric vehicles, such as tax credits, reduced registration fees etc.
- Regenerative Braking: EVs often have regenerative braking systems which recapture energy during braking and store it in the battery, further improving energy efficiency.

Disadvantages: [AKTU 2022-23]

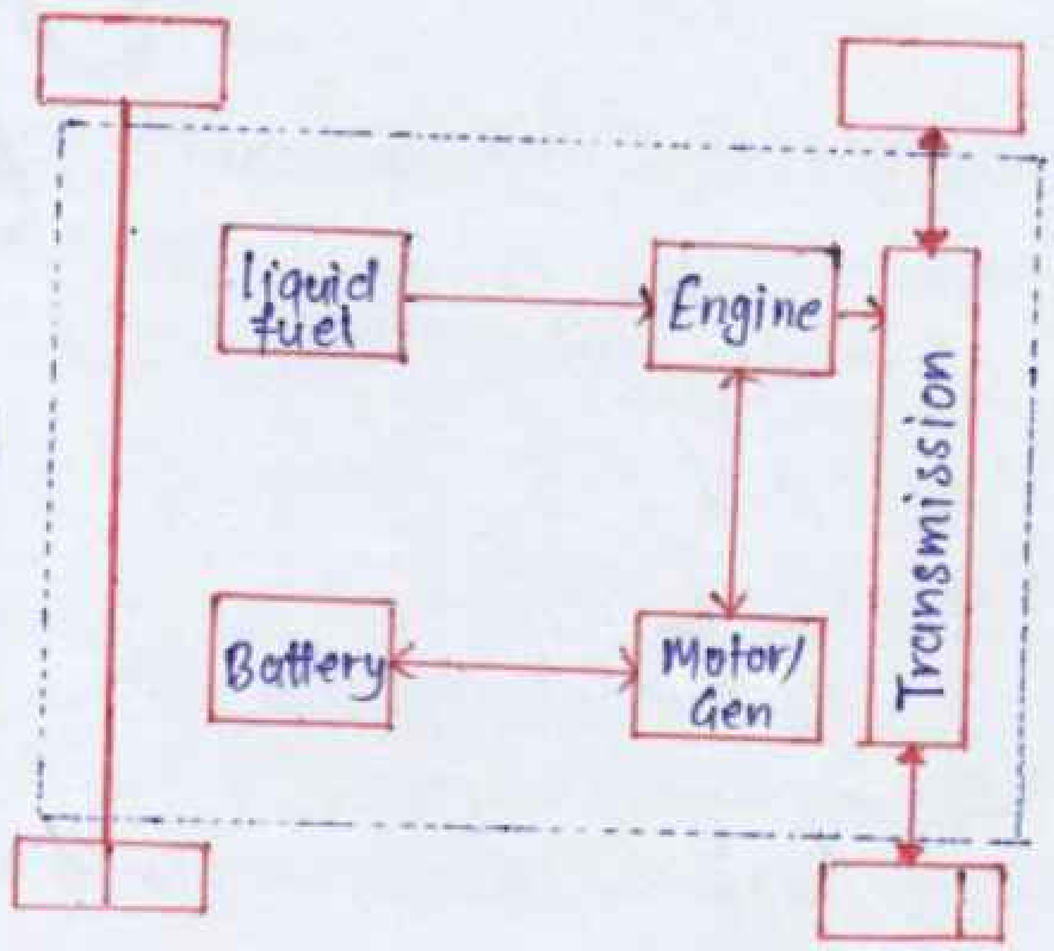
- Limited Driving Range: One of the primary challenges with EVs is their limited driving range compared to conventional vehicles. Although ranges are improving, some EVs may still not be suitable for long-distance travel without frequent charging.
- Charging Infrastructure: The availability of charging stations can be limited in some areas, making it difficult for EV drivers to charge their vehicle conveniently, especially in remote regions.
- Longer Refueling Time:- Charging an EV takes longer than refueling a conventional vehicle with gasoline. Even with fast-charging tech-nology, it may still take several minutes to an hour to charge fully

depending on the battery capacity and charging speed.

- **Initial cost:** Electric vehicles generally have a higher cost compared to traditional gasoline-powered cars, mainly due to the cost of batteries. However, prices have been decreasing as technology advances and production scales up.
- **Battery life and Recycling:** Battery life and recycling are ongoing concerns for EVs. While battery technology is improving eventually all batteries will degrade and need replacement. Proper battery recycling and disposal are essential to minimize environmental impacts.

Hybrid Electric Vehicles (HEV)

- A hybrid vehicle is a type of automobile that combines two or more power sources to provide propulsion.
- The most common type of hybrid vehicle is the hybrid electric vehicle (HEV), which typically combines an internal combustion engine (ICE) and electric motor.



Types of hybrid vehicles

Parallel Hybrid Electric Vehicle (PHEV): [AKTU 2022-23 Odd Sem]

- In a parallel hybrid, both the internal combustion engine and the electric motor are connected to the vehicle's transmission, allowing either or both power sources to drive the wheels simultaneously.

- The eletric motor assists the engine during acceleration and provides regenerative braking to recharge the battery when the vehicle slows down.

Series Hybrid Electric Vehicle (SHEV):

- In a series hybrid, the internal combustion engine does not direct-ly drive the wheels.
- Instead, it serves as a generator to charge the battery, which then powers the electric motor that drives the wheels.
- The engine may come into direct operation in certain situations, such as when the battery charge is low or during high power demands.

EV Batteries [AKTU 2023-24 odd sem]

- Electric vehicle (EV) batteries are a critical component of electric vehicles, providing the energy storage needed to power the electric motor and propel the vehicle.
- These batteries are typically rechargeable and store electrical energy in the form of chemical energy allowing the vehicle to travel without the need for an internal combustion engine.

Types of EV Batteries

1. Lithium-ion (Li-ion) Batteries
2. Solid-state Batteries

1. Lithium-ion (Li-ion) Batteries:

- Lithium-ion batteries are the most common type used in electric vehicles due to their high energy density, which allows for longer driving ranges and better performance.

- They offer a good balance between energy capacity, weight, and cost. Many EV manufacturers use variations of lithium-ion chemistry, such as lithium iron phosphate ($LiFePO_4$) and lithium nickel manganese cobalt oxide (NMC).

2. Solid-State Batteries:

- Solid-state batteries are an emerging technology that aims to replace the liquid electrolyte in traditional lithium-ion batteries with a solid-state electrolyte.
- These batteries have the potential to offer higher energy densities, faster charging times, and improved safety compared to conventional lithium-ion batteries. However, they are still in the early stages of commercialization and not yet widely used in EVs.

Electric Vehicle (EV) Chargers

- Electric vehicle (EV) chargers are devices used to recharge the batteries of electric vehicles.
- There are different types of EV chargers, each with varying charging speeds and applications.

Types of EV Chargers:

1. Level 1 charger (120V):

- Level 1 chargers are the most basic and usually come with the electric vehicle when purchased. They operate on a standard 120-volt household outlet.
- These chargers are relatively slow and are suitable for overnight charging at home. Level 1 chargers typically provide a charging rate of about 3 to 5 miles of range per hour of charging.

2. Level 2 charger (240V):

- Level 2 chargers are more powerful than Level 1 chargers and require a 240-volt outlet. They commonly installed at homes, work-places, and public charging stations.
- Level 2 chargers provide faster charging rates, typically adding around 10 to 30 miles of range per hour of charging, depending on the vehicle and charger specifications.

3. DC Fast charger (Level 3 charger):

- DC fast chargers, also known as Level 3 chargers, are high-powered chargers commonly found at public charging stations, rest areas, and along highways.
- They provide rapid charging by delivering direct current (DC) power to the vehicle's battery.
- DC fast chargers can recharge an EV to 80% capacity in around 30 minutes, making them ideal for long-distance travel and quick top-ups.

4. Tesla Supercharger:

- Tesla Superchargers are exclusive to Tesla electric vehicles.
- They are high-speed DC fast chargers designed specifically for Tesla cars.
- Superchargers can provide fast charging rates and are strategically placed along highways and popular travel routes to support long-distance travel for Tesla owners.

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