Date 4.10.23.

Subject Name → Fundamental of Mechanical Engineering
Subject Code → BME-101

Syllabus →
1. Simple stress and strain (N+T)
2. I.C., Engine, Ev, HEV (T)
3. R.A.C (Refrigeration and air Conditioner)
4. Fluid Mechanics / Machinery
5. Measurement

Date 6-10-23.

# Unit - 2
## [ I.C. Engine, EV, HEV ]

Topics →

1. Intro to I.C. Engine
2. Classification of IC Engine
3. Parts / component of IC engine
4. Termnology used in IC Engine
5. Fourstroke petrol and diesel engine working
   - petrol → S.I engine (spark ignition)
   - diesel → C.I engine (compressed ignition)
6. Working of twostroke engine.
7. Diff b/w petrol and diesel engine
8. Diff b/w fourstroke and two stroke engine.
9. Scavenging process.

• Engine → An engine is a device which transform the chemical energy of the fuel into thermal energy and used this thermal energy to produce mechanical work.

Fuel energy (chemical energy) ⟶ Thermal energy (heat energy) ⟶ useful work done.

Engine

- External Combustion
- Internal Combustion
  - Stroke used
  - fuel used
  - Position of cylinder
  - Ignition used
  - Thermodynamics cycle
  - No. of cylinder
  - Cooling of cylinder

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#Engine can be broadly classified into →
1. External combustion engine (E.C)
2. Internal combustion engine (I.C)

1. E.C. → External combustion engine are those in which combust of fuel take place outside the engine cylinder.
For ex → Steam Engine

2. I.C. → In internal combustion engine, the combustion of fuel take place inside the engine cylinder.
For ex → 1. Reciprocating engine, 2. Rotor, 3. V-line engine, 4. Petrol engine, 5. diesel engine.

#classification of I.C. Engine →
→ Engine can be classified on the following basis →
1. According to stroke used to execute 1 cycle →
a. 2 Stroke → 1 cycle executed in 2 ~~cycle~~ stroke
b. 4 Stroke → 1 cycle executed in 4 stroke.

2. According to the fuel used →
a. Petrol engine → Petrol is used as fuel in this engine.
b. diesel engine → diesel is used as fuel in this type of engine
c. Gasoline engine → gasoline is used as fuel in this engine.

3. According to position of cylinder →
a. Horizontal engine
b. Vertical engine
c. V-engine
d. Radial engine

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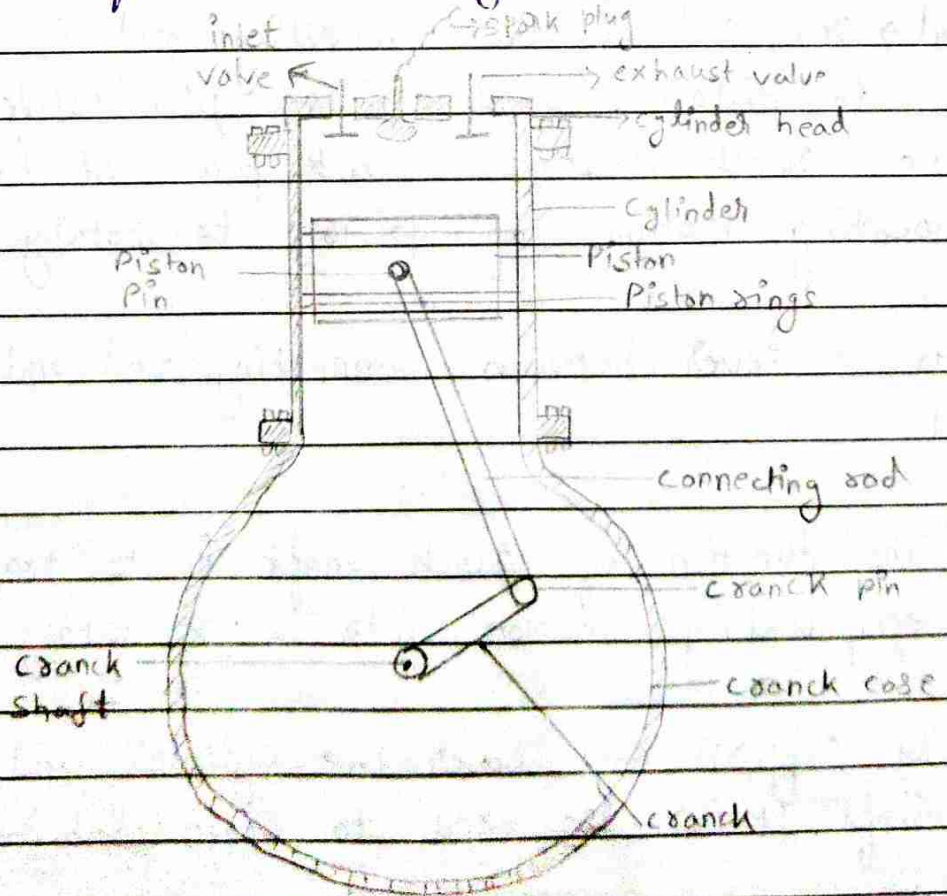
4. According to the ignition used →
   a. spark ignition (SI) (Petrol engine)
   b. Compression ignition (CI) (diesel engine)

5. According to the Thermodynamics cycle →
   a. otto cycle engine (constant volume heat addition cycle)
   b. diesel cycle engine (constant pressure heat addition cycle)
   c. dual cycle engine (heat is supplied as constant volume & constant pressure)

6. According to number of cylinders →
   a. Single cylinder (engine that contain only 1 cylinder)
   b. Multi cylinder (engine that contain more than 1 cylinder)

7. According to cooling of cylinder →
   a. Air cooled engine
   b. Water/liquid cooled engine.

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# Components of IC Engine →

1. Cylinder → It is a metallic cylindrical container fitted with a piston, where the fuel is burned and power is produced.

2. Cylinder head/cover → One end of the cylinder is closed by means of cylinder head. It consists of inlet valve for admitting fresh air fuel mixture and exhaust valve for removing the products of combustion.

3. Piston → Piston is used to reciprocate inside the cylinder, it transmite the energy to crankshaft through connecting rod.

4. Piston ring → These are used to maintain a pressure tight seal between the piston and cylinder wall.

5. Connecting rod → One end of the connecting rod is connected to piston through piston pin, while the other is connected to crank through crank pin. It is used to transmit reciprocating motion of piston to rotary crank.

6. Crank → It is a lever between connecting rod and crank shaft.

7. Crank shaft → The function of crank shaft is to transform reciprocating motion into a rotatory motion.

8. Crank case → It support and cover the cylinder and crank shaft. It is also used to store lubricating oil.

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# Termnology used in IC Engine →

1. TDC (Top dead centre) → The lowest position of the piston towards the crank shaft is called The top most position of the piston towards cylinder head is called TDC. In case of horizontal engine TDC is known as inner dead centre (IDC).

2. BDC (Bottom dead centre) → The lowest position of the piston towards the crank shaft is called bottom dead centre In case of horizontal engine, it is called outer dead centre (ODC).

3. Stroke → The linear distance along the cylindrical axis between the two limiting position of the piston is called stroke.
Displacement of piston from TDC to BDC executes 1 stroke.

4. Bore → The inside diameter of cylinder or outside diameter of the piston is called bore.

5. Clearance Volume → The volume contained in the cylinder above the top of the piston, when it is at top dead centre. is called clearance volume.

6. Swept Volume → Volume of cylinder cover by piston from TDC to BDC is called swept volume.

$$V_s = \frac{\pi}{4} (\text{Bore})^2 \times \text{stroke}$$

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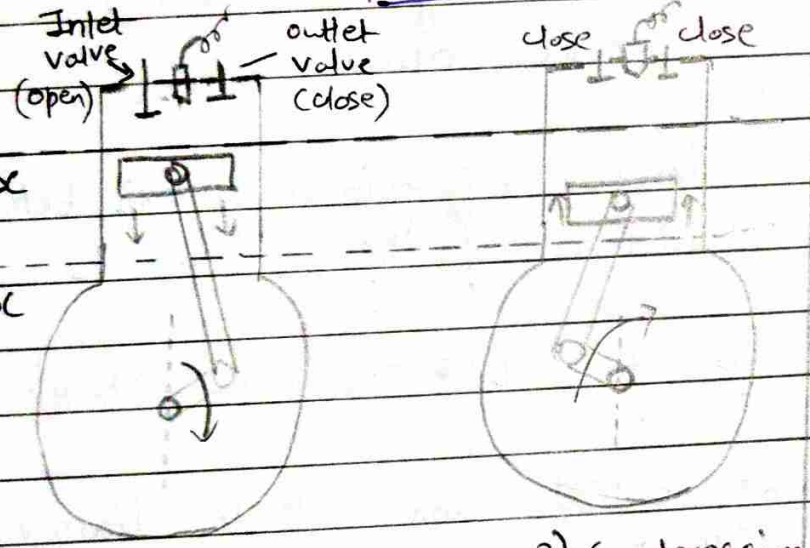
7. Total Volume → Sum of clearance volume and swept volume

$$V_T = V_s + V_c$$

8. Compression Ratio → (C.R.) → It is a ratio of total volume of cylinder (without fuel combustion) to the clearance volume of the cylinder.

$$C.R = 1 + \frac{V_s}{V_c}$$

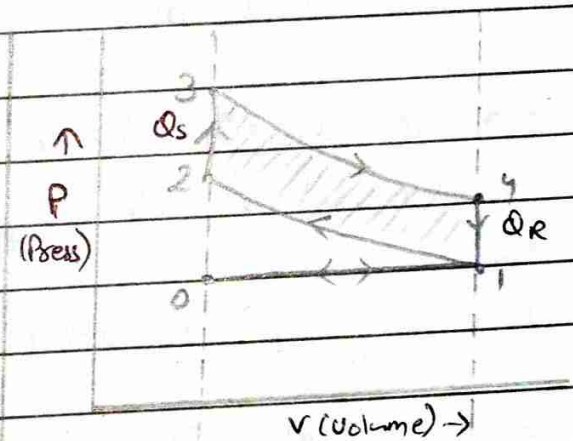
• Four strokes petrol engine (Based on otto cycle) CSI engine

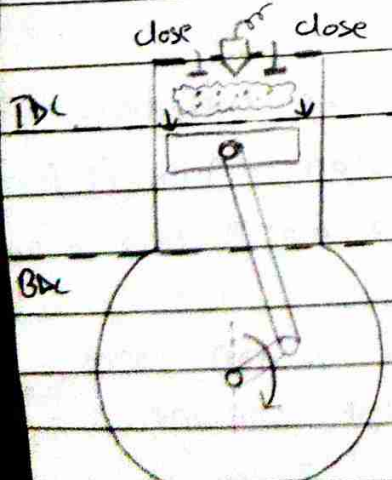



1) Suction

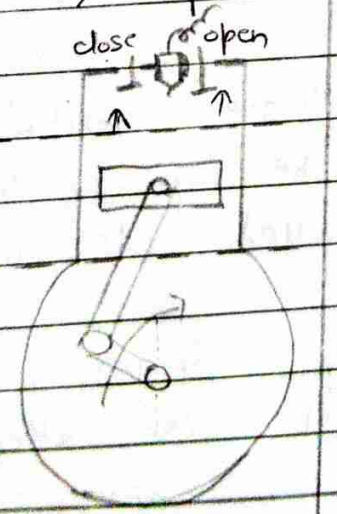



2) Compression

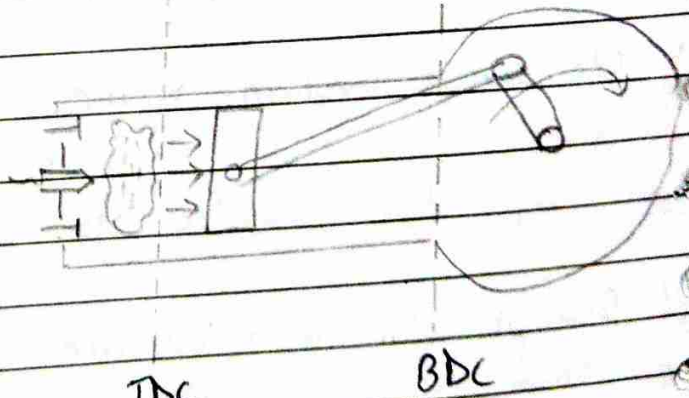



3) Expansion or Power




4) Exhaust



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• Four stroke petrol engine / four stroke spark ignition (SI) engine. (otto engine)

→ The four stroke petrol engine operates on otto cycle (constant volume, heat cycle) since ignition is due to spark plug, they are called spark ignition engine. During one cycle of engine or two revolution of crank shaft four different stroke are performed.

1. Suction stroke
2. Compression stroke
3. Expansion or power or working stroke
4. Exhaust stroke

1. Suction stroke → During suction stroke the piston is moved from Top dead centre (TDC) to Bottom dead centre (BDC) by the revolution of crank shaft, initially the crank shaft is revolved either by the movement of fly wheel or the electric starting motor. The inlet valve is open and the exhaust valve is remain closed during this stroke. The proportionate air-petrol mixture which is prepared in carburator (is pumped into the cylinder due to the downward movement of the piston from TDC to BDC. This operation is represented by the line 0-1 on PV diagram.

2. Compression stroke → During compression stroke the piston is moved from BDC to TDC by the revolution of crank shaft and the both inlet and outlet valve remain close. The fresh air-fuel mixture get compressed and the pressure and temperature of fresh mixture is increased as shown in line 1-2 On PV diagram. Just before the end of this stroke the spark plug initiates a spark which ignite the mixture and combustion take place at constant volume, as shown by 2-3 line on PV diagram.

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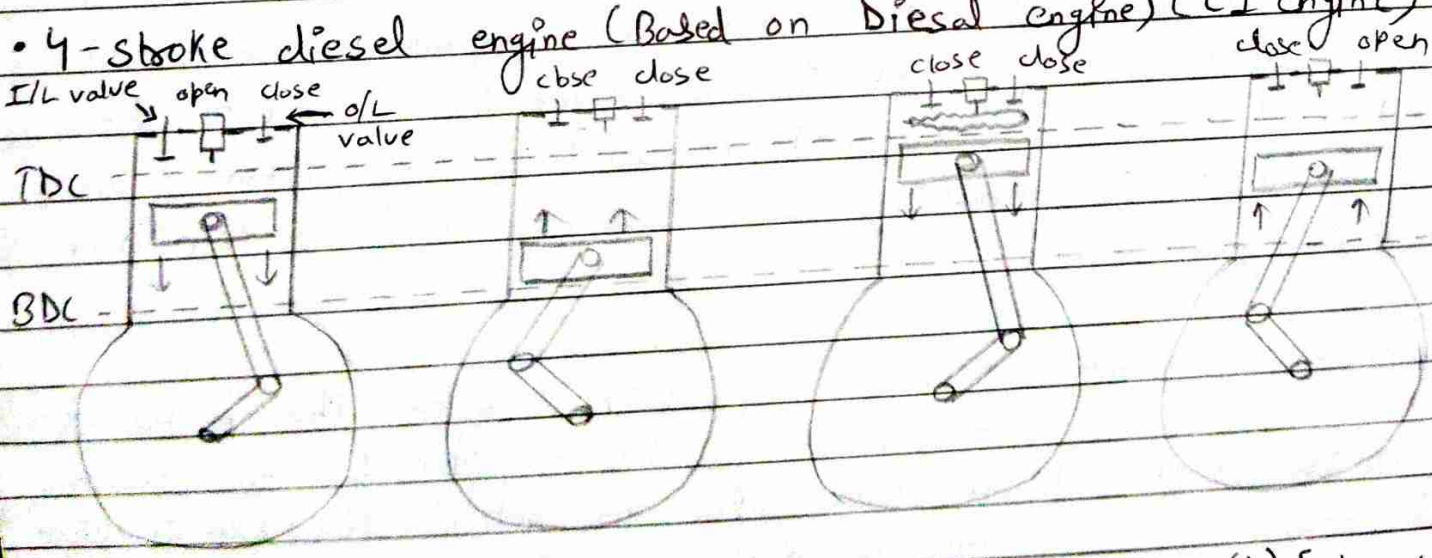
3. Expansion or working stroke → The expansion of hot gases after burning of fuel exerts a pressure on the piston. Due to this pressure, the piston moves from TDC to BDC. Thus the work is obtained in this stroke. Both the inlet and outlet valves are remained closed during this stroke. This expansion of gases is shown by line 3-4 on PV diagram.

4. Exhaust stroke → During this stroke inlet valve remain close and outlet valve is opened and the burned gases are moved out to the environment by the movement of piston from BDC to TDC. when piston is reached to TDC, the exhaust valve closed and cyle is completed. This stroke is represented by the line 1-0 on P-V-diagram. The operations are repeated over and over again in running the engine. Thus a four stroke engine complete one working cycle, during the 2 revolution of the crank shaft.

• 4-stroke diesel engine (Based on Diesal engine) (CI engine)




(a) Suction stroke (b) Compression stroke (c) Expansion/ Power/ working stroke (d) Exhaust stroke

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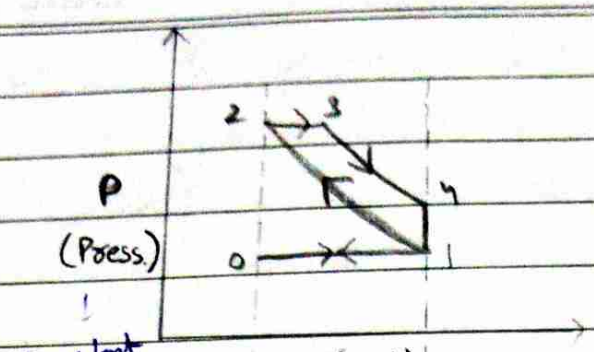


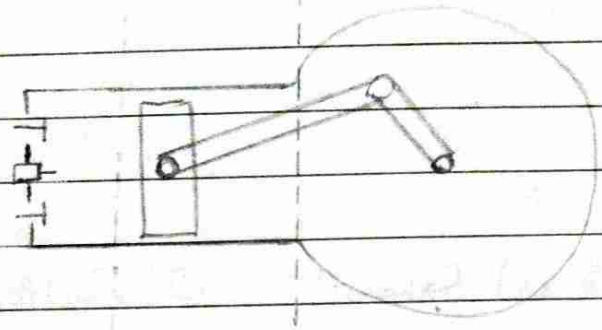

TDC BDC

1. Suction stroke → The piston moves from TDC to BDC by the revolution of crank shaft. The inlet valve is open and outlet valve remain close during this stroke.

~~2 stroke engine~~

2. Compression stroke → During this stroke the piston moves from BDC to TDC. Both the value remain close in this stroke. The fuel (diesel) is injected in this stroke by injector. The fuel and air mix here.

3. Expansion / power / working stroke → Here, fuel - air mixture get compressed by the movement of piston from TDC to BDC because of compression pressure. Both valve remain close in this stroke. The work is obtained in this stroke.

4. Exhaust stroke → During this stroke inlet valve remain close and outlet valve is open and the burned gases are moved to the environment by the movement of piston from BDC to TDC. Here cycle is completed.

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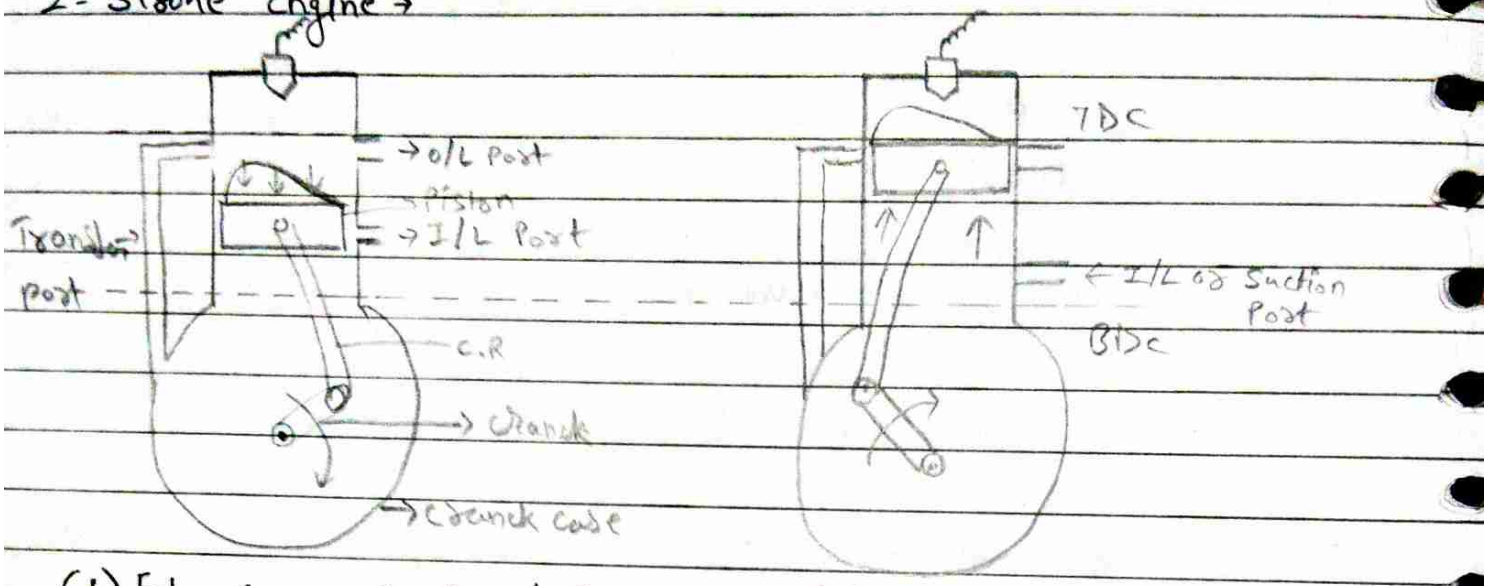
• 2-Stroke Engine →




(1) Expansion or Power and Exhaust (2) Suction and compression.

In two stroke cycle engine the whole sequence of events that is suction, compression, power or expansion and exhaust are completed in two stroke of the piston or one revolution of the crank shaft. There is no valve in this type of engine, fuel/gas movement take place through holes called ports in the cylinder. The crank case of the engine is air-tight in which the crank shaft rotates.

Upward stroke of the piston (suction ~~or~~ compression)

When the piston move upwards it covers two of the ports exhaust port and transfer ports, which is normally are opposite to each other. This trap the charges of air-fuel mixture burn already into the cylinder.

Further upward movement of the piston compress the charge and also uncover the suction port and fresh mixture of fuel ~~and~~ air into the crank case. Just before the end of this stroke, the mixture ~~is~~ in the cylinder is ignited by the spark plug. Thus, during this stroke both suction and compression is completed

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Downward stroke of the piston (Exhaust and Expansion or Power)

- Burning of the fuel rises the temperature of the fuel and gases which force the piston to move down. When the piston move down it close the suction port and trapping the fresh charge drawn into the crank case during previous upward stroke.
- Further downward movement of the piston uncover first the exhaust port and then the transfer port. Now, the fresh charge in the crank case moves into cylinder through transfer port and driving out the burned gases.
- Special shape piston crown deflecting the incoming mix. up around the cylinder so that it can help in driving out the exhaust gases.
- During the downward stroke of the piston power and Exhaust strokes are completed.

- Difference between 4-stroke and 2-stroke engine.

| 4 - Stroke | 2 - Stroke |
|---|---|
| 1. Whole cycle is complete in 2 revolution of crank shaft. | 1 whole cycle is completed in 1 revolution of crank shaft. |
| 2. Valves are used. [Inlet and outlet] | 2. Ports are used. [Inlet and outlet] |
| 3. Flat head piston is used. | 3. Crown head piston is used. |
| 4. Fuel completely used in 4 stroke Fully consumed | 4. Few quantity of fresh fuel is out in 2 stroke. Partially consumed due to ~~scavenging~~ Scavenging |
| 5. Effeciency is high | 5. Effeciency comparitively low |
| 6. Weight of engine is more. | 6. Weight of the engine is less. |

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| | |
|---|---|
| 7. Removal of exhaust gases is easy. | 7. Removal of exhaust gases is compatibility difficult. |
| 8. | |
| 8. In 4 stroke, flywheel is thick or big. | 8. In 2 stroke, flywheel is thin or small. |

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- Difference between Diesel Engine and Petrol Engine.

| Diesel Engine | Petrol Engine. |
|---|---|
| 1. Diesel is used as a fuel in diesel engine. | 1. Petrol is used as a fuel in petrol engine. |
| 2. It has no carborator, ignition coil and spark plug. | 2. It has carborator, ignition coil and spark plug. |
| 3. Compression ratio varies from 14:1 to 22:1 | 3. Compression ration varies from 5.2:1 to 8:1 |
| 4. Only air is sucked during suction stroke | 4. Mixture of air - petrol is supplied during suction stroke |
| 5. Engine weight per horsepower is high. | 5. Engine weight comparitively low. |
| 6. operating cost is low. | 6. Operating cost is high. |

- Define Scavenging process →

→ Scavenging is the process of replacing the exhaust gas in a cylinder with fresh air-fuel mixture for the next cycle. If scavenging is incomplete the remaining exhaust gas can cause improper combustion for the next cycle and leading to reduce power output.

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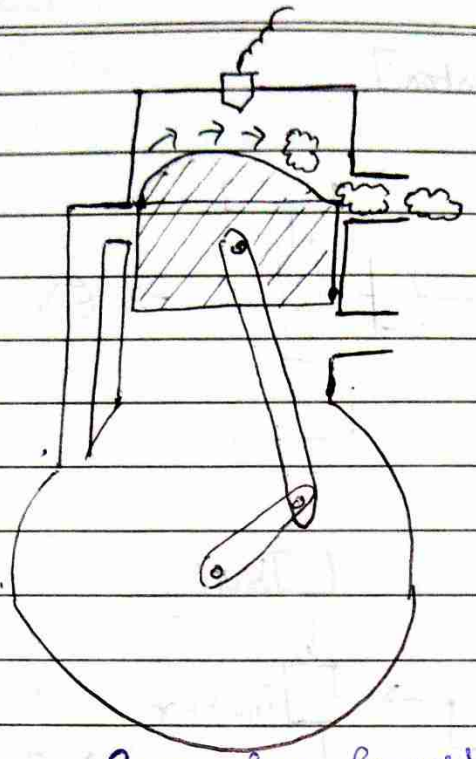

Scavenging Process

- Electric Vehicle (EV) → An electric vehicle (EV) also called "electric drive vehicle", it use one or more electric motors or traction motors for propulsion. An electric vehicle maybe powered to a collector system by electricity from off vehicle sources or may be self contained battery, solar panel or generator to convert fuel to electricity. An electric vehicle contains main three parts → 1. Energy source
  2. Power convertor
  3. Traction motor

1. Energy Source → It consists of rechargable batteries, ultra capacitors and fuel cells. The electronic controller controls the flow of power from energy source to traction motor.

2. Power convertor → It adjust the voltage according to the load demand.

3. Traction motor → Li-ion batteries are better preffered as energy source because of long life and higher ~~dens~~ energy density but it is not economically feasible.

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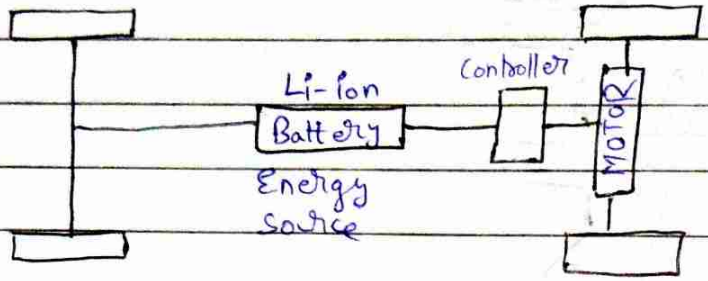
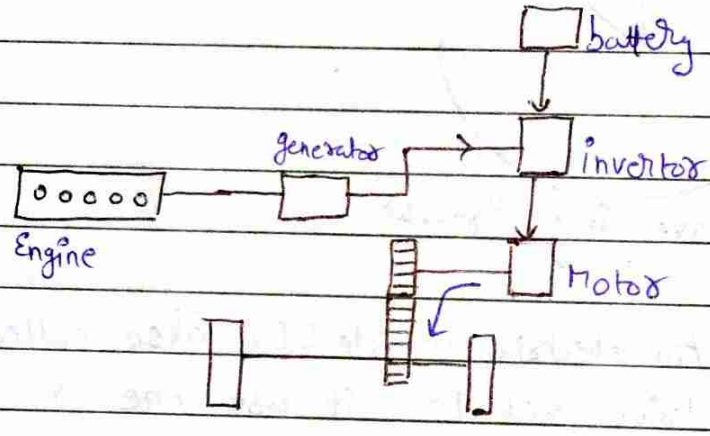
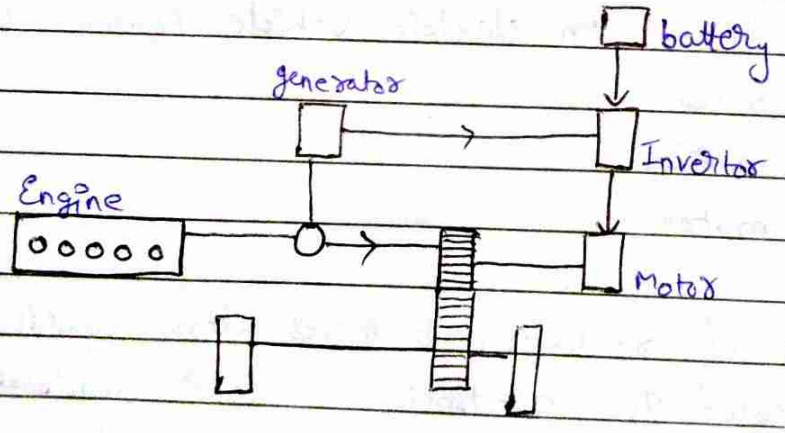
- H.E.V. → [Hybrid Electric motor]



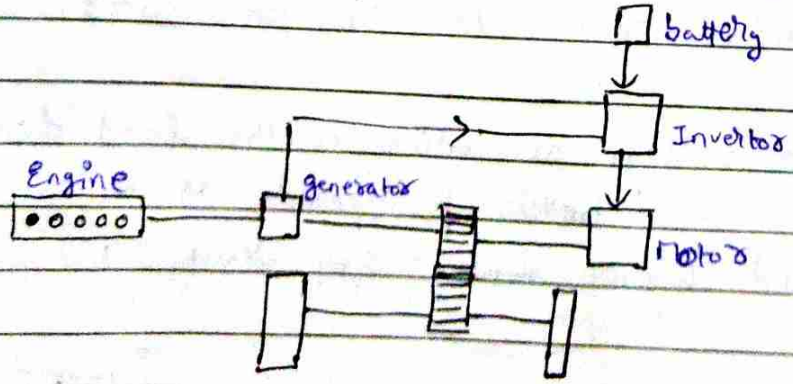

→ EV




→ Series hybrid vehicle




→ Parallel Hybrid vehicle




→ Series and Parallel hybrid vehicle

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- A hybrid vehicle combines any two power sources. Possible combination include diesel/electric, gasoline/flywheel, and fuel cell/battery.
- Typically one energy source is storage and the other is conversion of a fuel to energy.
- The combination of two power sources may support two seperate propulsion system. In general hybrid electric vehicle combine a gasoline engine with a electric motor and alternate arrangement is diesel engine with a electric motor.
- These two power sources may be paired in series meaning that the gas engine charges the battery of an electric motor that powers the car. In parallel both the mechanism drive the car directly.

- Series Hybrid System →

This is called series hybrid system because the power flow to the wheels in a series. A series hybrid system can run a small output engine in the effecient operating region relatively steadily generate and supply electricity to the electric motor and efficiently charge the battery.

- Parallel Hybrid System →

In Parallel Hybrid System both the electric engine and motor drives the wheel and the drive power from these two sources can be utilised according to the conditions.

- Series and Parallel Hybrid System →

This maximise both series and parallel system. It has two motors and depending on the driving conditions uses only the electric motor or the driving power from both the electric motor and engine. This is the system used in the advance hybrid vehicle.

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- The benefit of EV and HEV compare with conventional Vehicle

1. Zero pollution / carbon emission in EV.
2. The electric motor is more efficient than compare to IC Engine
   (70 - 80%) (30 - 40%)
3. EVs can use regenerative braking system. and can regain 30% of energy used.
4. HEVs are more enviormentally friendly and operating cost is economical. However, installation cost is higher.