Chapter 5 : CI Engines

The ideal combustion in CIE should have:

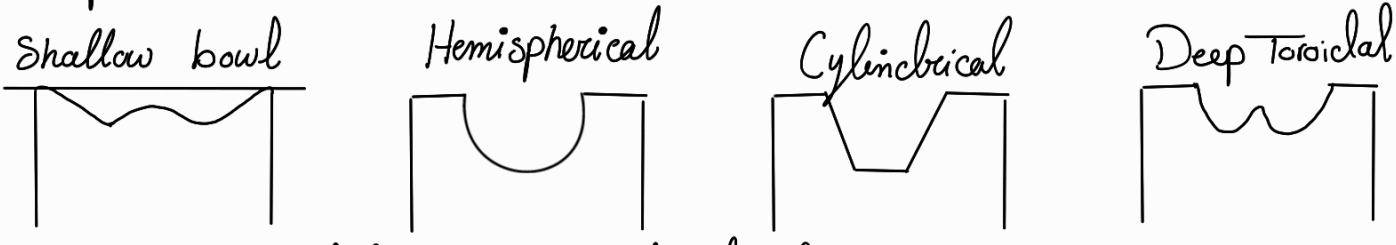
1. High output → bmep
2. High efficiency
3. Rapid combustion
4. Clean exhaust
5. To be Silent-

Combustion Chambers

- CC
  - → Direct injection: Injector → Main chamber
  - → Indirect injection : Injector → swirl chamber → Main chamber

Direct injection

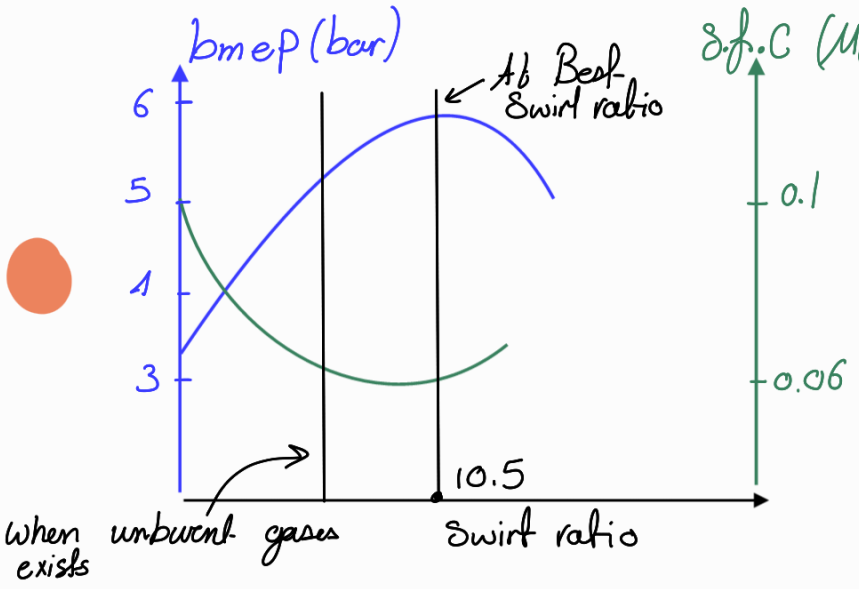
- Air motion inside the cylinder is a critical design requirement
- Shapes



- Swirl : The rotation of air about the cylinder axis

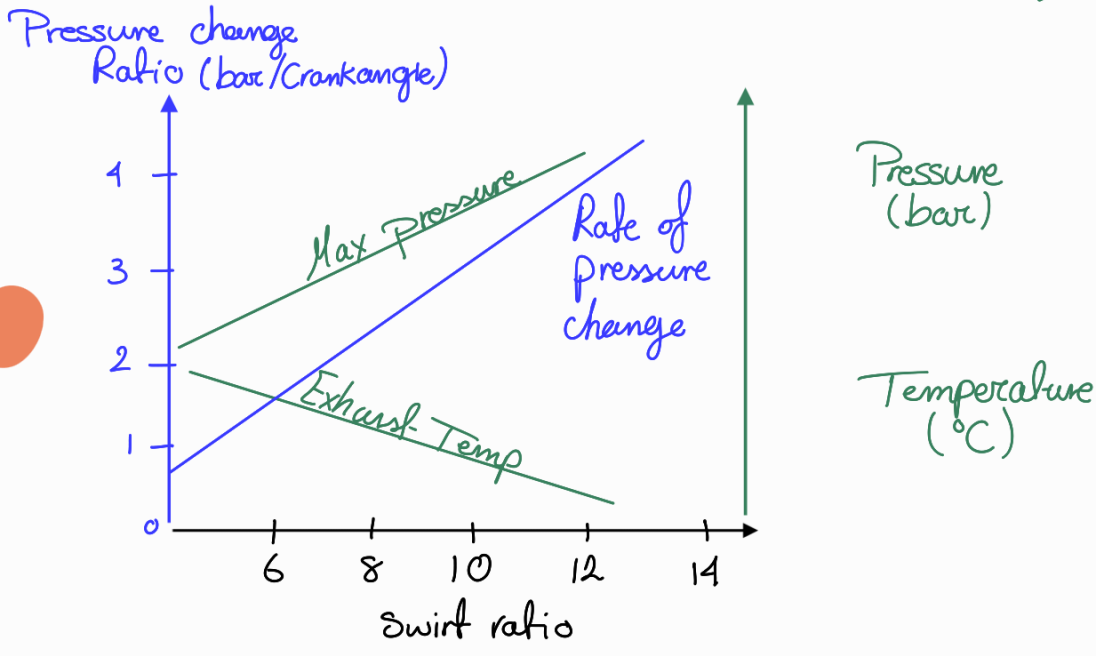
Swirl ratio = $\frac{\text{Swirl speed}}{\text{engine speed}}$

→ Induced by swirl ducted or masked inlet valves + Design of inlet passage



Note

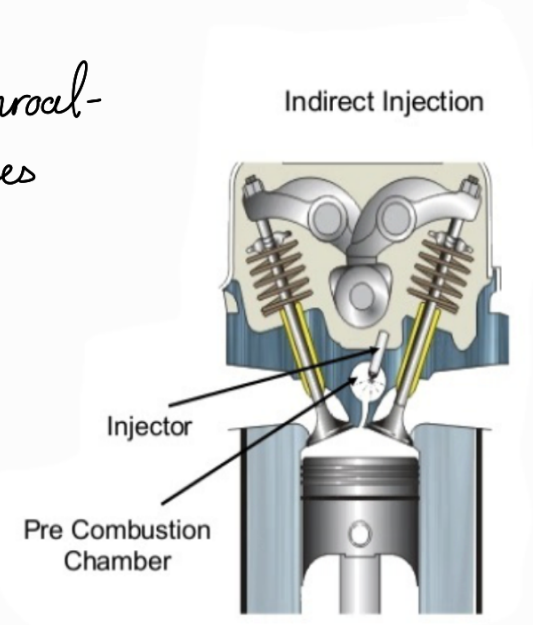
Power decreases after max value: due to centrifugal effect losses. Air is pushed to the cylinder wall where heat transfer is high which reduces cylinder pushing force



- When swirl ratio is increased, pressure and pressure change increases which results in noise and rough running

Indirect injection

- It has a divided Combustion chamber (pre-chamber (P.C))
- Results of this design:
  1. High air velocity through the throat- in the compression stroke → Causes turbulence in P.C
  2. High pressure rise in P.C
  3. Mixing process is accelerated
     Why? Because an incomplete combustion occurs in the pre chamber since air is insufficient
     This combustion increases the pressure in the P.C and so unburned fuel with P.C combustion are pushed to the main chamber with high velocities which causes rapid mixing with air in the main chamber

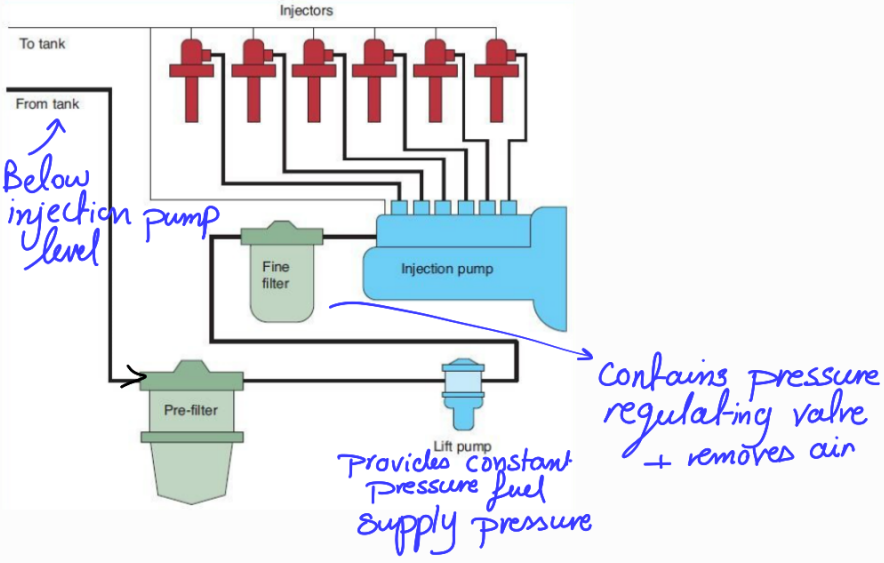


Advantages & disadvantages of indirect- injection

- Check Slide 14 & 15

Fuel System in CIE

- The system has two filters
  The Secondary filter (fine filter) is more accurate than the Pre-filter (Primary filter)
- There are two pumps in the System.



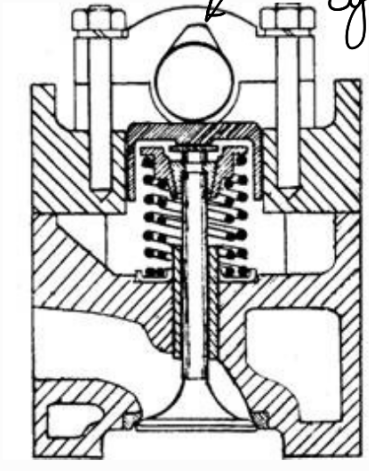
Induction and exhaust processes

(Back to Slide 19

- Controlled by valves in the combustion chamber
- Valves:

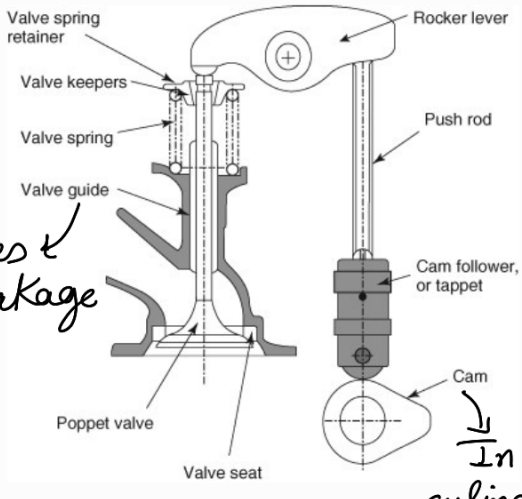
Poppet valve:

- Overhead valve: (camshaft) → . is located in cylinder head
- Cam shaft is mounted in the cylinder block or in the cylinder head (overhead camshaft)



Camshaft in the cylinder head

- less weight
- higher valve low area to piston area
- less friction and easy lubrication
- Good flow properties
- High Texhaust
- Difficult cooling and so hot spots are generated
- Material should resist T



causes ↓ leakage

In the cylinder Block

- Higher weight
- less valve low area to piston area

Flow characteristics

Orifice area :

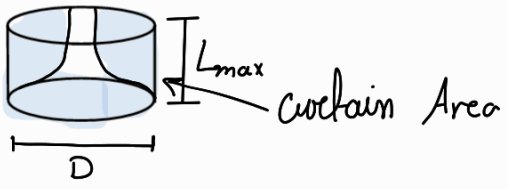
$A_e = \pi D L$

- D: Valve diameter
- L: Valve lift
- A_e: Effective area (real mass flow rate)

Discharge coefficient :

$C_D = \frac{A_e}{A_c}$

- A_c: curtain area : The area created at maximum valve lift
- C_D: varies with valve lift and flow rate



- For the exhaust valve:

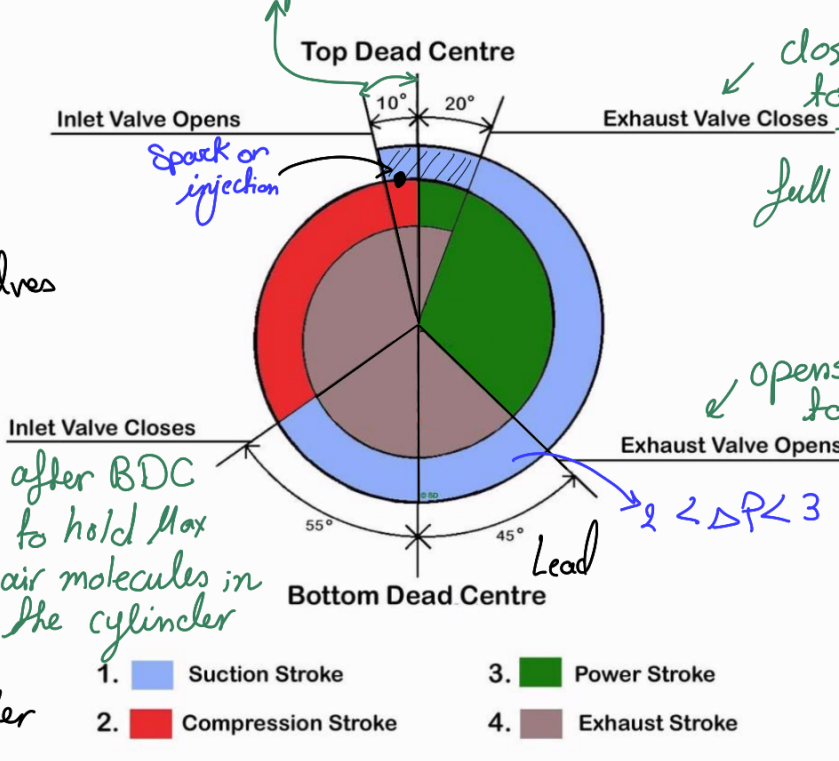
Range of pressure ratios are larger than inlet valves and so area of exhaust valve is less by 85%

Valve timing

Over lap period:
Period at which both inlet and exhaust- valves are opened

Blow down period
It is the period in which exhaust- gases escape from the cylinder

This period compensates for slow operation (assures silent operation)

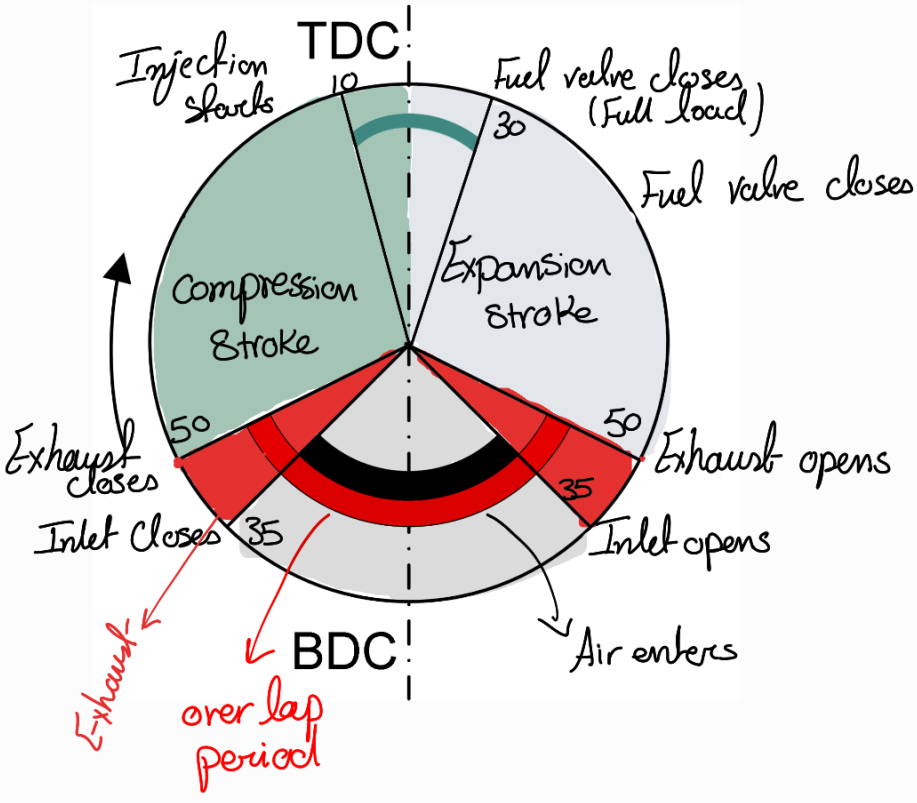


$2 < \Delta P < 3$

Note: In SIE over lap is larger to prevent back flow due to low pressure / Not economical at full load since unburned gases will flow pass through the engine

Two stroke timing

- Timing is controlled by the ports
- Overlap period occurs near the BDC



Note

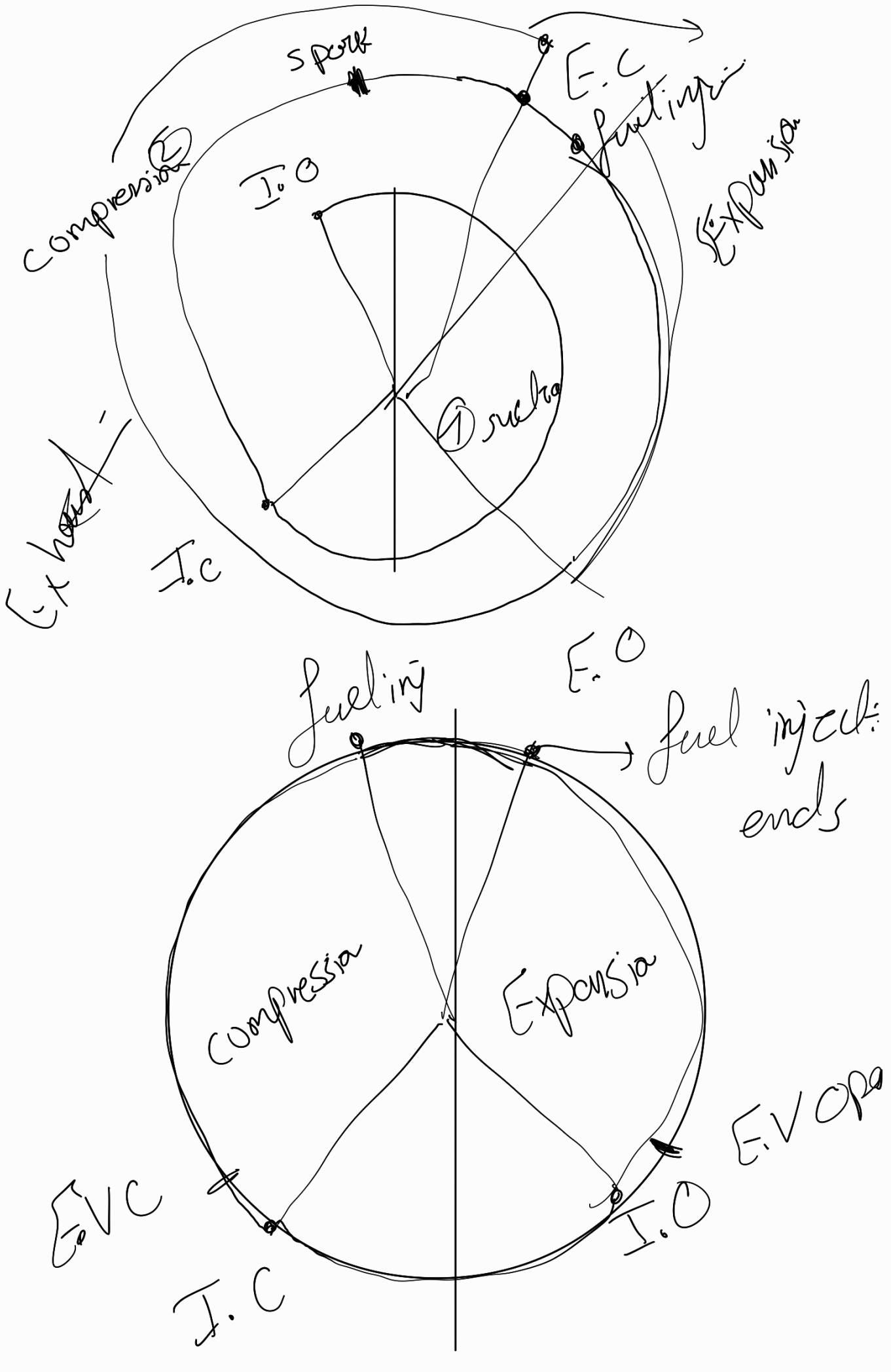
Oil leakage is caused by:

- Piston rings
- Valve guide
- Head gasket

- If oil is leaked to combustion chamber → Blue smoke results

Note

- Black smoke → Incomplete combustion → particulats if diesel engine
- White smoke → Water vapor → CO if gasoline engine


spark
E.C
Fueling
Compression
I.O
Expansion
Suction
Exhaust
I.C
Fueling
E.O
Fuel injection ends
Compressia
Expansia
EVC
E.V opens
I.C
I.O