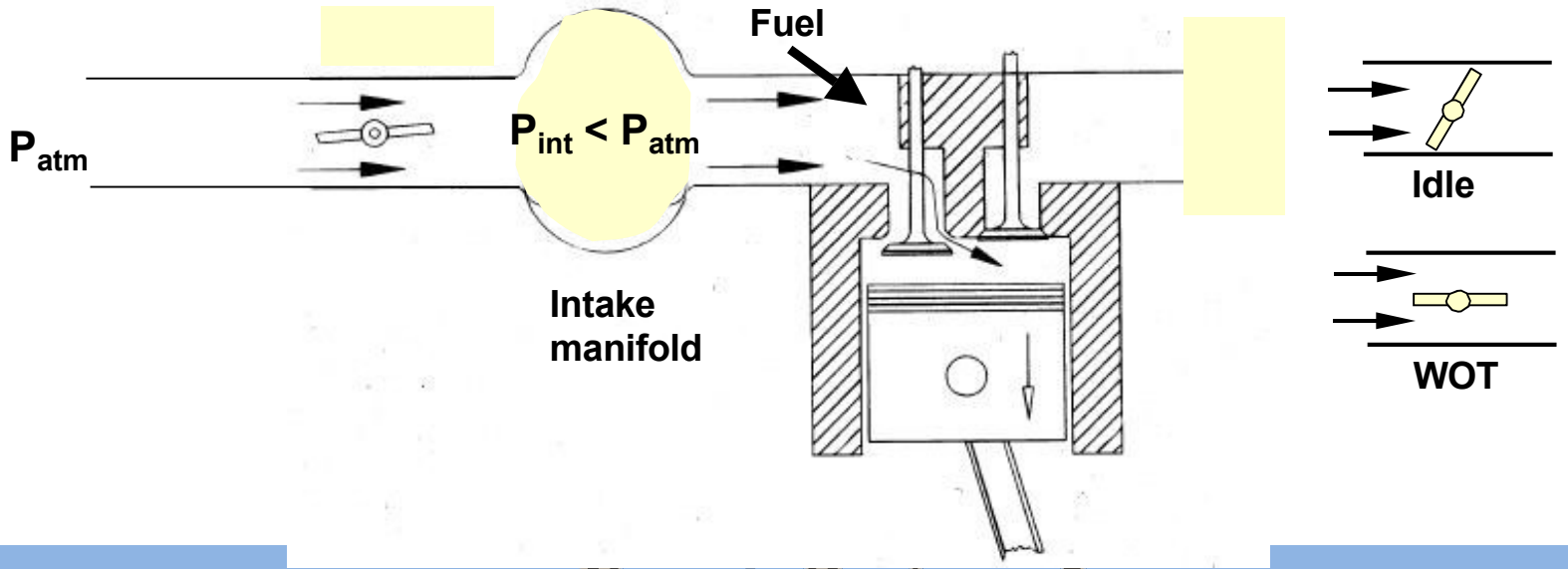
Power Regulation

Power can be increased by:

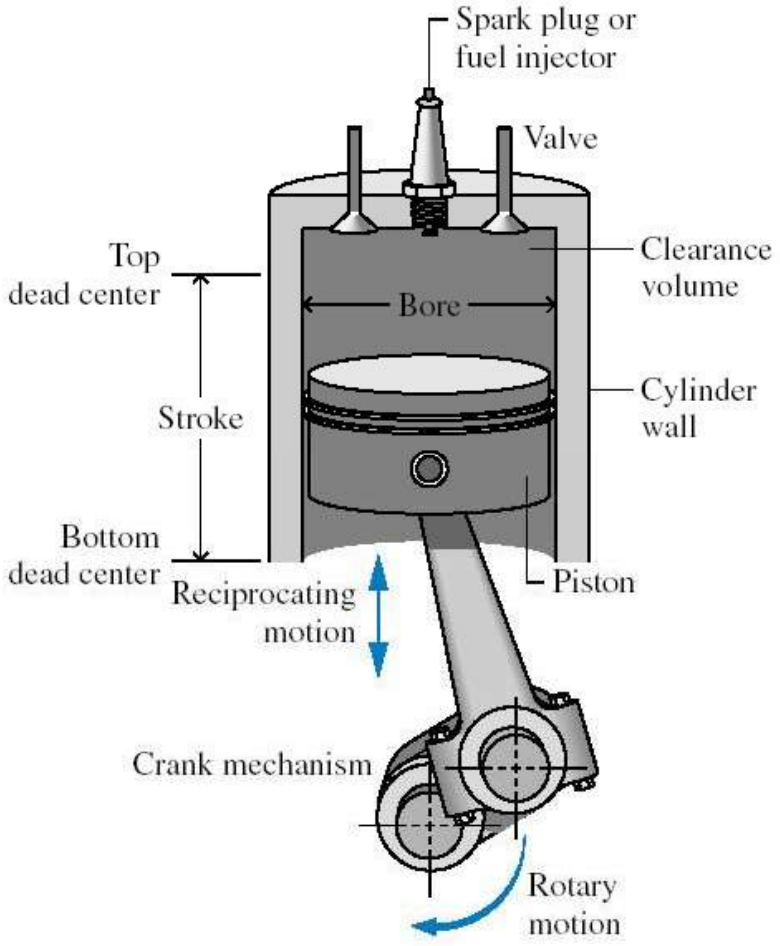
- the engine size, V_d
- compression ratio, r_c
- engine speed, N

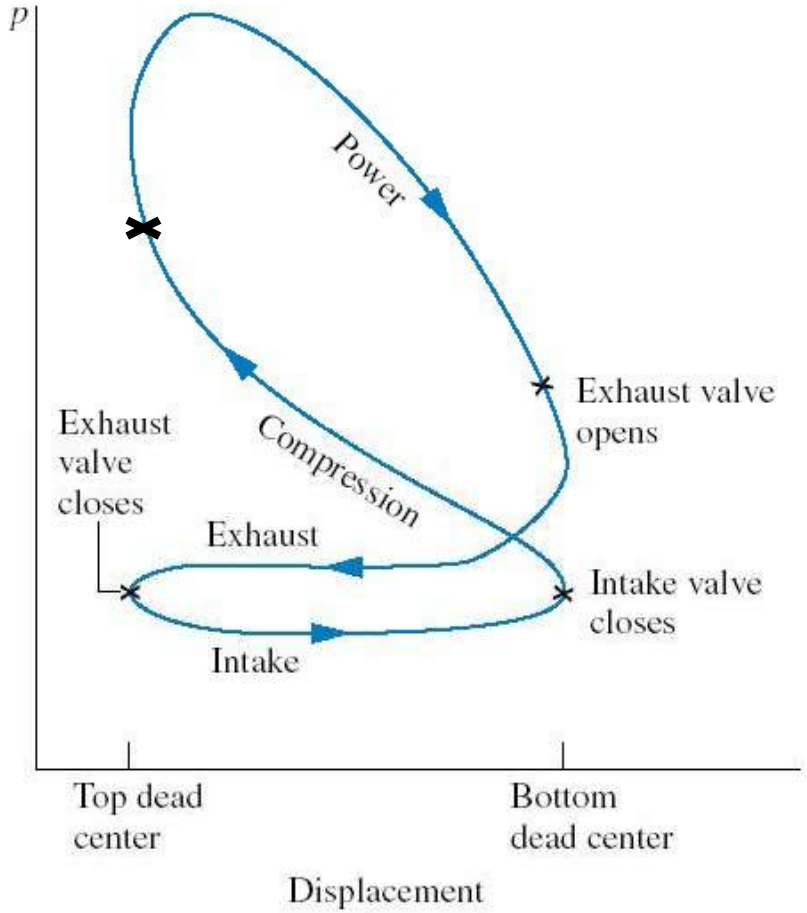
•An IC engine is basically an air engine, the more air you get into the cylinder, the more fuel you can burn, and more the power you get.

•Vary throttle position - Maximum intake pressure (and power) achieved at wide-open-throttle (WOT), and minimum at idle.

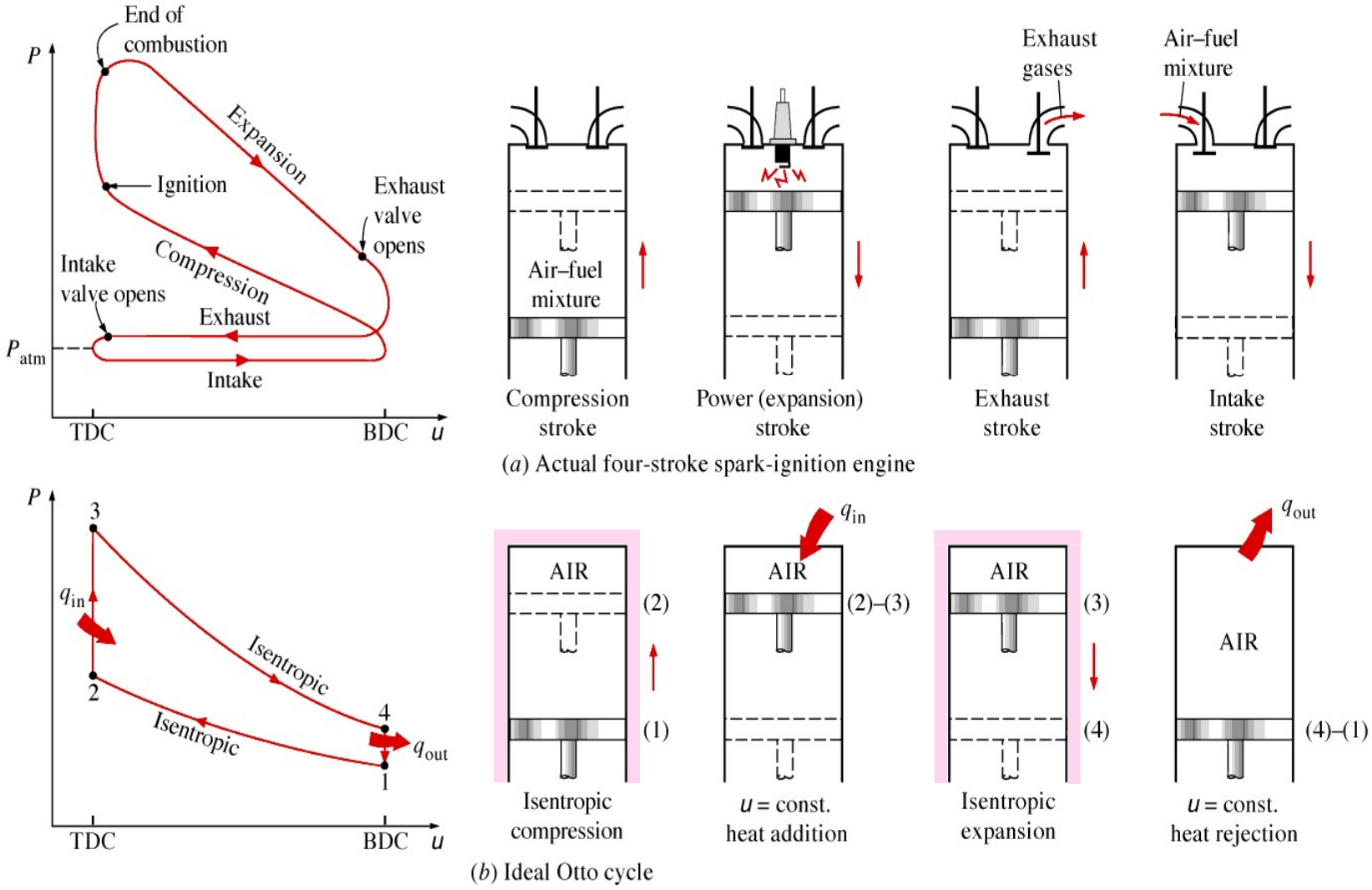


Internal Combustion Engine

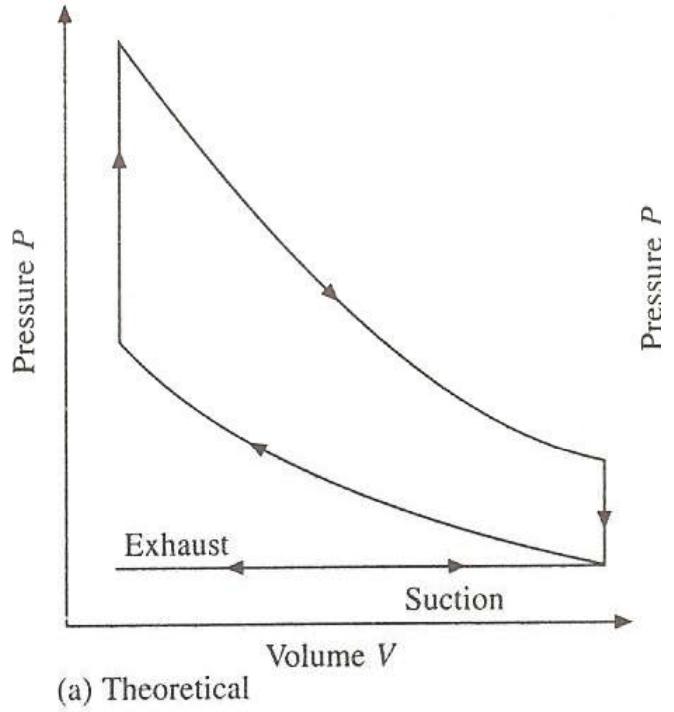


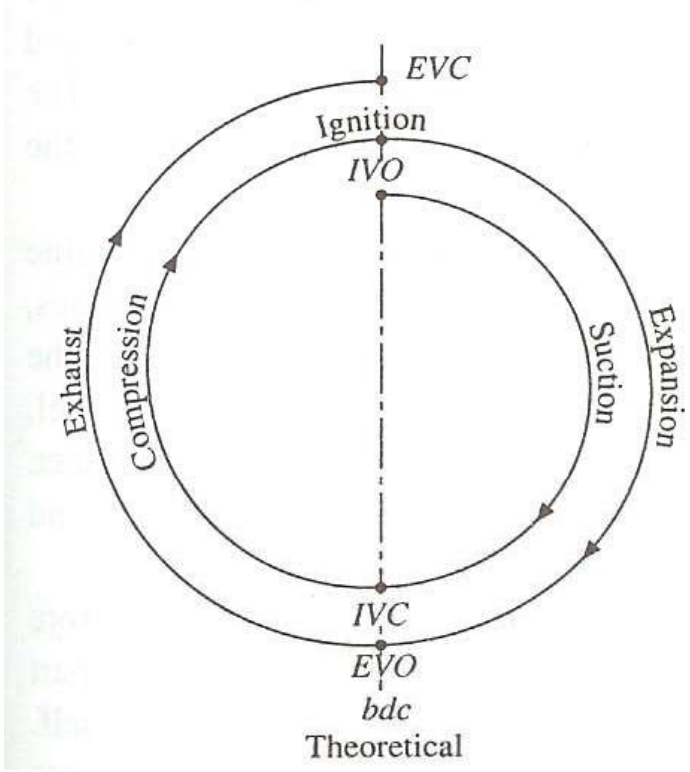


Actual and Ideal Cycles in Spark-Ignition Engines and Their *P-v* Diagram



Typical Theoretical P-V and Valve Timing Diagrams of a Four Stroke Spark Ignition Engine





Observations:

P-V diagram shows sharp edges

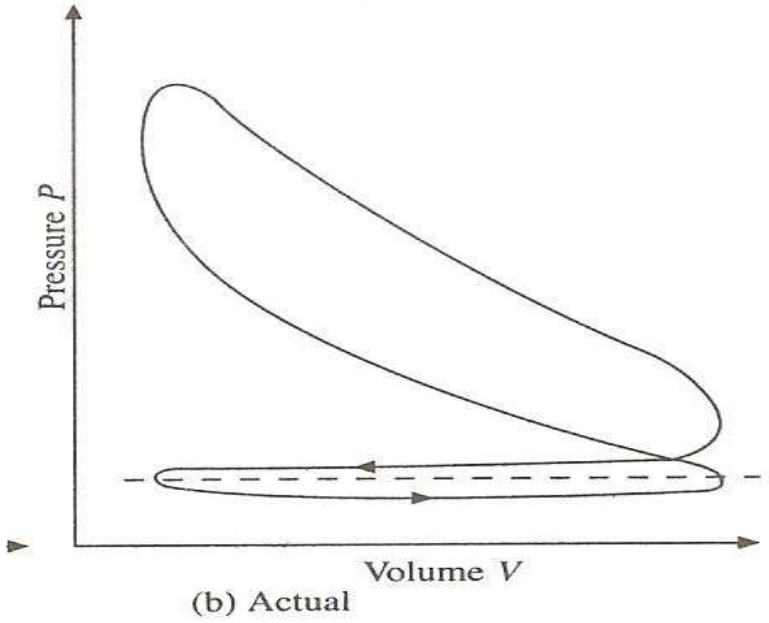
i.e., valves open/close instantaneously at dead centres

Actual Case:

Inlet and Exhaust Valves open/close before and after dead centres

- ✓ **Mechanical Factor**
- ✓ **Dynamic Factor of Gas Flow**

- ✓ **Valves are opened and closed by cam mechanism**
- ✓ **Valves will bounce on its seat if closed abruptly**
- ✓ **Opening/closing of valves spread over a certain crank angle**



(b) Actual

Every Corner in the P-V diagram is ROUNDED

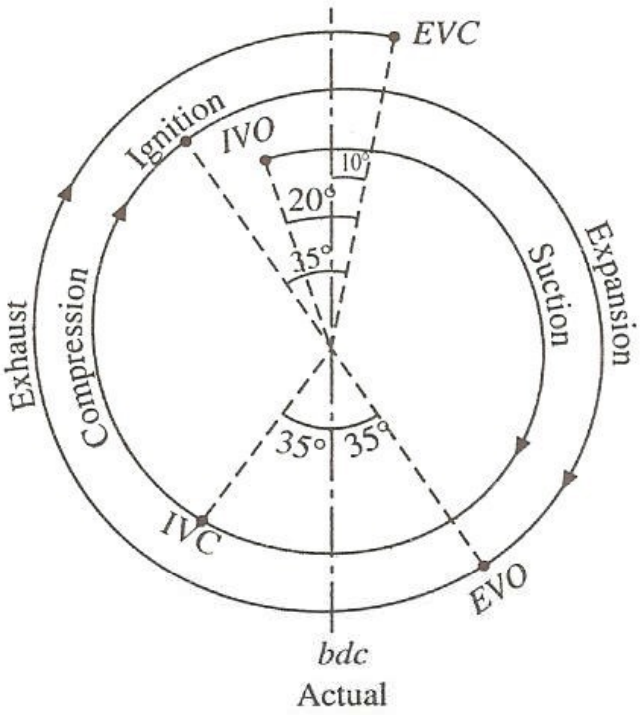
IV opens 20^0 before TDC.

IV closes 35^0 after BDC to take the advantage of momentum of rapidly moving gases (Ram Effect).

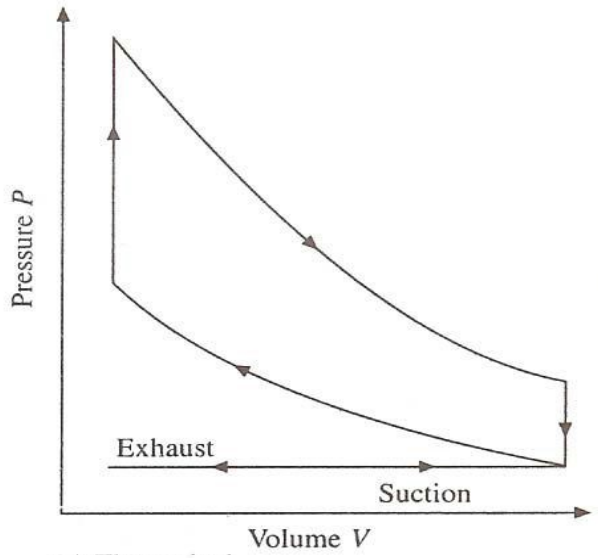
Ignition occurs 35^0 before TDC; this is to allow the time delay between the spark and commencement of combustion.

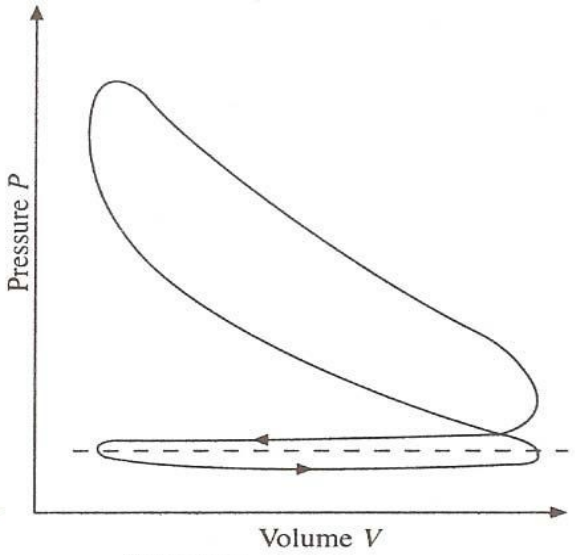
EV opens at 35^0 before BDC; else pressure will rise enormously, and the work required to expel the gas will increase.

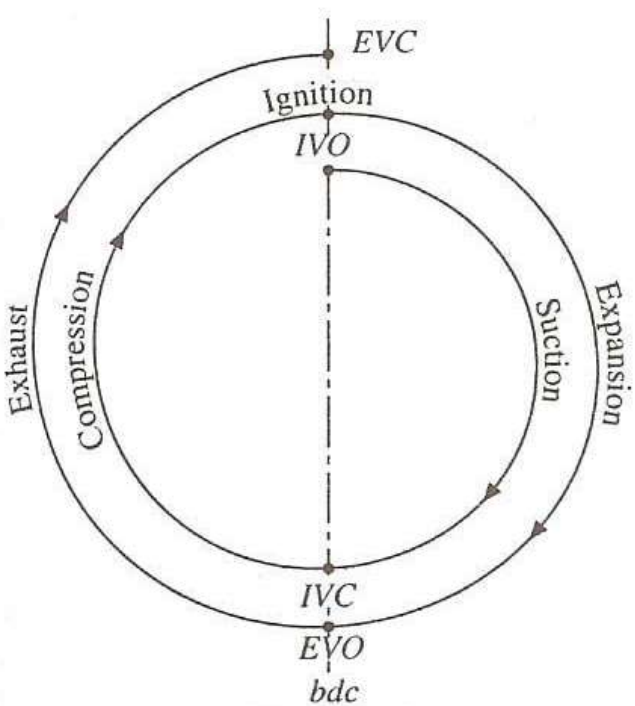
EV closes at 10^0 after TDC; this is to increase the volumetric efficiency.



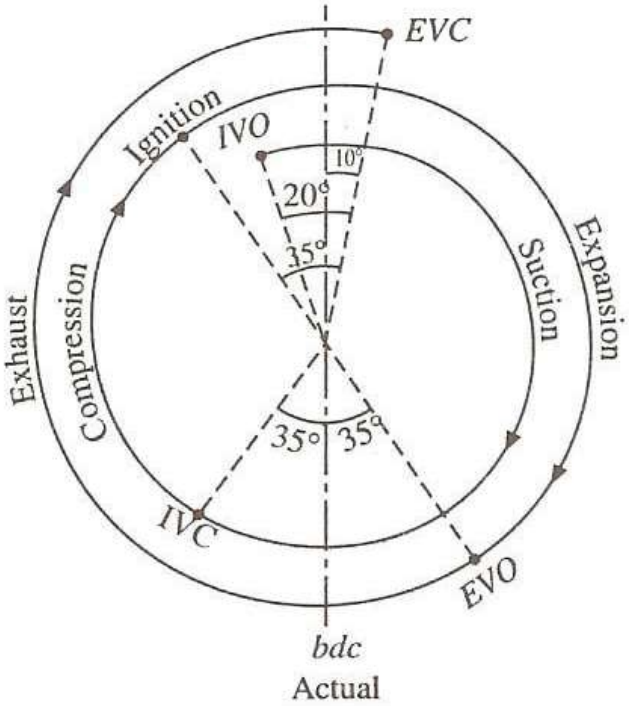
Actual Valve Timing Diagram of a Four-Stroke Spark Ignition Engine







Theoretical



Actual

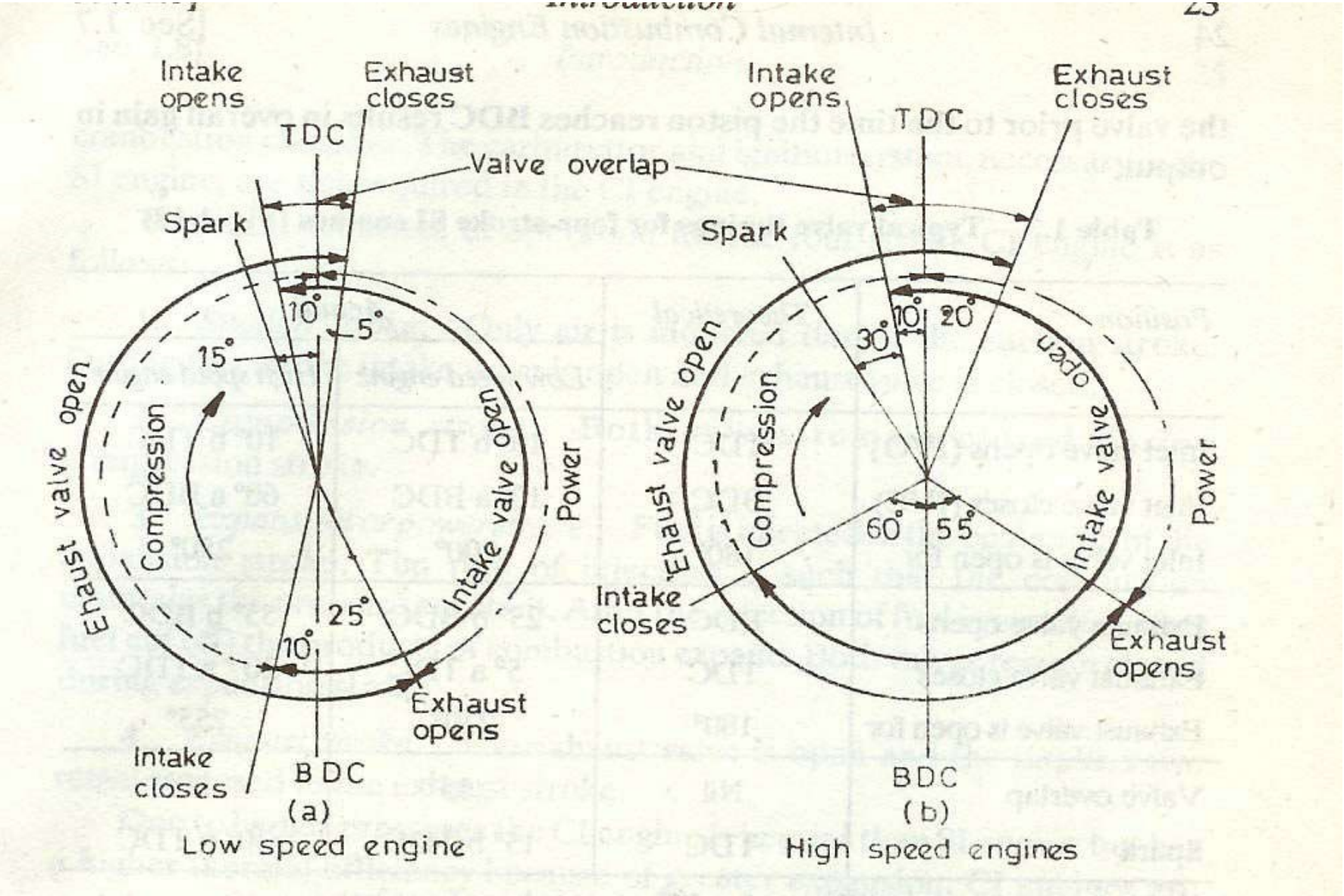
Remark

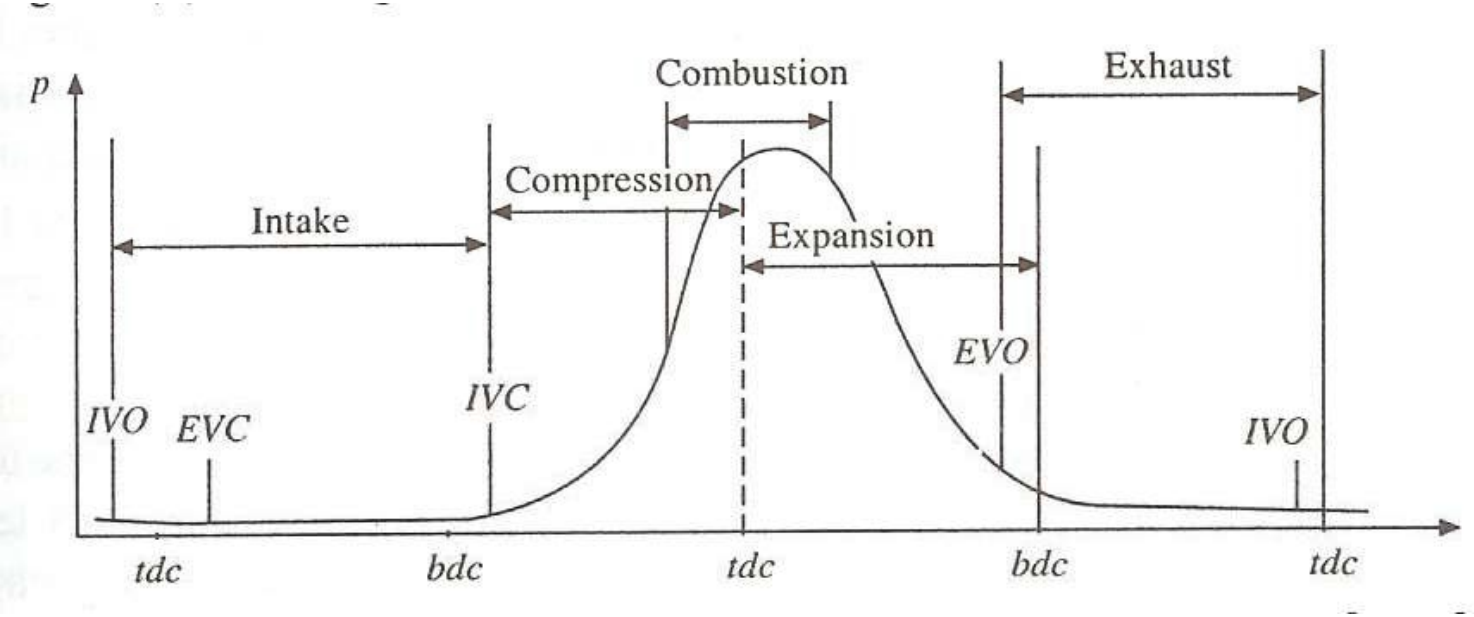
Valve Overlap: ***The time during which both the valves (inlet and exhaust) remain open at the same instant.***

The values quoted in the actual valve timing diagrams are the typical values, and may vary from engine to engine.

For HIGH SPEED engines, higher values of angles are desirable to take into account the short time interval.

Valve Timing for Low and High Speed Four-Stroke Spark Ignition Engines

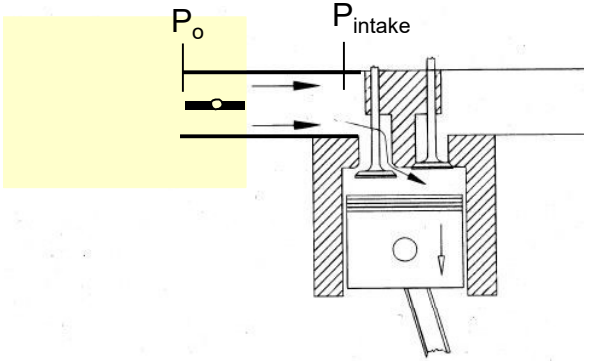


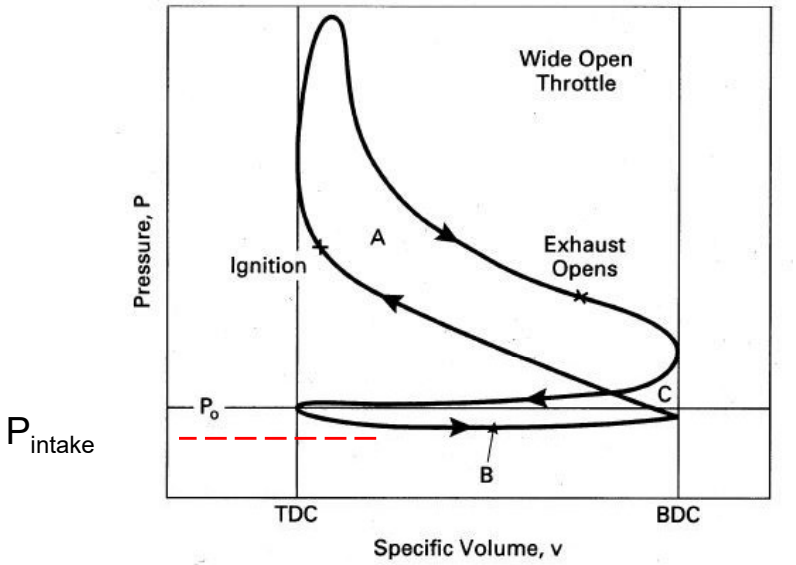


Sequence of Events in a Four-Stroke Spark Ignition Engine – Pressure vs. Crank Angle

p-V diagram of a Four Stroke SI Engine at WOT

The pressure at the intake port is just below atmospheric pressure

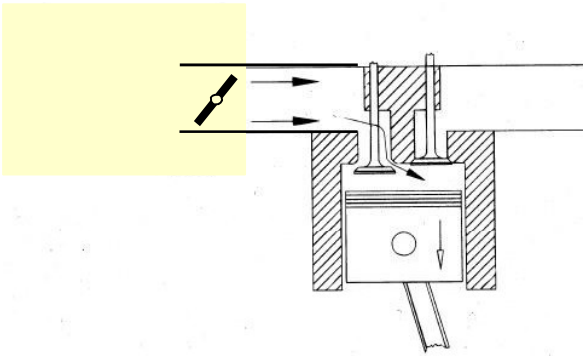


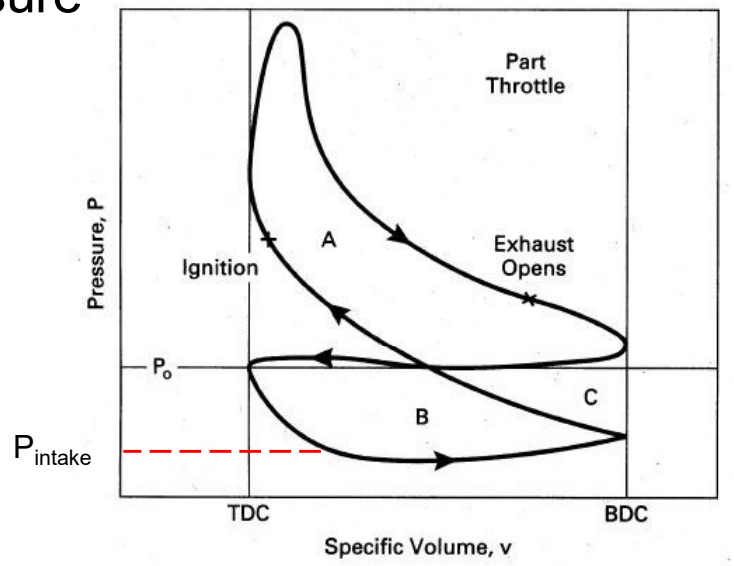


The upper loop consists of compression and power strokes and the area represents positive indicated work. The lower loop indicates negative work of the intake and exhaust stroke. This is called indicated pumping work.

p-V diagram of a Four Stroke SI Engine at Part-Throttle

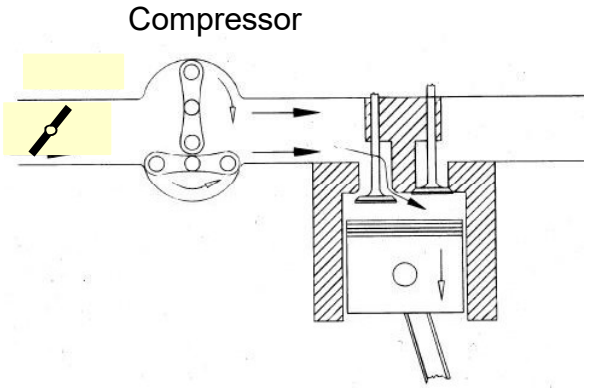
The pressure at the intake port is significantly lower than atmospheric pressure

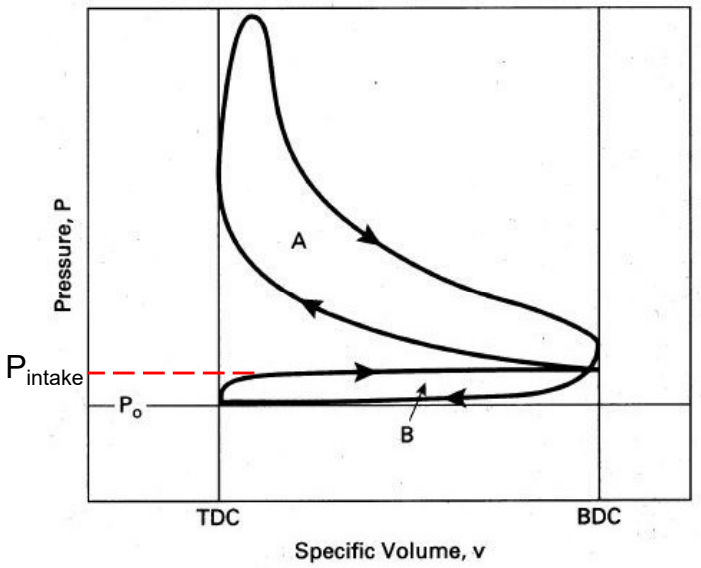




The upper loop consists of compression and power strokes and the area represents positive indicated work. The lower loop indicates negative work of the intake and exhaust strokes. This is called indicated pumping work.

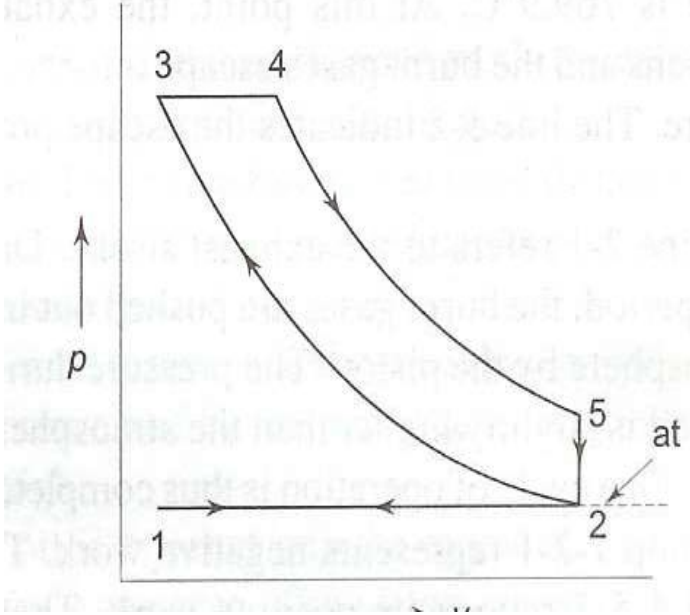
p-V diagram of a Four Stroke SI Engine with Supercharger

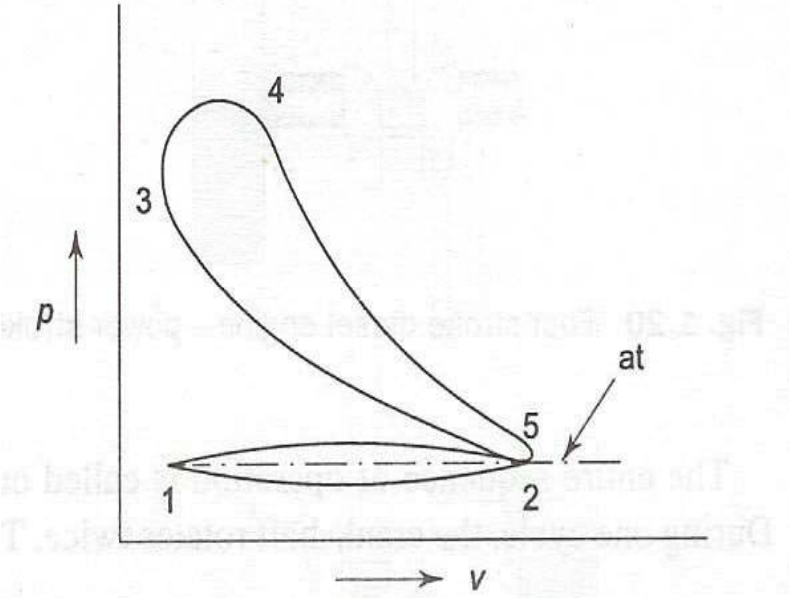




The engines with superchargers or turbochargers have intake pressures greater than the exhaust pressure, yielding a positive pump work.

Typical Theoretical and Actual p-V Diagrams of a Four-Stroke Compression Ignition Engine

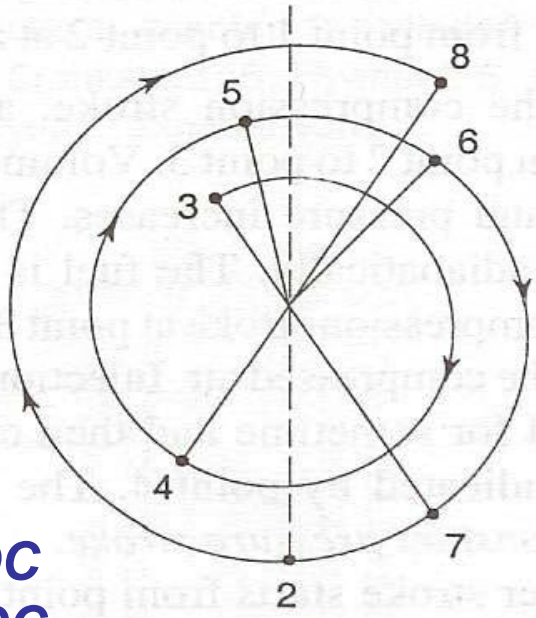




Actual Valve Timing Diagram of a Four-Stroke Compression Ignition Engine

1. TDC
2. BDC

3. IV opens at 25^0 before TDC
4. IV closes at 30^0 after BDC



5. Fuel injection starts at 5^0 before TDC
6. Fuel injection closes at 25^0 after TDC

7. EV opens at 45^0 before BDC
8. EV closes at 15^0 after TDC

Valve Timing – 4 Stroke SI Engine

Valve timing angles:

		Open	Close	Duration
Intake	Conventional	5° before tdc	45° after bdc	230°
	High performance	30° before tdc	75° after bdc	285°
Exhaust	Conventional	45° before bdc	10° after tdc	235°
	High performance	70° before bdc	35° after tdc	285°

Conventional engines operate at low rpms, with idle and part load important
High performance engines operate at high rpms at WOT, with power and volumetric efficiency important

At high engine speeds, less time available for fresh gas intake so need more crank angles to get high volumetric efficiency ⇗ large valve overlap

At low engine speed and part throttle valve overlap is minimized by reducing the angle duration for valves staying open.

Variable Valve Timing used to obtain optimum performance over wide range