2.61 Internal Combustion Engines
Spring 2008

2.61 Internal Combustion Engines   Lecture 1

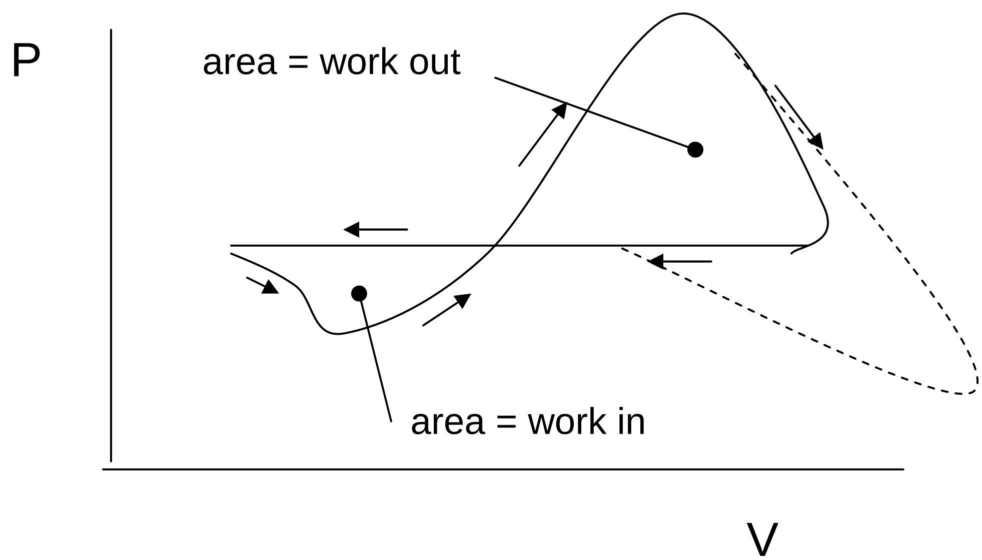
Engines

-There are two types of engines:

1. Internal combustion - combustion occurs in the working fluid
    - open cycle – the working fluid is replenished in each cycle
    - ie) exhaust gas is dumped into the atmosphere
2. External combustion – use of heat exchanger to transfer energy to the working fluid
    - Open or closed cycle
    - Ex) steam engine, sterling engine

History

1860 – Lenoir engine
- air and fuel were hand pumped
-"spark," or ignition was a candle / kerosene lamp →done all by hand
- operated at about 10 RPM
- 500 sold
- 2 stroke
-ignition occurs while still in the expansion stage
→limited expansion ratio
→ low efficiency (<5%)



(Graph: Lenoir and Otto engine shown, dashed portion shows Otto expansion)

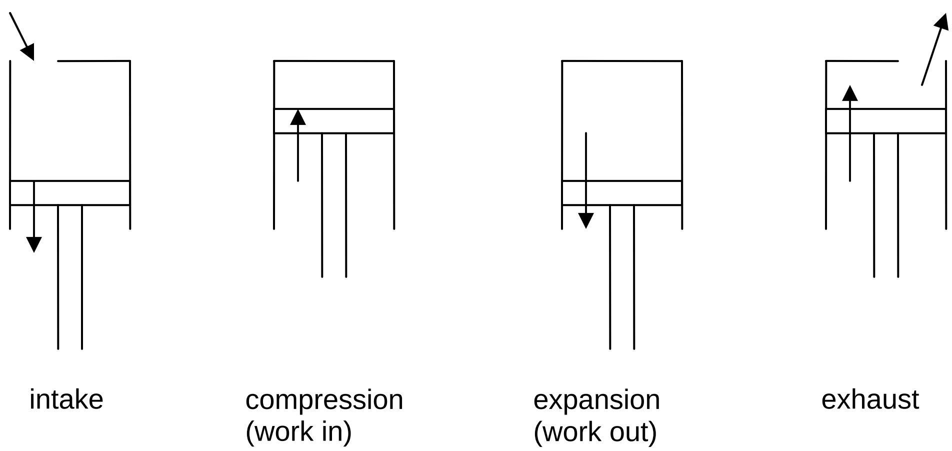
1867 – Otto engine (Nicholas Otto, Germany)
- used a rack and pinion flywheel as a crank
-efficiency was better than Lenoir (~11%)
- 4 stroke

1892 – Diesel engine (Rudolf Diesel, Germany)

Other Developments

1870 – Petroleum industry
1888 – Pneumatic tires
1905 – Spark plugs (Champion)
1920 – Internal Combustion Engine (ICE) takes over steam engine for transportation
- main advantage – don't need to carry around water
1920-1960 – steady development
1960 – Emission standards start
Heagen Smith – smog mechanism
1970 – Fuel crisis
1980 – Global competition
1990 – Greenhouse gases
2000 – Fuel and CO_2

4 stroke engine



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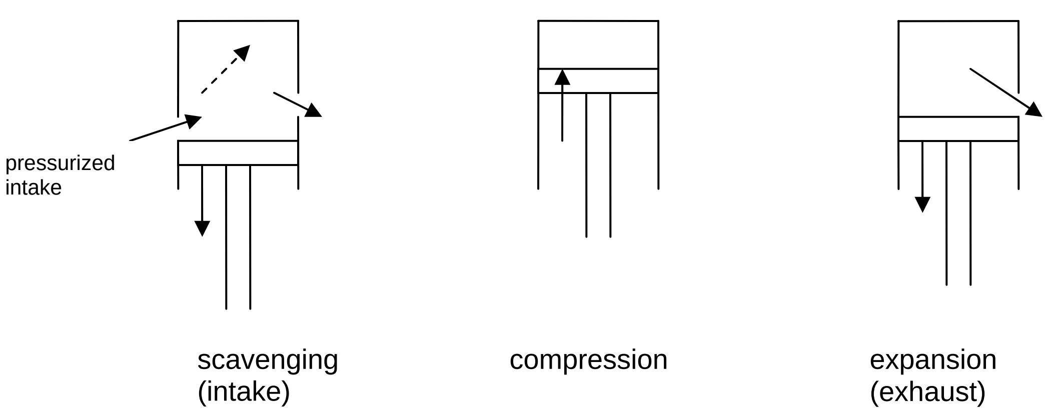
2 Stroke engine



Engine Size

-Piston bore ranges from 1 cm to 1m (large diesels)

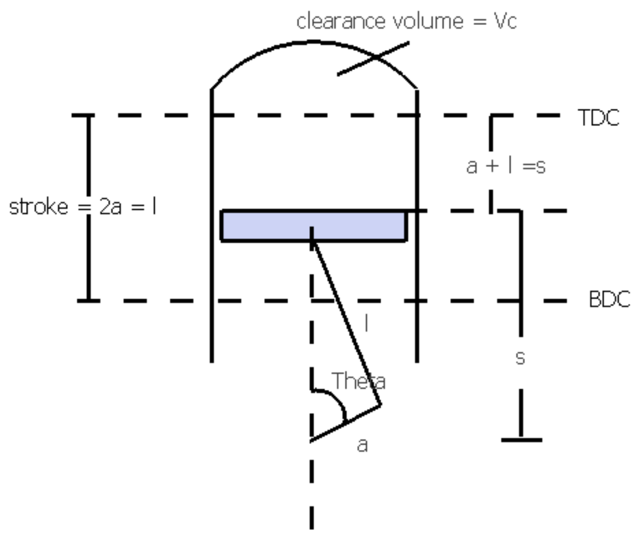
-heat loss and friction are surface phenomenon → bigger engine, less losses

Engine Geometry

Crank radius – a

Connecting rod length – l

Displacement volume - $V_d = \frac{\pi B^2}{4} l$



Compression ratio (geometric) - $C_R = \frac{V_D + V_C}{V_c}$

Piston position - $s(\theta) = a\cos\theta + \sqrt{l^2 + a^2 \sin^2\theta}$

Instantaneous volume - $V(\theta) = V_C + \frac{\pi B^2}{4} S$

$$\frac{V}{V_C} = 1 + \frac{1}{2}(C_R - 1)\left[R + 1 - \cos\theta - (R^2 - \sin^2\theta)^{0.5}\right]$$

Piston velocity

$$\dot{s}(\theta) = \left[-\sin\theta - \frac{\sin^2\theta}{2(R^2 - \sin^2\theta)^{0.5}}\right] a\dot{\theta}$$

where $\dot{\theta} = 2\pi N$ and N=RPM

Mean piston speed

$$S_p = 2NL$$

-typical numbers for engines

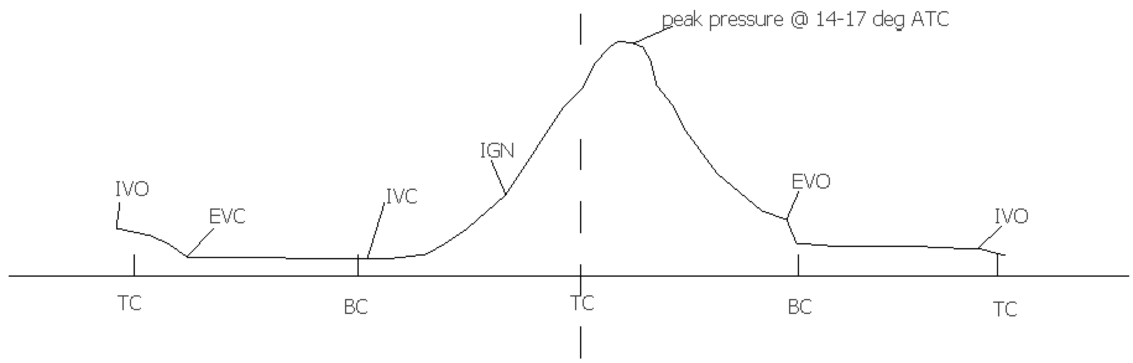
-L/B (stroke/bore) ~ 1 for passenger cars

-L/B ~0.2 for racing engines

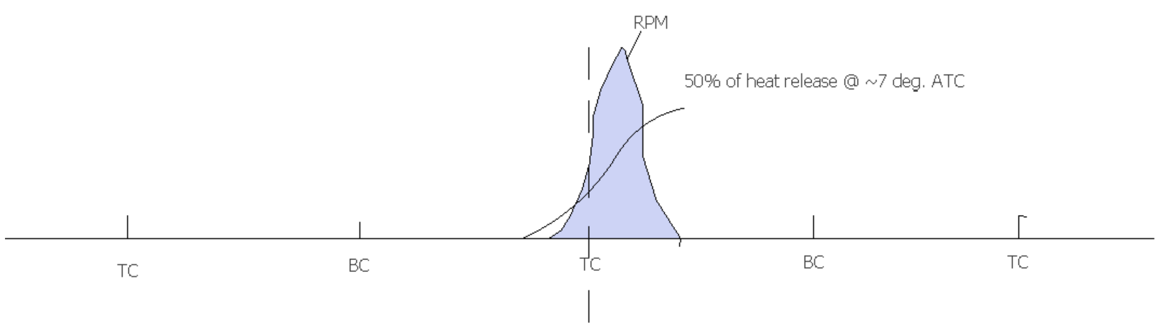
-L/B ~ 2 for large engines

-R = l/a is 3~4 for typical passenger cars

Pressures – normally aspirated 4 stroke SI



Heat release – normally aspirated 4 stroke SI



Pressure - normally aspirated 4-stroke Diesel