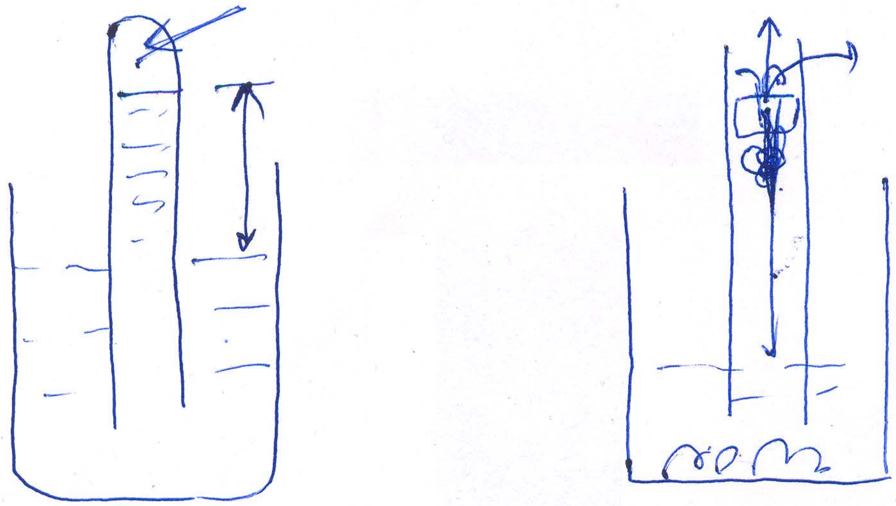
Applied Thermo-Fluids I ME30608
Part- Internal Combustion Engine Spring 2016-2017
3 - 1 - 0: 4 Credits
Indian Institute of Technology Kharagpur
Department of Mechanical Engineering

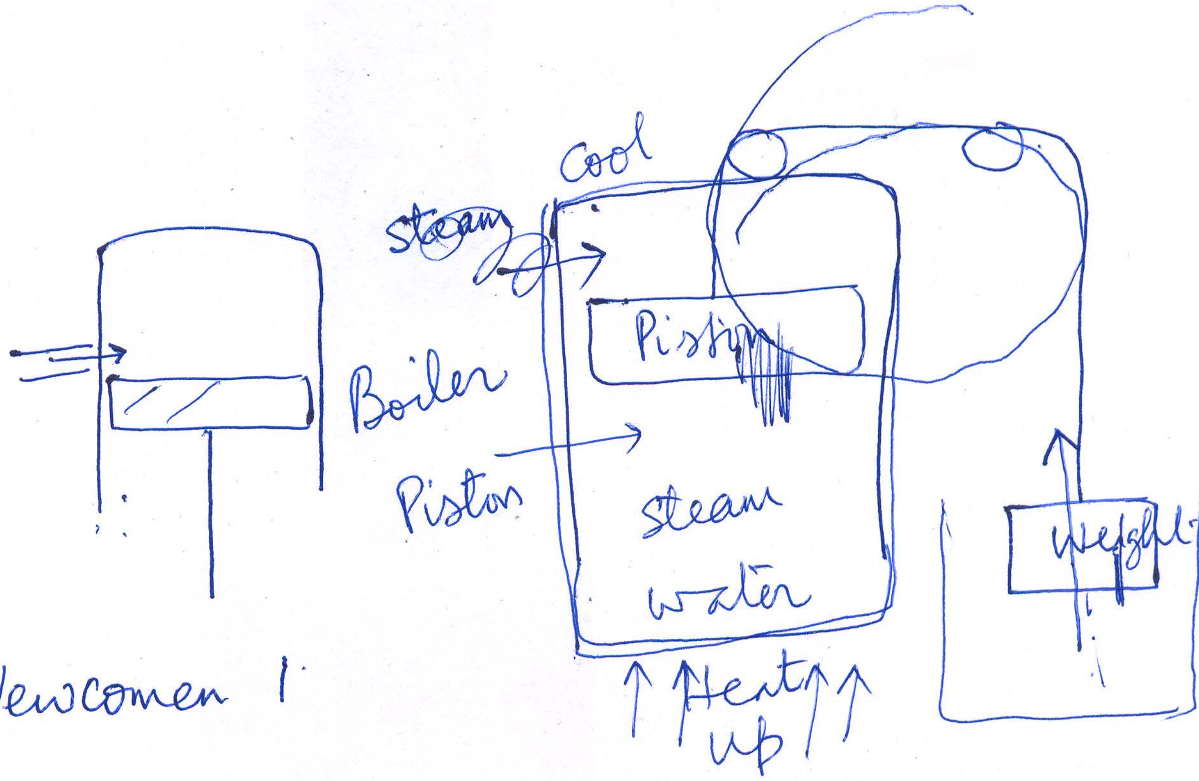
1. *Introduction*: Engine classifications; components of an engine; some useful definitions; engine operation.
2. *Basic cycles*: four stroke SI and CI engine cycles; two stroke SI engine cycle; comparisons.
3. *A detailed classification of engines*; fuels used; arrangement of cylinders; cooling type; application areas.
4. *Operating parameters*; various terminology; compression ratio; torque; power, mean effective pressure.
5. *Engine efficiencies*; bsfc; thermal and mechanical efficiencies; combustion efficiency; volumetric efficiency;
6. *Valve timing diagrams* for SI and CI engines; actual and ideal cycle; effect of speed, part- throttle, supercharger
7. *Air standard cycles*; Otto, Diesel and Dual cycles; comparison of efficiencies.
8. *Fuel air cycles*; assumptions; effects of various parameters.
9. *Actual cycles*; various losses and their effects on performance.
10. *Carburetion*; factors affecting carburetion; different types of carburetor; drawbacks and their remedy.
11. *Fuels*; different types; rating of fuels; octane and cetane number; alternative fuels; environmental characteristics; ignition systems; different types
12. *Combustion in S.I. Engines*; flame speed; stages of combustion; knocking; combustion chamber design; fuel rating.
13. *Combustion in C.I. Engines*; stages of combustion; various factors affecting combustion; cetane number.
14. *Supercharging and turbocharging*; after-coolers and inter-coolers.
15. *Engine heat transfer*; energy distribution; modes of heat transfer; effect of variables on heat transfer; different cooling systems; air cooling; liquid cooling

Required Text:
Ganesan, V., (2003), *Internal Combustion Engines*, Tata McGraw Hill.

Reference:
Pulkrabek, W.W., (1997), *Engineering Fundamentals of the I. C. Engine*, Prentice Hall.
Mathur, M.L. and Sharma, R.P., (2007) Internal Combustion Engine, Dhanpat Rai Publications,
Taylor, C.F., The Internal Combustion Engine in Theory and Practice: Vol. 1 – 2, MIT Press

Coal





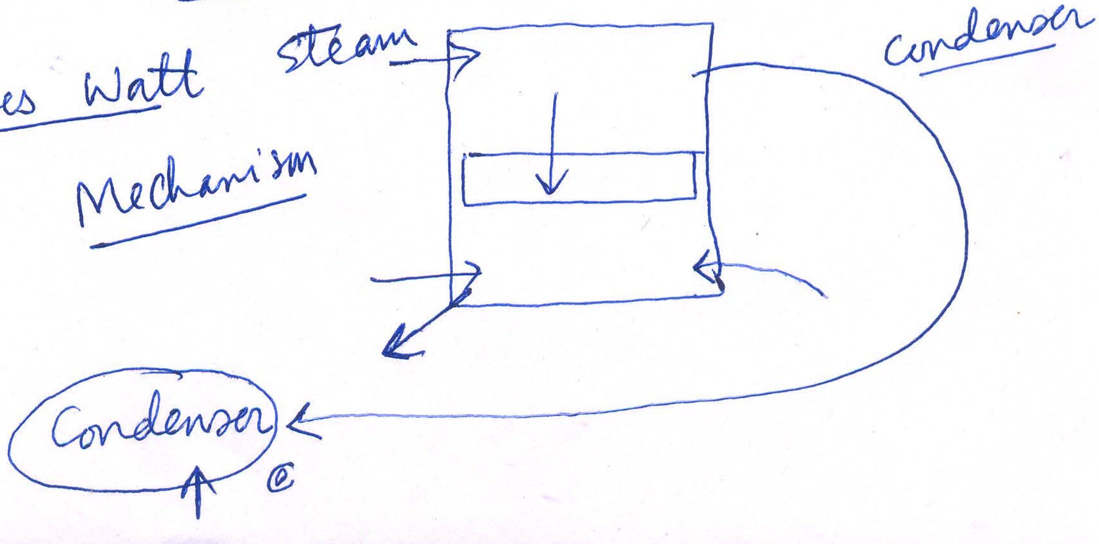
Newcomen 1

~3% - 5%

James Watt

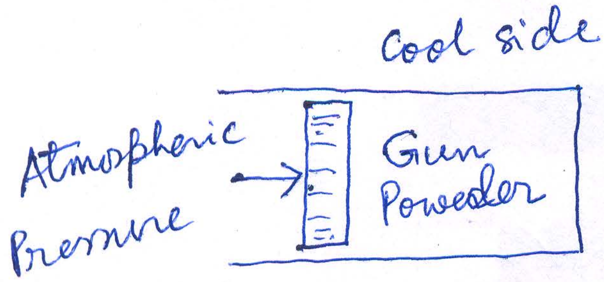
Mechanism

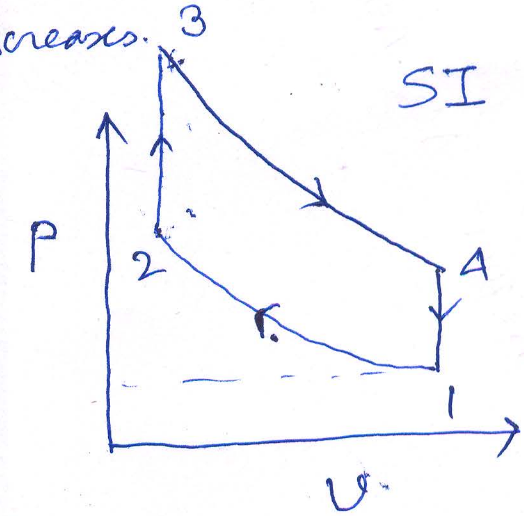
~18-20%



Atmospheric Engine

1859 Petroleum



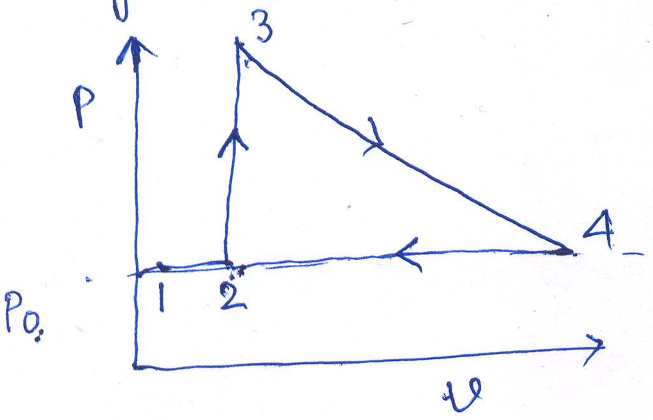


Lenoir Engines

1862

1-2 was absent.

Cycle of Lenoir engine



1-2 compression

2-3 Constant ~~temperature~~ volume heat addition

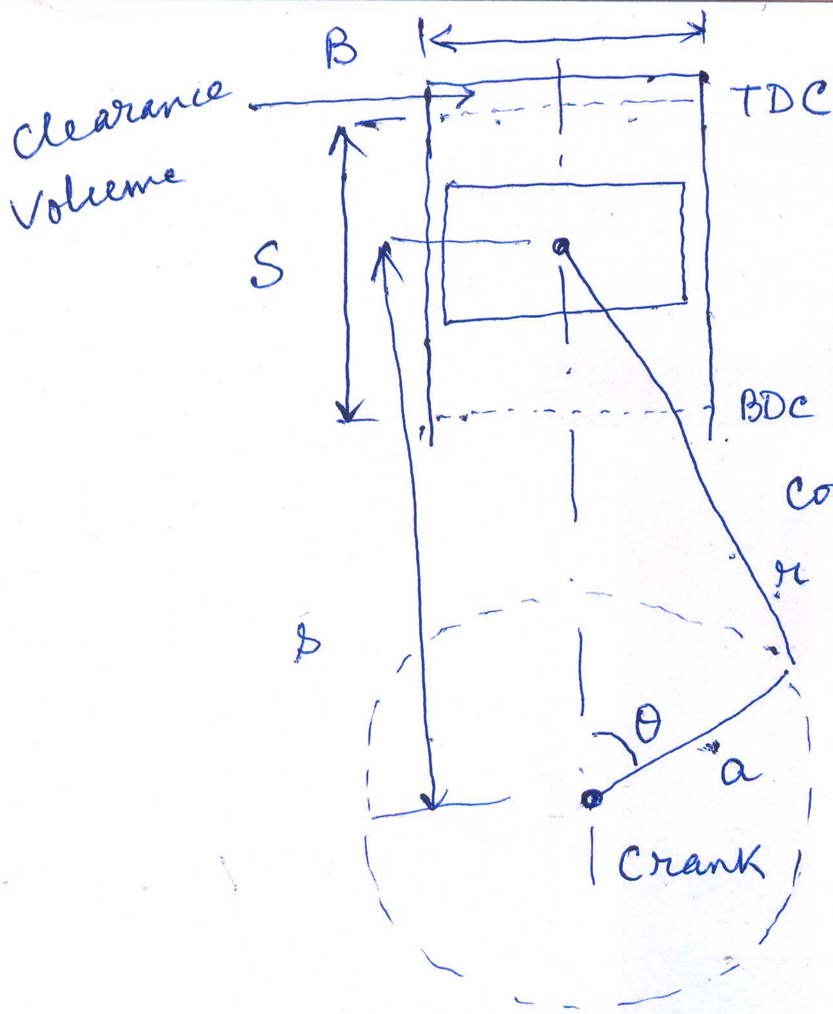
3-4 Expansion process

4-1 constant volume Heat rejection

P_0 = atmospheric pressure

absence of compression process 1-2 reduced the efficiency of the engine.

⇒ Pulse jet engine (One application of Lenoir Engine)



TDC - Top Dead Center

BDC - Bottom Dead Center

B - Engine Cylinder bore

S - Engine stroke

V_c - Clearance volume

V_{BDC} - Volume of Cylinder at ~~Bot~~ BDC

V_{TDC} - Volume of Cylinder at TDC (also V_c)

V_s - Displacement volume (also stroke volume, or swept volume)

$$r_c = \frac{\cancel{V_D}\, V_{BDC}}{V_{TDC}} = \frac{V_c + V_s}{V_c}$$

$$V_s = \frac{\pi}{4} B^2 S$$

$$r_c = 1 + \frac{V_s}{V_c}$$

$$s = a\cos\theta + \sqrt{r^2 - a^2\sin^2\theta}$$

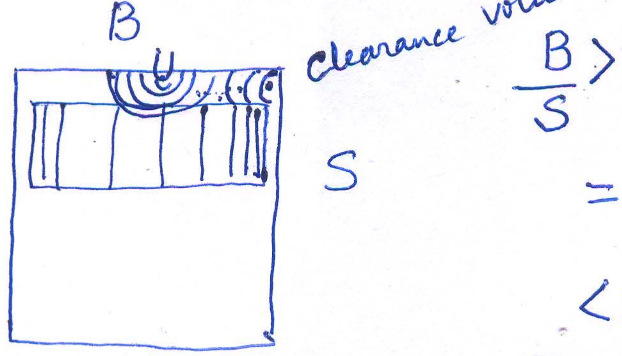
$$= a\left[\cos\theta + \sqrt{R^2 - \sin^2\theta}\right] \qquad R = \frac{r}{a} \sim 3\text{-}10$$

$$\frac{ds}{dt} = U_p = a\left[-\sin\theta - \frac{1}{2}\frac{1}{\sqrt{R^2 - \sin^2\theta}} \cdot 2\sin\theta\cos\theta\right]\omega$$

$$= -a\sin\theta\left[1 + \frac{\cos\theta}{\sqrt{R^2 - \sin^2\theta}}\right]\omega$$

$$V = V_c + A_p\,(r + a - s)$$ A_p = Piston area $= \frac{\pi}{4}B^2$

$$\bar{U}_p = \frac{2SN}{60}\ \text{m/s} \qquad 5\text{-}20\ \text{m/s}$$



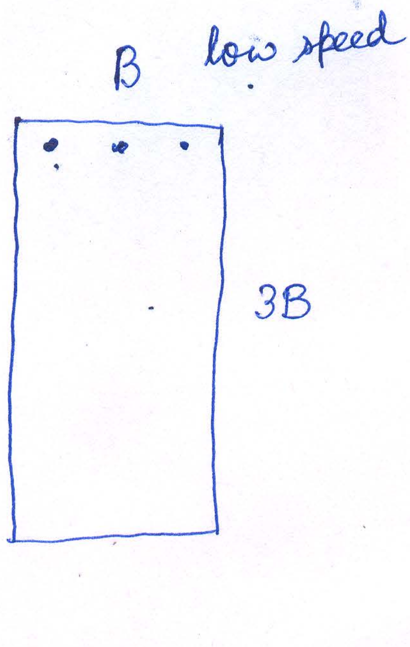
$\frac{B}{S} > 1$ over square

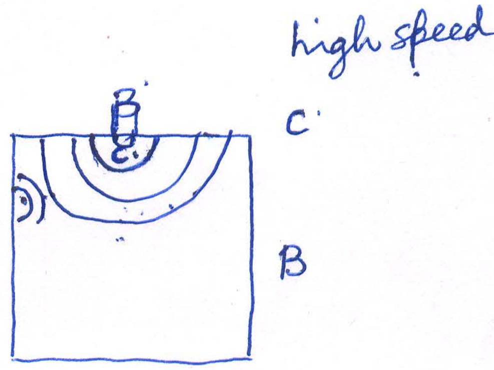
$= 1$ square engine

< 1 under square engine

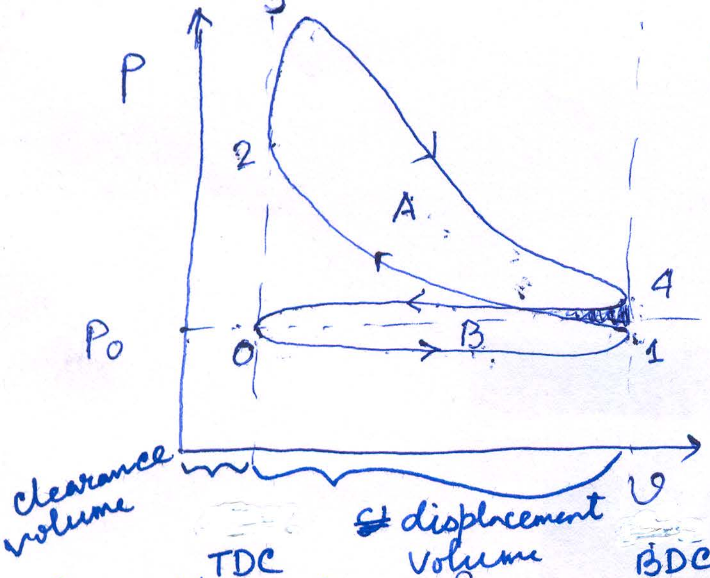
CI

X SI





SIT = Self Ignition Temperature



$$W \times \frac{N/2}{60}$$

Indicator diagram

01 - Suction stroke

12 - Compression "

23 - Heat addition process

34 - Expansion stroke

40 - Exhaust stroke

P_0 = Atmospheric Pressure

$$W_i = W_A - W_B$$

W_A = Work output in loop A

W_B = Work input in loop B

$$w_i = w_A - w_B$$

$$w_b = w_i - (\text{frictional} + \text{parasitic load})$$

AC

W_i = Indicated power

w lower case are specific

indicated thermal efficiency

$$\eta_{ith} = \frac{w_i}{Q}$$

$$W_i = kW = m w_i$$

$$w_i = \frac{kW}{kg/sec} = \frac{kJ}{kg}$$

$$\eta_{bth} = \frac{w_b}{Q}$$

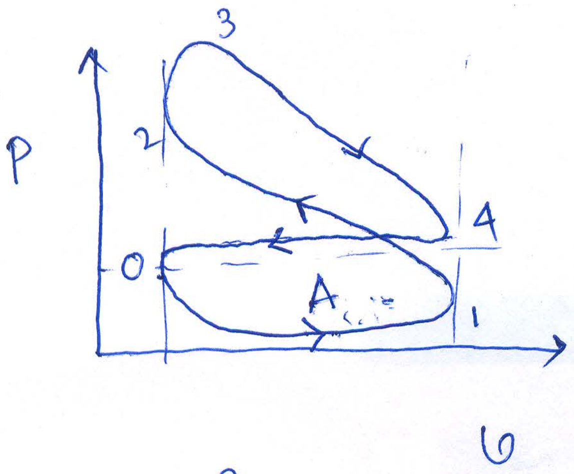
m_f = mass of fuel added per cycle, kg

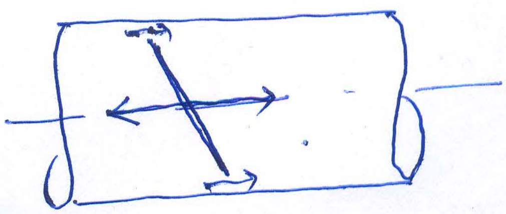
$$\eta_m = \frac{\eta_{bth}}{\eta_{ith}} = \frac{w_b}{w_i}$$

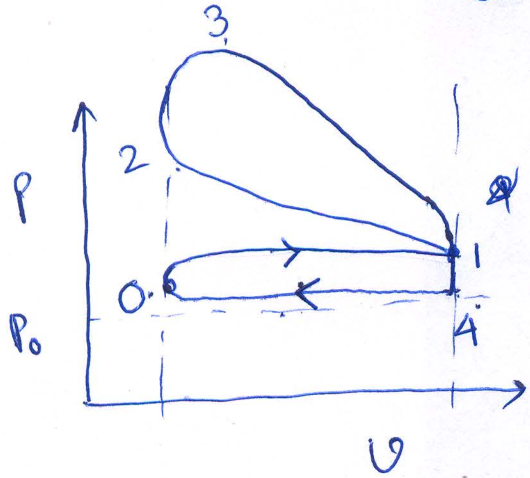
Q_{cv} = Calorific value of fuel, $\frac{kJ}{kg}$

WOT → Wide open Throttle

η_c = Combustion efficiency ~ 98% - 98.5%


3
P
2
4
0
A
1
v




3
2
P
4
1
0
P_0
A
v