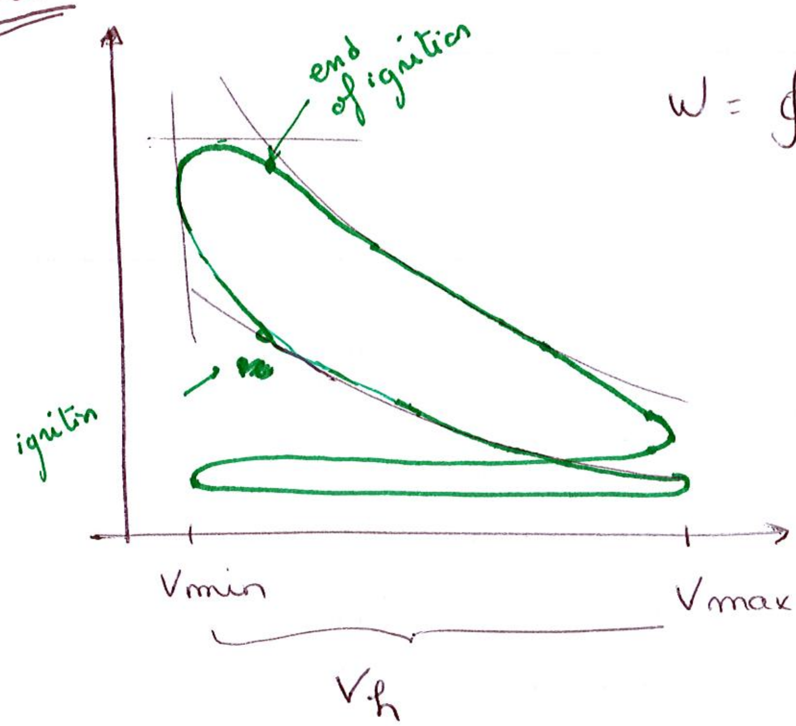
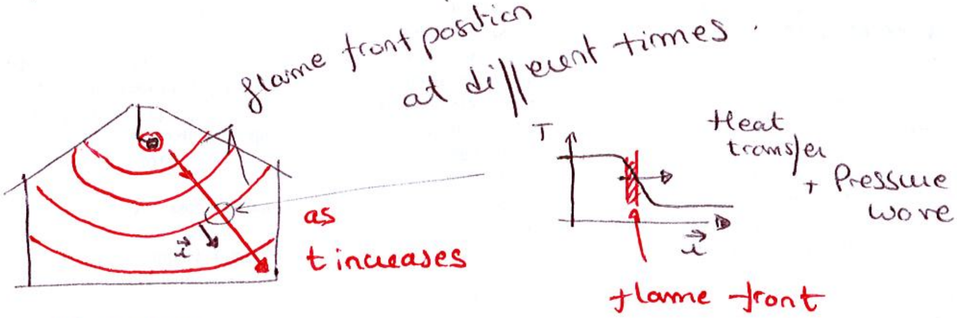
WKA Notes 2
J. Prof B. Fond

IMEP

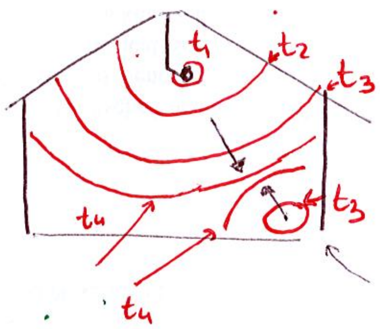
$$W = \oint P\,dV = imep \times V_h$$



Knock

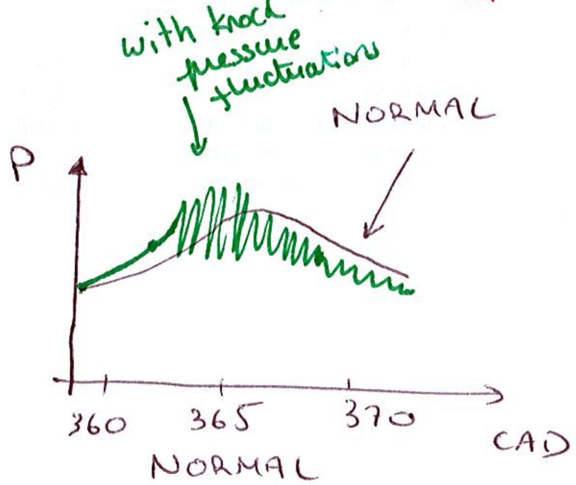


NORMAL PROPAGATION

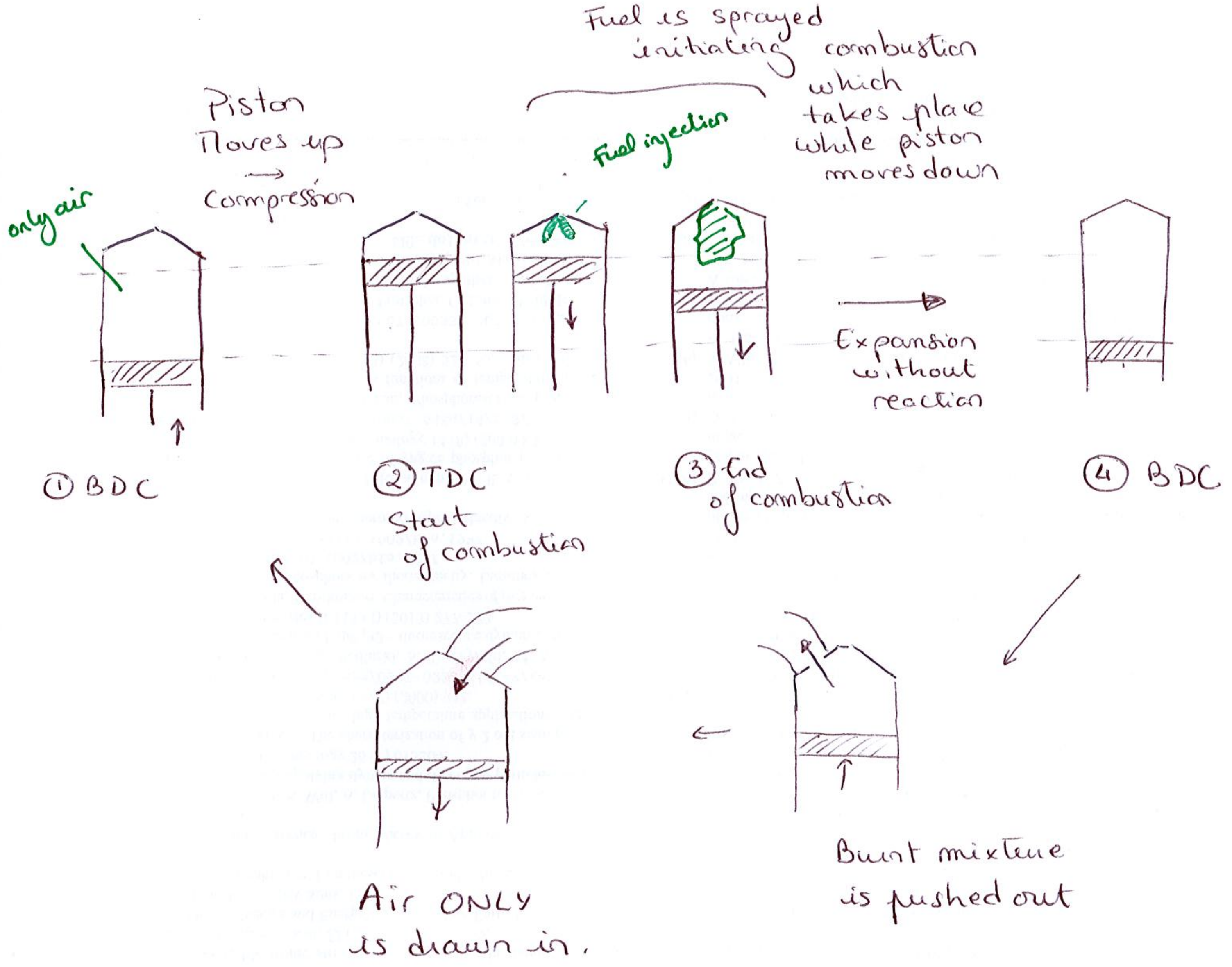


This pocket has ignited ahead of the flame due to compression

KNOCK



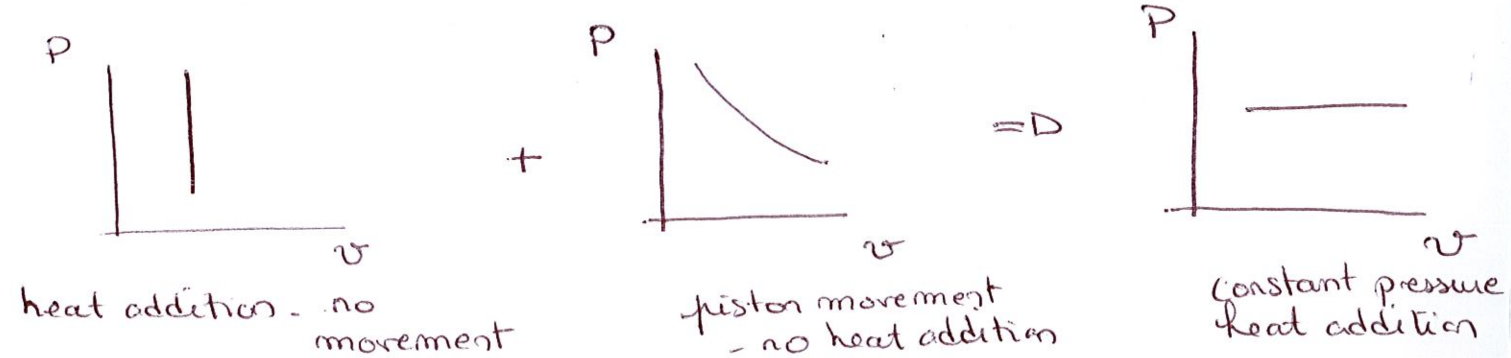
Diesel Cycle   Compression Ignition



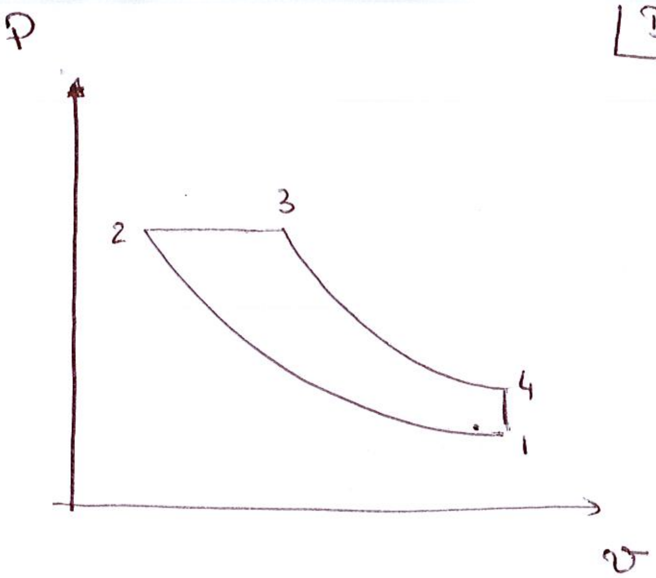
As in Otto cycle, the 2 gas-exchange strokes are modelled as constant volume heat rejection

From ② to ③

HEAT ADDITION AND EXPANSION TAKE PLACE SIMULTANEOUSLY



DIESEL CYCLE



- working fluid has fixed mass
- perfect gas | $Pv = RT$
  C_p, C_v are constant

$1 \to 2$ Isentropic compression

$2 \to 3$ Constant pressure heat addition (spray combustion)

$3 \to 4$ Isentropic expansion

$4 \to 1$ Constant volume heat rejection

$$\eta_{th} = 1 - \frac{Q_{out}}{Q_{in}}$$

$Q_{14} < 0$

$$= 1 - \frac{|m C_v (T_1 - T_4)|}{m C_p (T_3 - T_2)}$$

Constant pressure heat addition

$$= 1 - \frac{C_v}{C_p} \times \frac{(T_4 - T_1)}{(T_3 - T_2)} = 1 - \frac{1}{\gamma} \frac{T_1}{T_2} \times \left(\frac{T_4/T_1 - 1}{T_3/T_2 - 1} \right)$$

Definition $r_v = \frac{V_1}{V_2} = \frac{v_1}{v_2}$ Compression ratio

$\varphi = \frac{V_3}{V_2}$ Cutoff ratio

$1 \to 2$ $Tv^{\gamma-1} = cst \to \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{\gamma-1} = r_v^{\gamma-1}$

$2 \to 3$ $P = cst \to \frac{RT_2}{v_2} = \frac{RT_3}{v_3} \to \frac{T_3}{T_2} = \frac{v_3}{v_2} = \varphi$

$3 \to 4$ $Tv^{\gamma-1} = cst \to \frac{T_4}{T_3} = \left(\frac{v_3}{v_4}\right)^{\gamma-1} = \left(\frac{v_3}{v_2} \times \frac{v_2}{v_1} \times \frac{v_1}{v_4}\right)^{\gamma-1}$

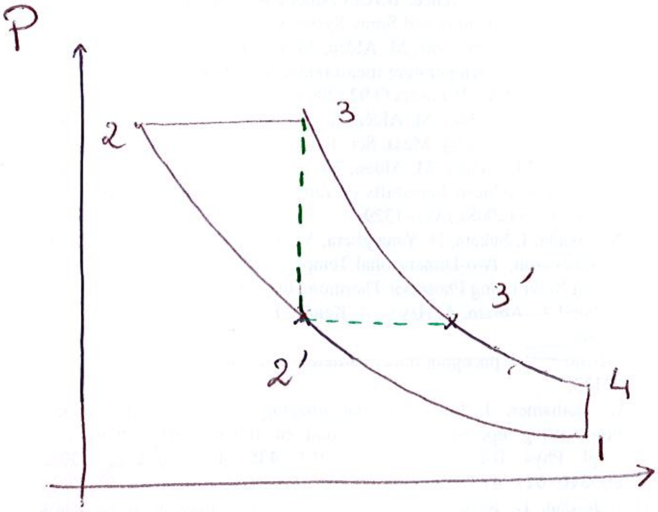
$$= \left(\frac{\varphi}{r_v}\right)^{\gamma-1}$$

DIESEL CYCLE

$$\eta_{th} = 1 - \frac{1}{\gamma}\frac{T_1}{T_2} \times \frac{\left(T_4/T_1 - 1\right)}{\left(T_3/T_2 - 1\right)}$$

$$\frac{T_4}{T_1} = \frac{T_4}{T_3} \times \frac{T_3}{T_2} \times \frac{T_2}{T_1} = \frac{\varphi^{\gamma-1}}{r_v^{\gamma-1}} \times \varphi \times r_v^{\gamma-1} = \varphi^{\gamma}$$

$$\boxed{\eta_{th} = 1 - \frac{1}{\gamma\, r_v^{\gamma-1}} \times \frac{\varphi^{\gamma} - 1}{\varphi - 1}}$$



At fixed compression ratio

Otto 1-2'-3-4 is more efficient than Diesel 1-2'-3'-4

Note:

Heat rejection is fixed

$$\sum_i Q_i - |W_{net}| = 0$$

$$-Q_{out} + Q_{in} - |W_{net}| = 0$$

$$\eta_{th} = \frac{|W_{net}|}{Q_{in}} = \frac{|W_{net}|}{|W_{net}| + Q_{out}} = \frac{1}{1 + \frac{Q_{out}}{|W_{net}|}}$$

Area within the curve

At fixed peak pressure

Diesel 1-2-3-4 is more efficient than 1-2'-3-4 (Otto)