Chap 2: Cycles

ME419

Reaction	Equilibrium constant
$CO_2 \rightleftharpoons CO + \frac{1}{2}O_2$	$K_p = \frac{p_{CO} \cdot p_{O_2}{}^{0.5}}{p_{CO_2}}$
$H_2O \rightleftharpoons H_2 + \frac{1}{2}O_2$	$K_p = \frac{p_{H_2} \cdot p_{O_2}{}^{0.5}}{p_{CO_2}}$
$H_2O \rightleftharpoons \frac{1}{2}H_2 + OH$	$K_p = \frac{p_{H_2}^{0.5} \cdot p_{OH}}{p_{H_2O}}$
$\frac{1}{2}H_2 \rightleftharpoons H$	$K_p = \frac{p_H}{p_{H_2}^{0.5}}$
$\frac{1}{2}O_2 \rightleftharpoons O$	$K_p = \frac{p_O}{p_{O_2}^{0.5}}$
$\frac{1}{2}N_2 \rightleftharpoons N$	$K_p = \frac{p_N}{p_{N_2}^{0.5}}$
$\frac{1}{2}N_2 + \frac{1}{2}O_2 \rightleftharpoons NO$	$K_p = \frac{p_{NO}}{p_{N_2}^{0.5} \cdot p_{O_2}^{0.5}}$

Table 2.3: The set of equilibrium reactions and corresponding equilibrium constants used to determine the equilibrium composition of combustion products for hydrocarbon fuels

Variable	$\gamma = 1.4$	Variable γ
T_2 - K	812.1	781.2
T_3 - K	4363	3456
T_4 - K	1773	1794
p_2 - kPa	2338	2249
p_3 - kPa	12560	9948
p_4 - kPa	537.2	543.5
η_i -	0.5936	0.5114
$imep$ - kPa	1785	1537

Table 2.2: Comparison of Otto cycle with specific heat ratio of 1.4 with that for variable specific heat of air. Compresson ratio = 9.5, heat addition=2548 kJ/kg, $p_1 = 100kPa, T_1 = 330K$

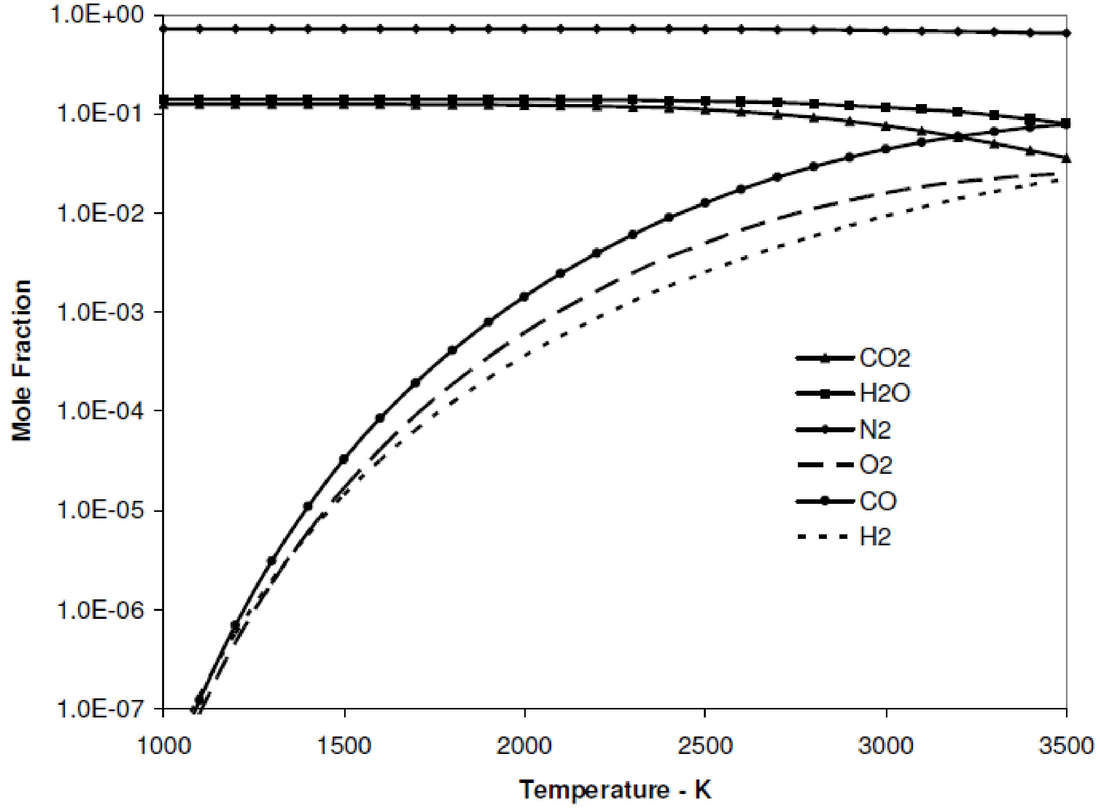


Figure 2.17: Main equilibrium combustion products for a stoichiometric octane air mixture at 20 atm pressure

compression ratio

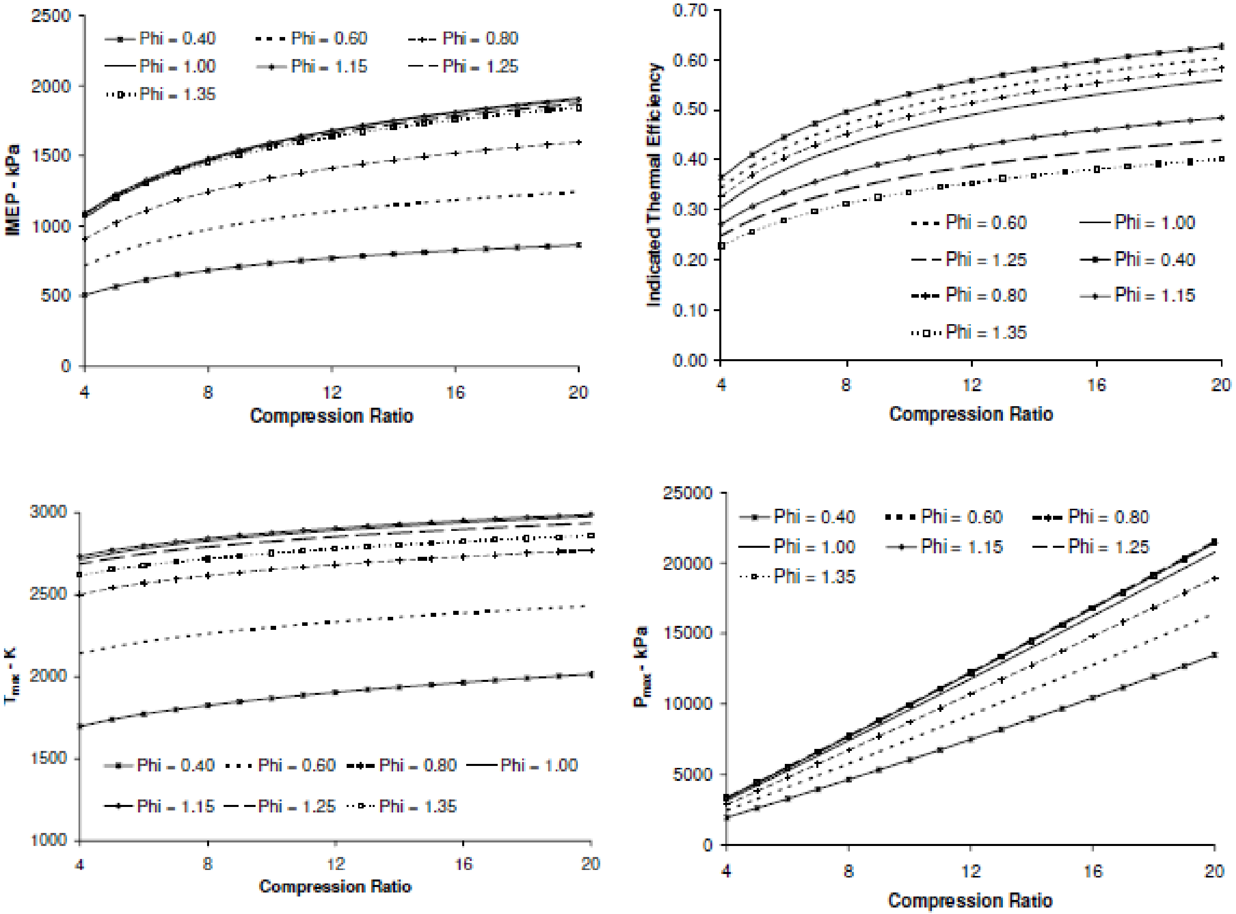
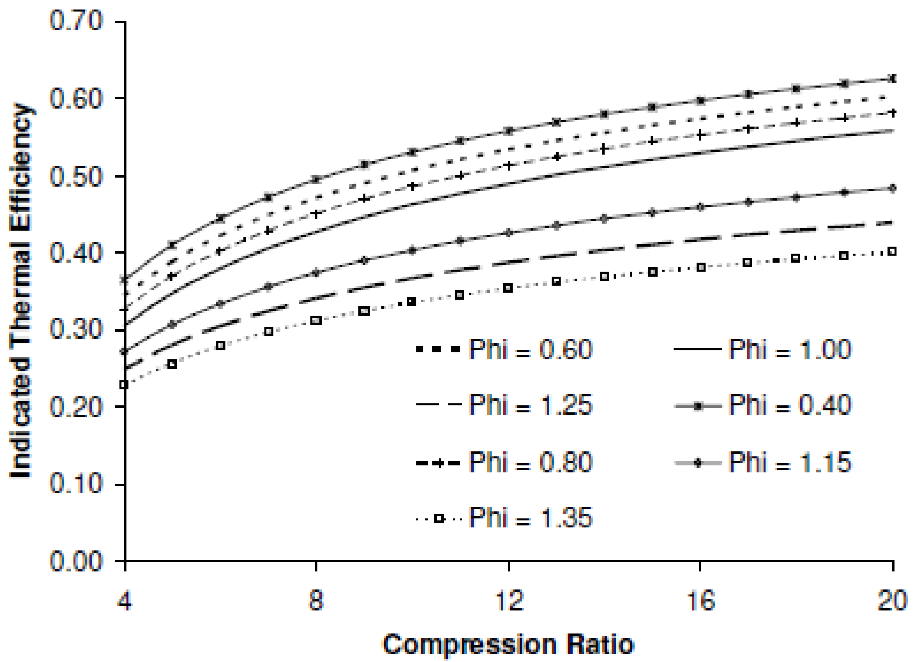


Figure 2.19: Indicated thermal efficiency, indicated mean effective pressure, maximum cycle temperature and pressure for the ideal fuel air cycle with constant volume combustion as a function of fuel air equivalence ratio and compression ratio and for iso-octane. Intake temperature and pressure 298K, 100 kPa, exhaust pressure 100 kPa.



0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Indicated Thermal Efficiency
4
8
12
16
20
Compression Ratio
Phi = 0.60
Phi = 1.00
Phi = 1.25
Phi = 0.40
Phi = 0.80
Phi = 1.15
Phi = 1.35

equivalence ratio

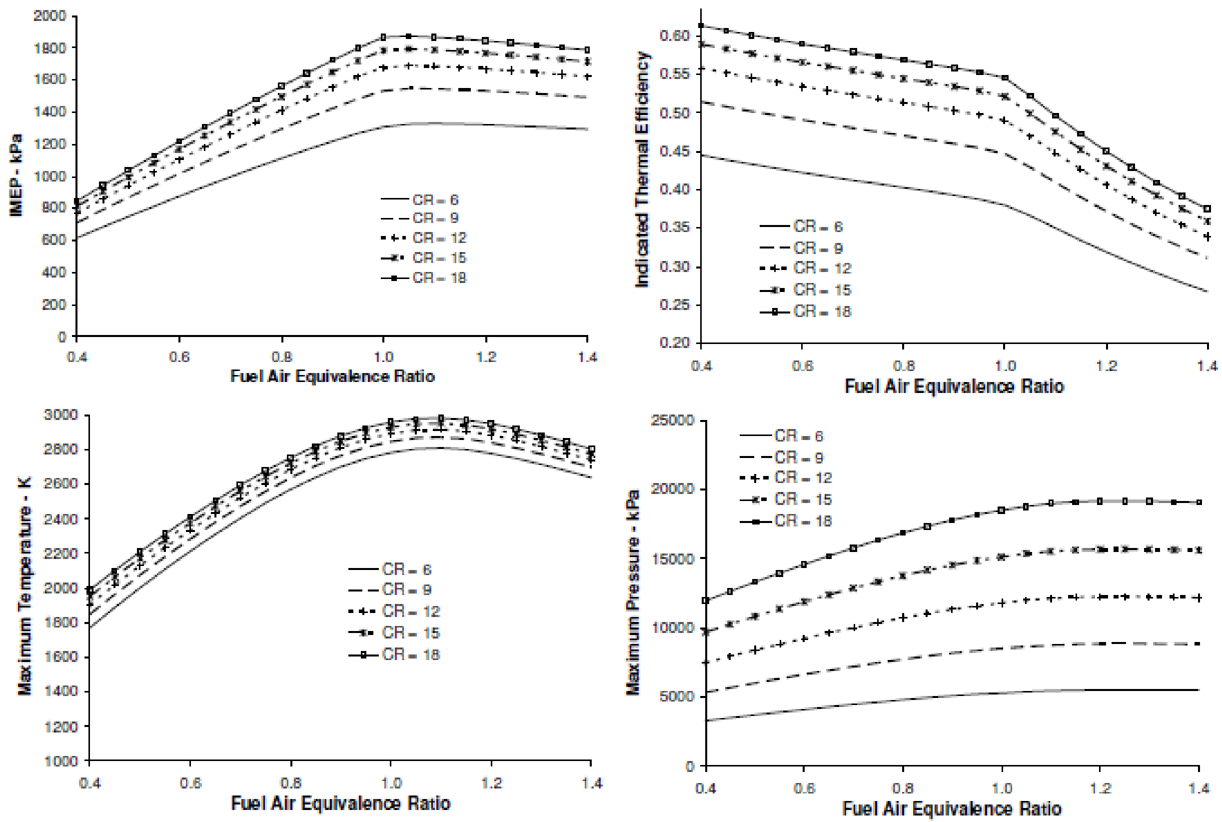
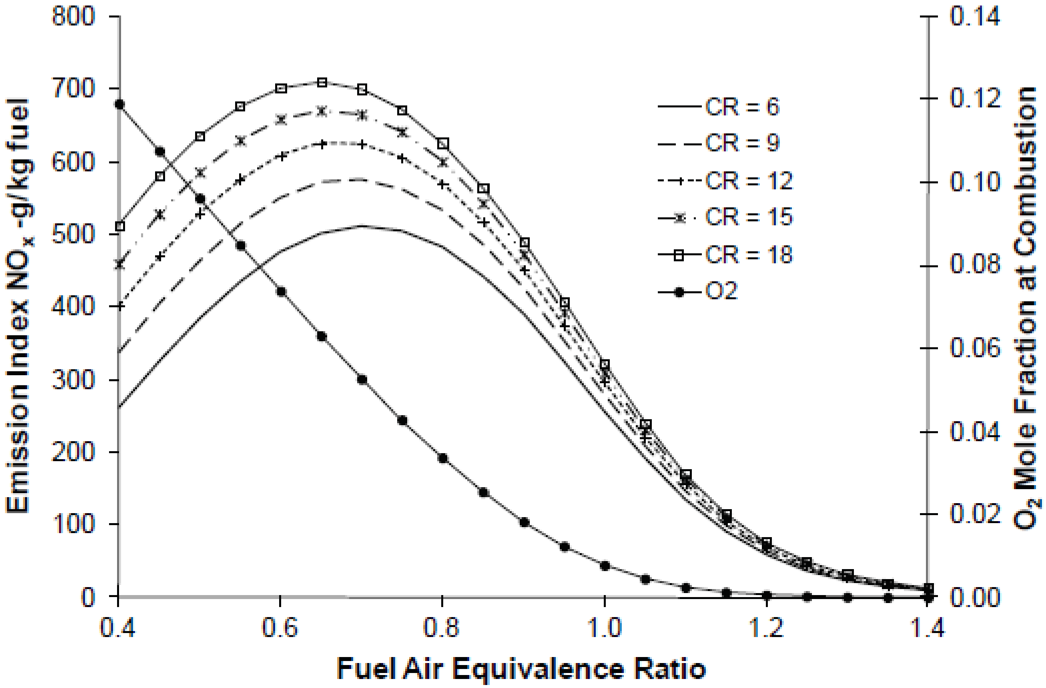


Figure 2.20: Indicated thermal efficiency, indicated mean effective pressure, maximum cycle temperature and pressure for the ideal Fuel Air cycle with constant volume combustion as a function of fuel air equivalence ratio and compression ratio and for iso-octane. Intake temperature and pressure 298K, 100 kPa, exhaust pressure 100 kPa.



$\phi = FA/FA_s$

Figure 2.21: The amount of NO_x, as gram NO_2 per kg of fuel, at peak temperature and pressure in the ideal Fuel Air cycle with constant volume combustion as a function mixture ratio and compression ratio for iso-octane. Intake temperature 298K, exhaust pressure = intake pressure = 100 kPa. Also shown is the mole fraction of Oxygen.

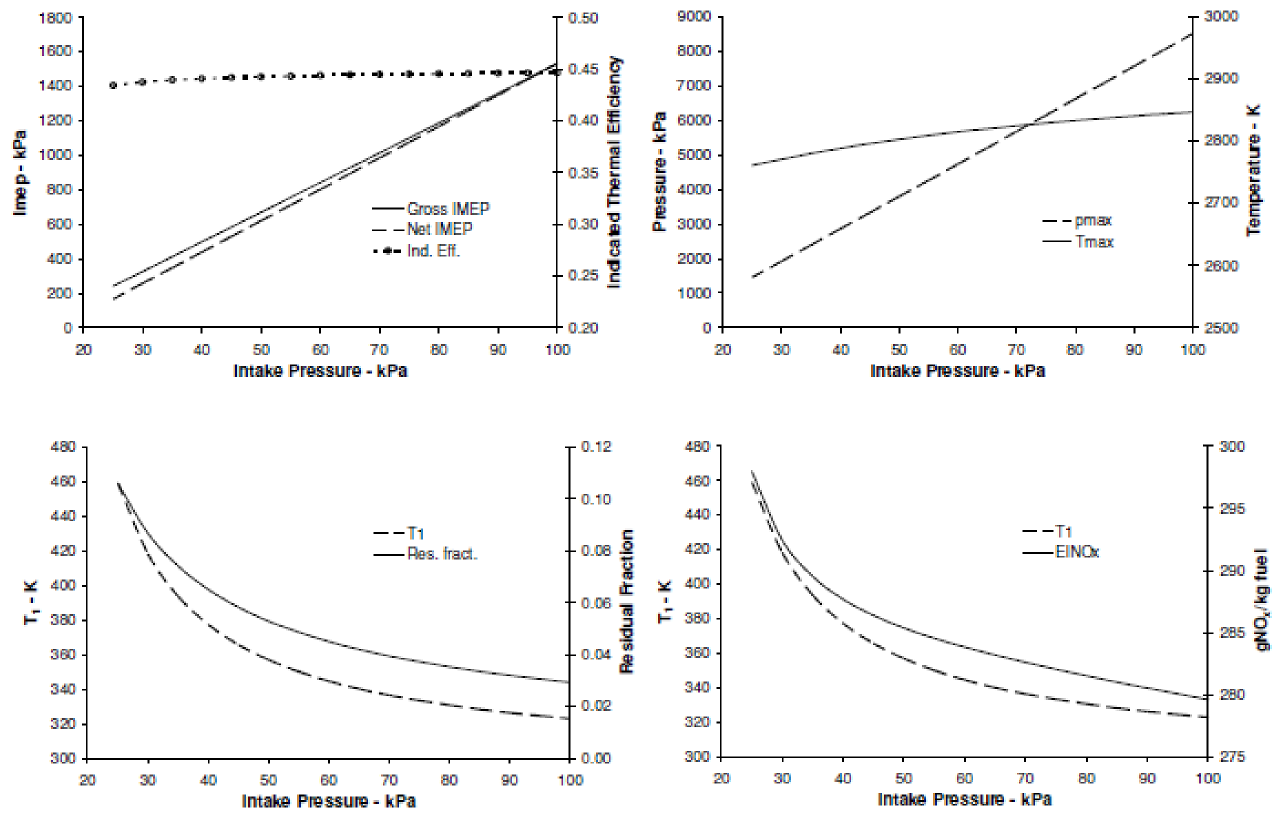


Figure 2.22: Indicated thermal efficiency, indicated mean effective pressure, maximum cycle temperature and pressure for the ideal Fuel Air cycle with constant volume combustion as a function of intake pressure for a stoichiometric mixture and compression ratio of 9:1 for iso-octane. Intake temperature 298K, exhaust pressure 100 kPa. Also shown are the temperature at the start of compression, T_1, residual fraction, and grams of NO_x produced per kg fuel

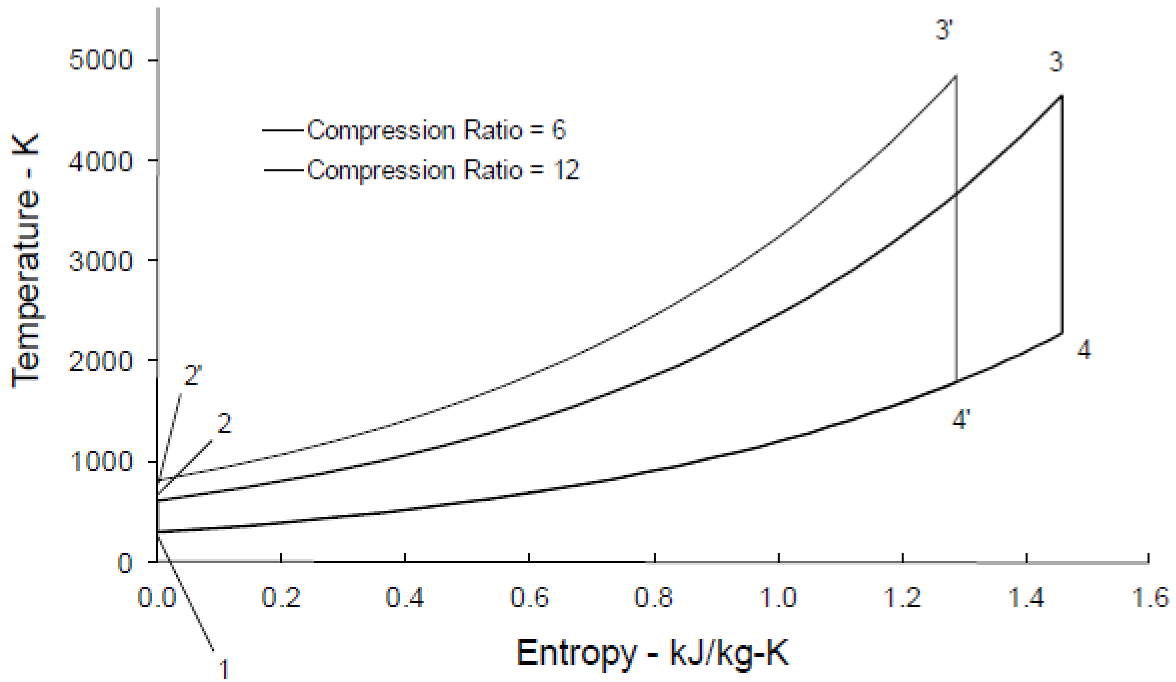


Figure 2.13: T-s diagrams for two Otto ideal air cycles with different compression ratios and the same heat addition, 2900 kJ/kg.

s

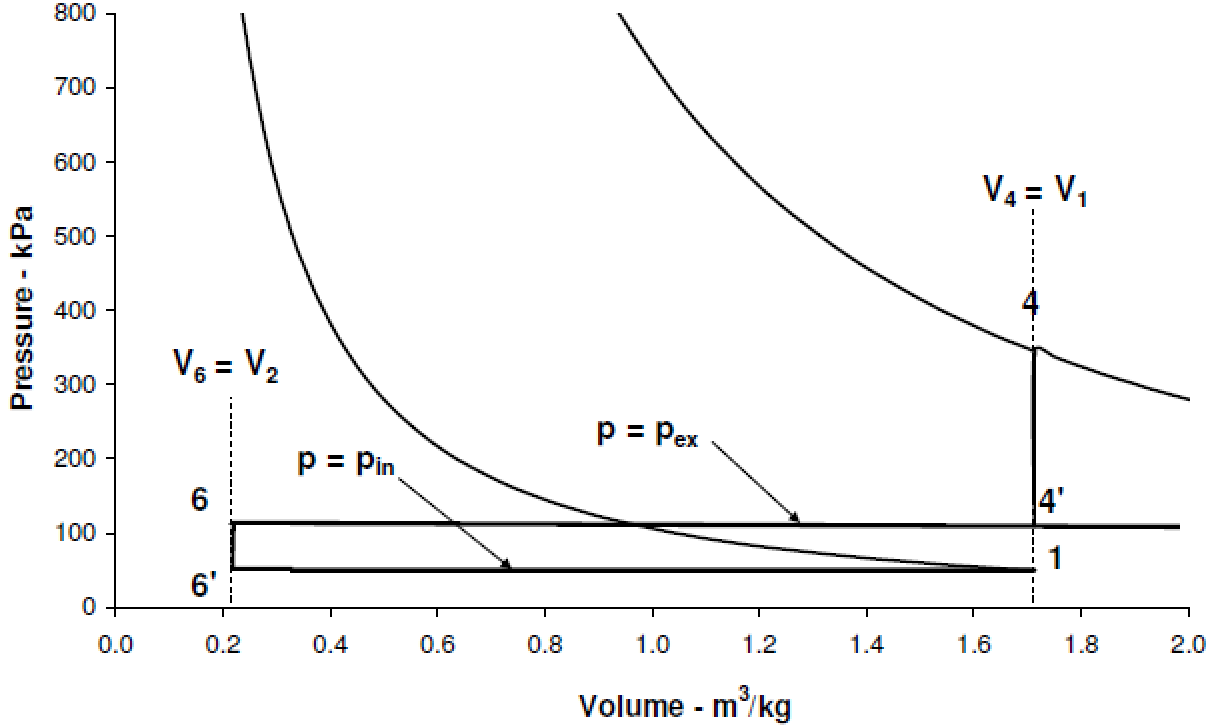
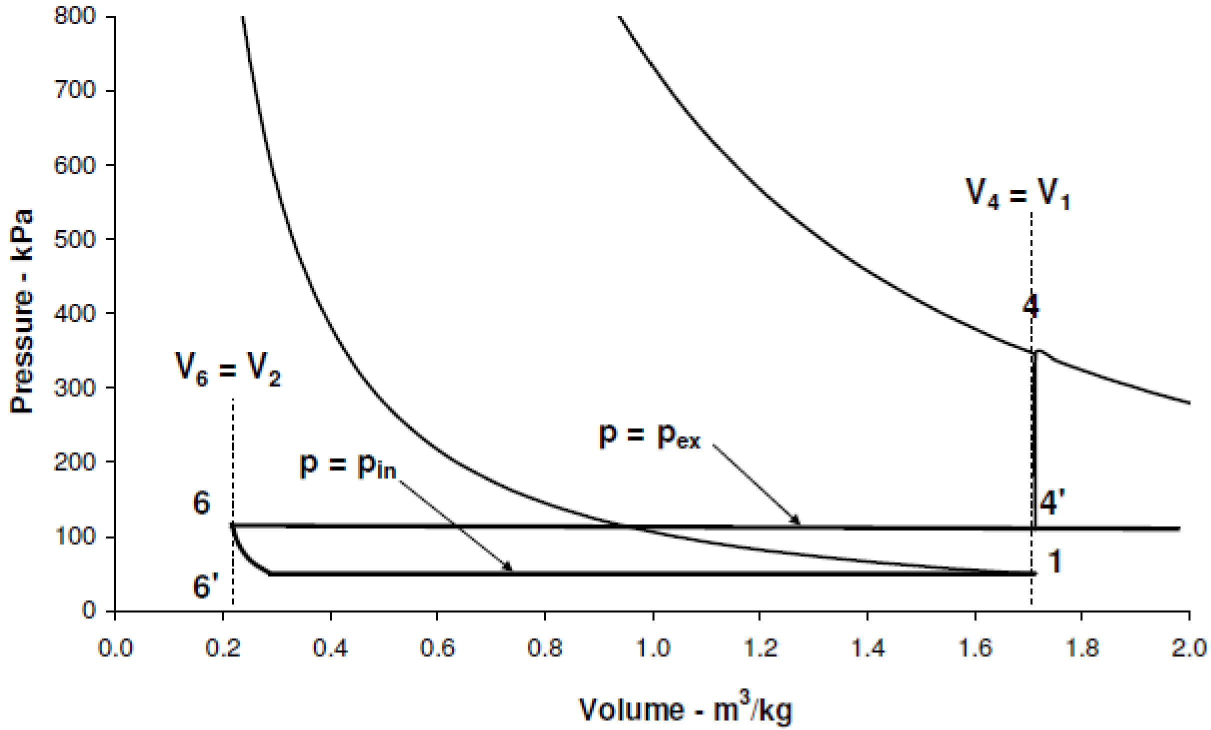


Figure 2.14: The intake and exhaust processes in an ideal engine with an early opening of the intake valve.



800
700
600
500
400
300
200
100
0
Pressure - kPa
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Volume - m3/kg
V6 = V2
V4 = V1
4
4'
6
6'
1
p = pin
p = pex