Engine Principles (Part 1)

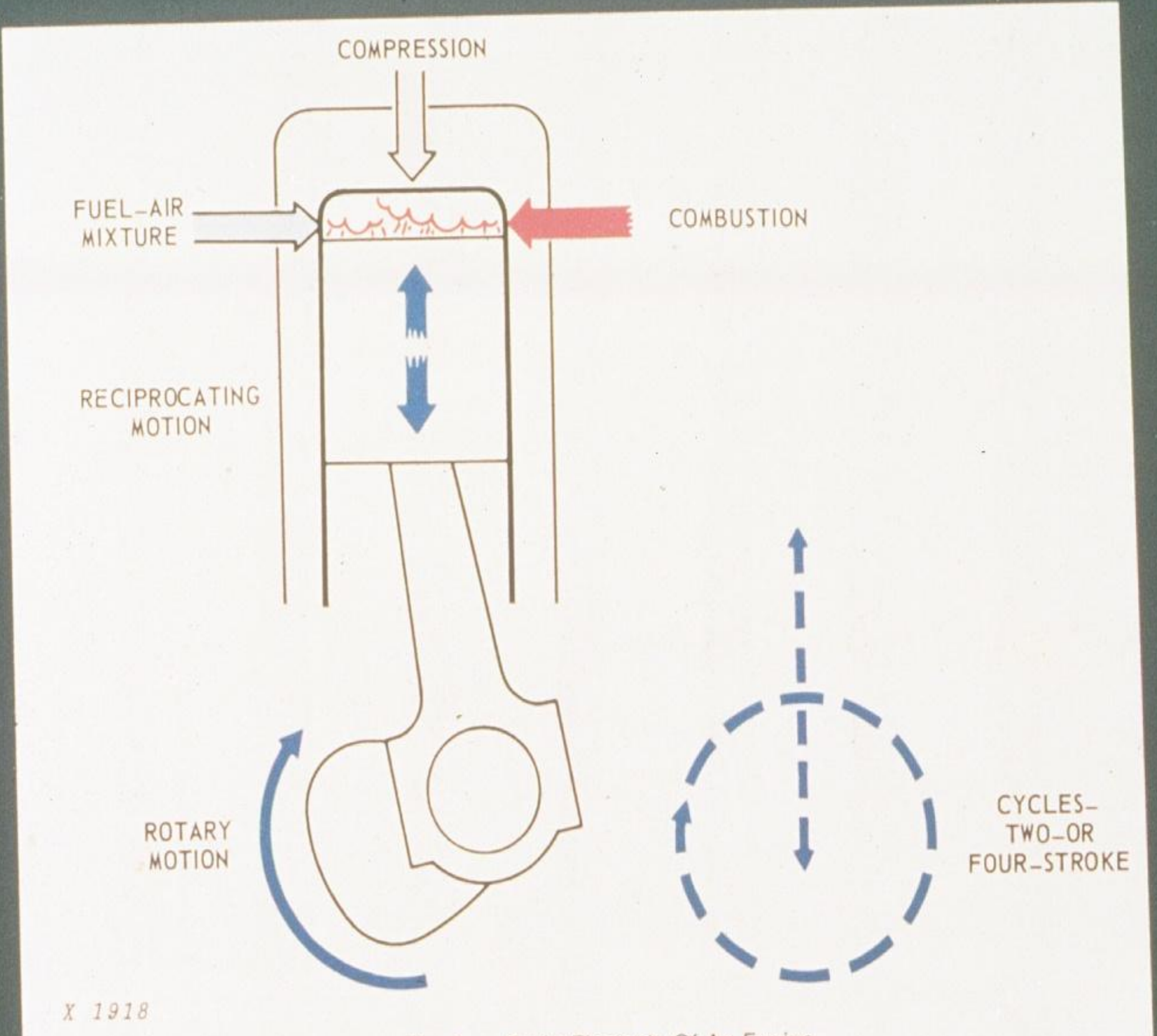


Fig. 1 — Basic Elements Of An Engine

Air Fuel & Combustion

- Air
  - Air will compress

$$pV=MRT$$

p = Pressure (kPa, psi), V= volume (m3, ft3), M=Mass (kg, lb), T= Absolute Temperature (K, R)

R=specific gas constant (8.314/molecular weight [metric], 10.72/molecular weight [English])

- Constant Mass of air
  - Decrease in Volume ⇨ Increase in Temperature
  - Increase in Pressure

  - Addition of Energy ⇨ Increase in Temperature
  - Increase in Pressure

Gas Laws

Ideal Gas Equation

$$pV=MRT$$

p = Pressure (kPa, psi), V= volume (m3, ft3), M=Mass (kg, lb), T= Absolute Temperature (K, R)

R=specific gas constant (8.314/molecular weight [metric], 10.72/molecular weight [English])

- Constant Volume

  $p_b/p_a = T_b/T_a$

  $Q/M = C_v *(T_b - T_a)$

- Constant Pressure

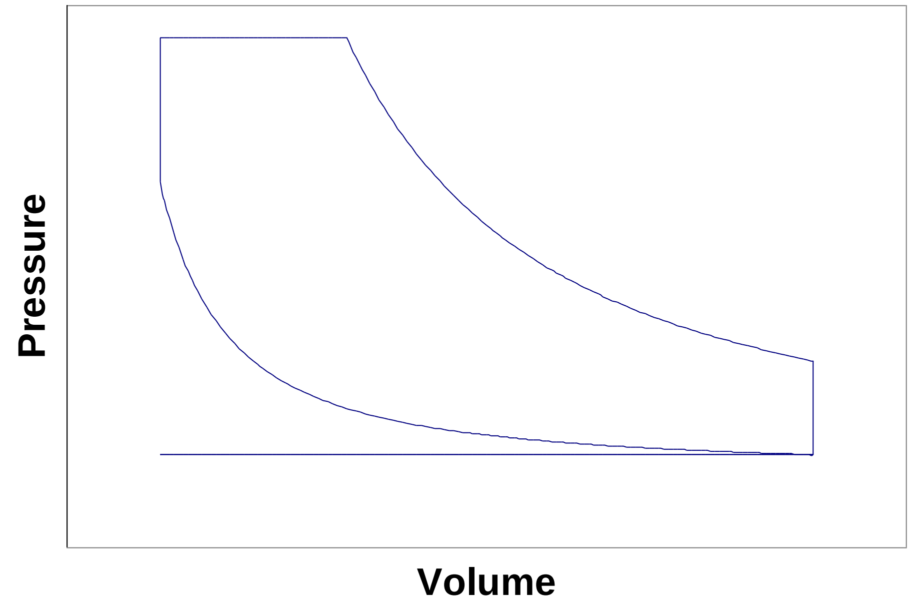
  $V_b/V_a = T_b/T_a$

  $Q/M = C_p *(T_b - T_a)$

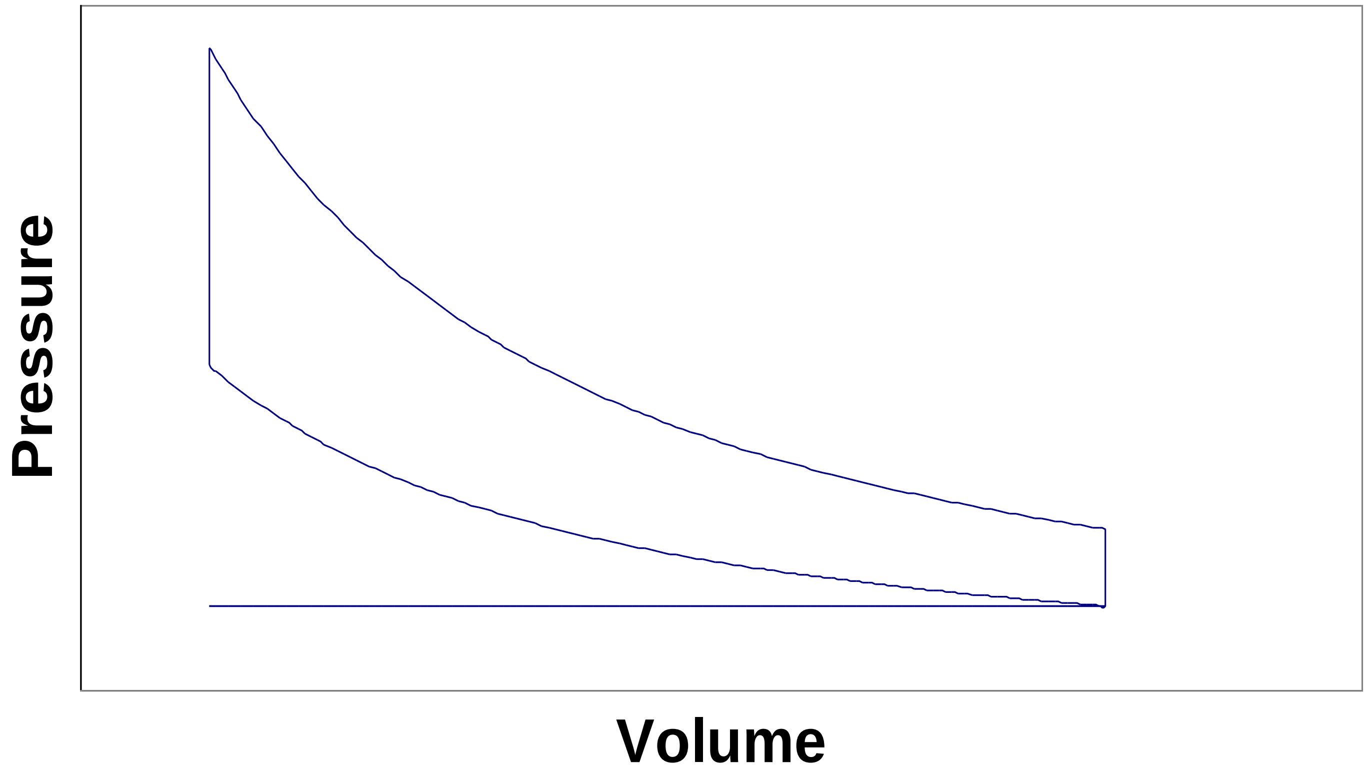
- Adiabatic Expansion/Compression

  $p_b/p_a = [V_a/V_b]^k = [T_b/T_a]^{k/(k-1)}$

  $T_b/T_a = [V_a/V_b]^{(k-1)} = [p_b/p_a]^{(k-1)/k}$

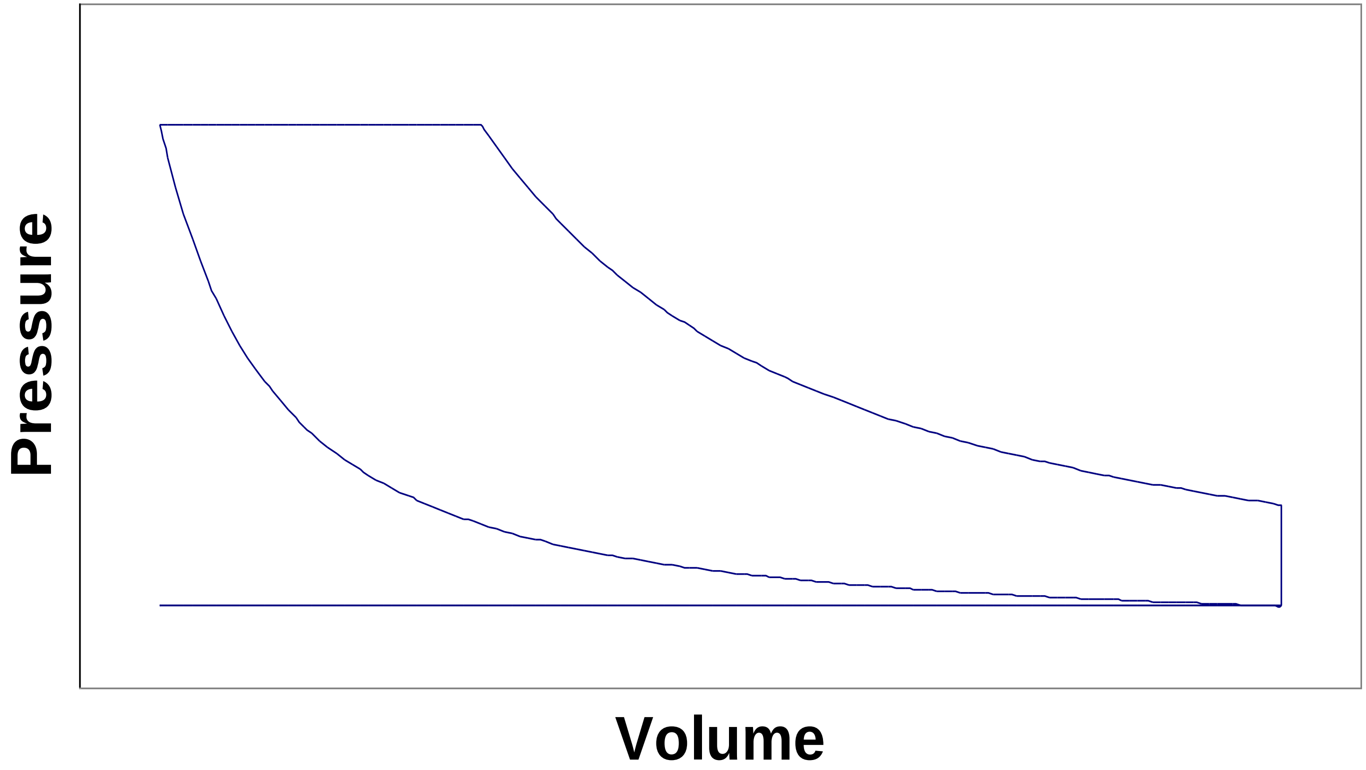


Theoretical Otto Cycle (SI)



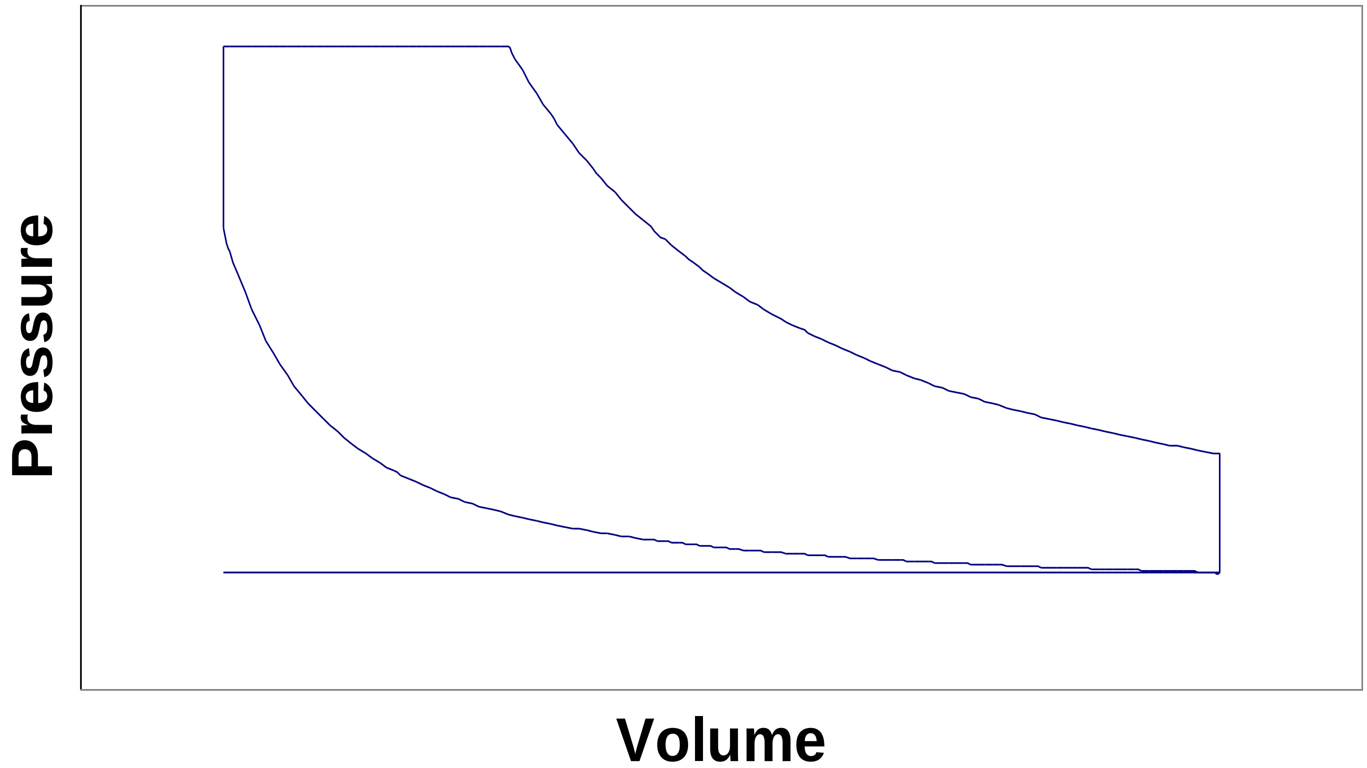
Theoretical Efficiency = $1-1/r^{(n-1)}$

Diesel Cycle (CI)



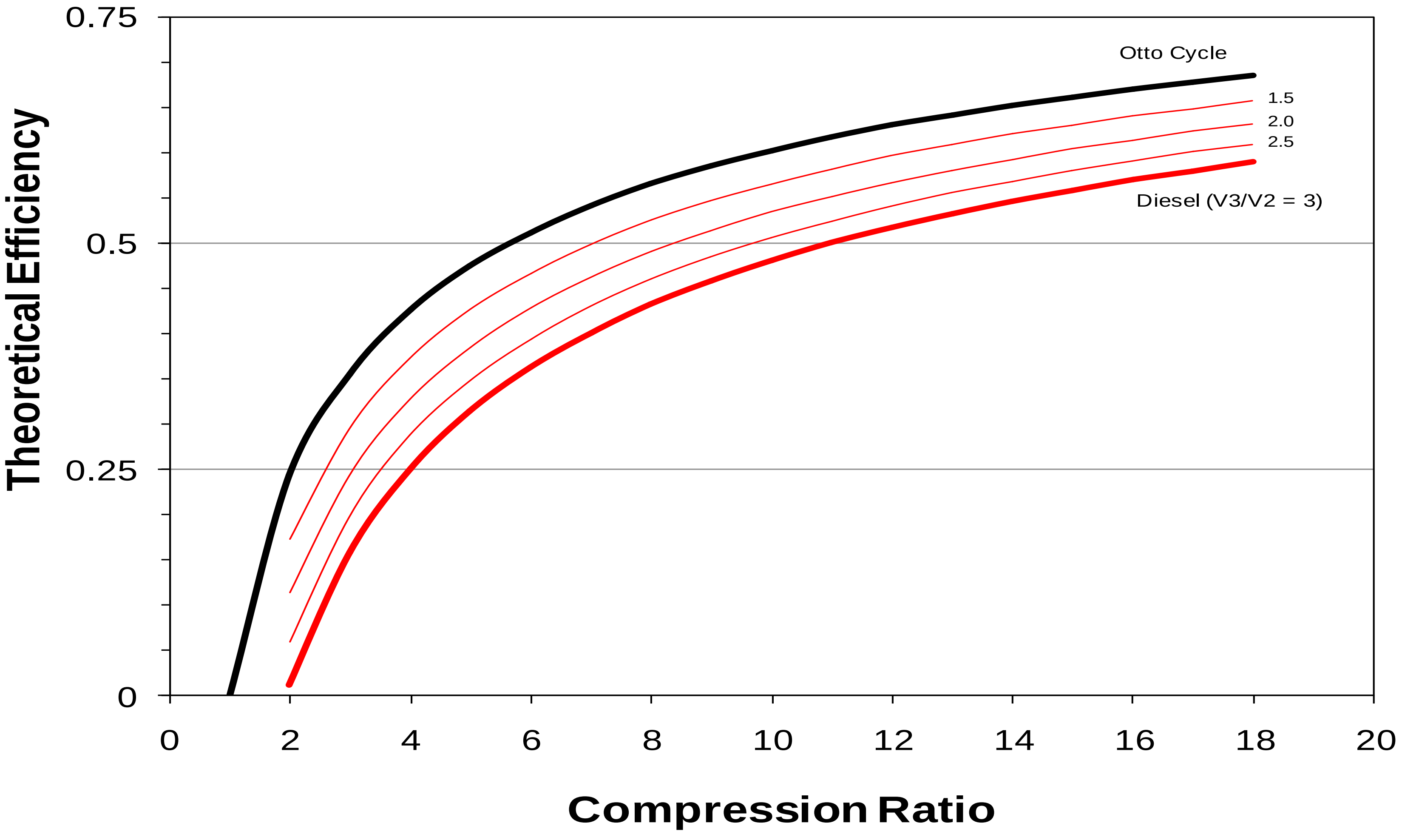
$$\text{Theoretical Efficiency} = 1-[1/r^{(n-1)}]*[(r_{co})^{n} -1] / [n(r_{co} -1)]$$

Dual Cycle



$$\textbf{Efficiency} = 1-[1/r^{(n-1)}]*[\{B(r_{co}^{\,n} - 1)+n(r_{co}-1)(1-B)\} / \{n(r_{co} - 1)\}]$$

Theoretical Cycle Efficiencies



Engine Cycles

- Otto Cycle
  - Theoretical Efficiency = $1-1/r^{(n-1)}$

    r = 8 Eff = 0.56

- Diesel Cycle
  - Theoretical Efficiency = $1-[1/r^{(n-1)}]*[(r_{co})^n -1] / [n(r_{co} -1)]$

    r = 8 r_{co} = 2.5 Eff = 0.46

    r = 16 r_{co} = 2.5 Eff = 0.59

- Dual Cycle
  - Efficiency = $1- [1/r^{(n-1)}]*\{[B(r_{co})^n -1]+n(r_{co}-1)(1-B)\}/[n(r_{co} -1)]$
  - Theoretical Efficiency

    Lower than Otto Cycle for same compression ratio

    Higher than Diesel Cycle for same compression ratio

COMPRESSION RATIOS: GASOLINE VS. DIESEL

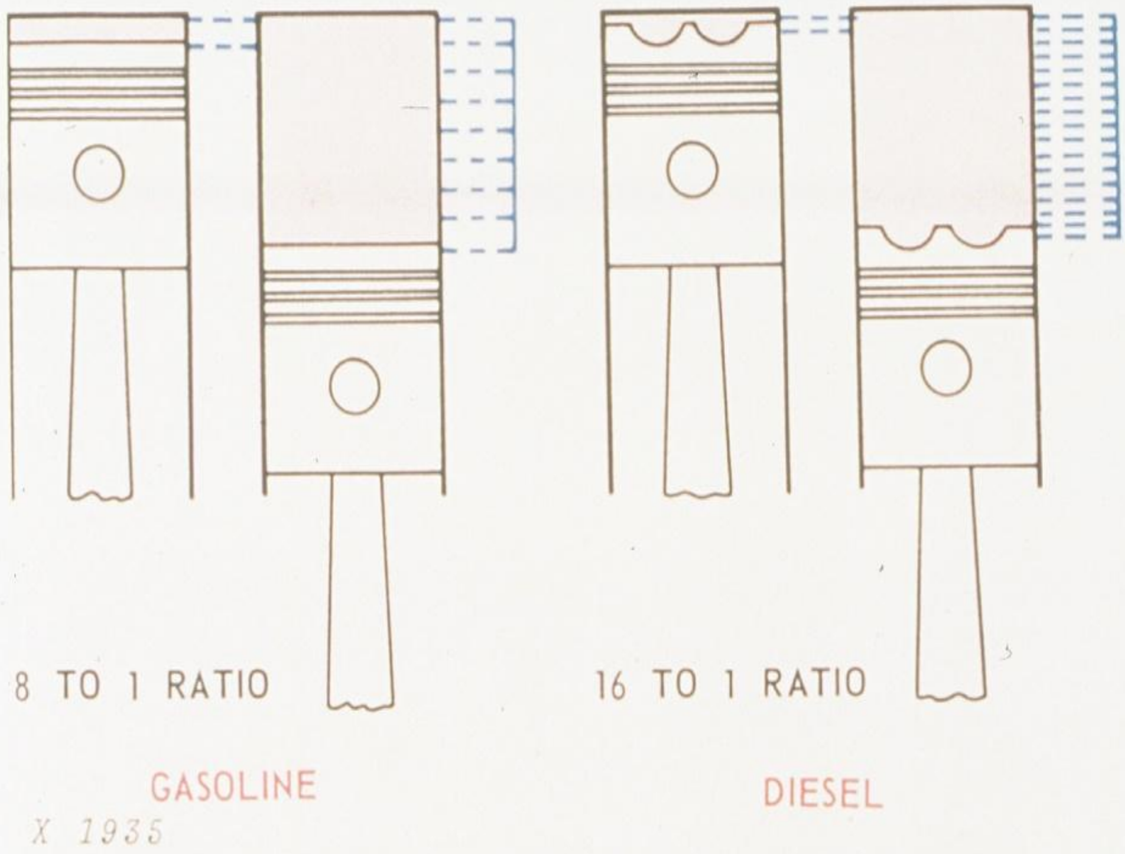


Fig. 25 — Compression Ratios Compared

Differences Between Gasoline And Diesel Engines

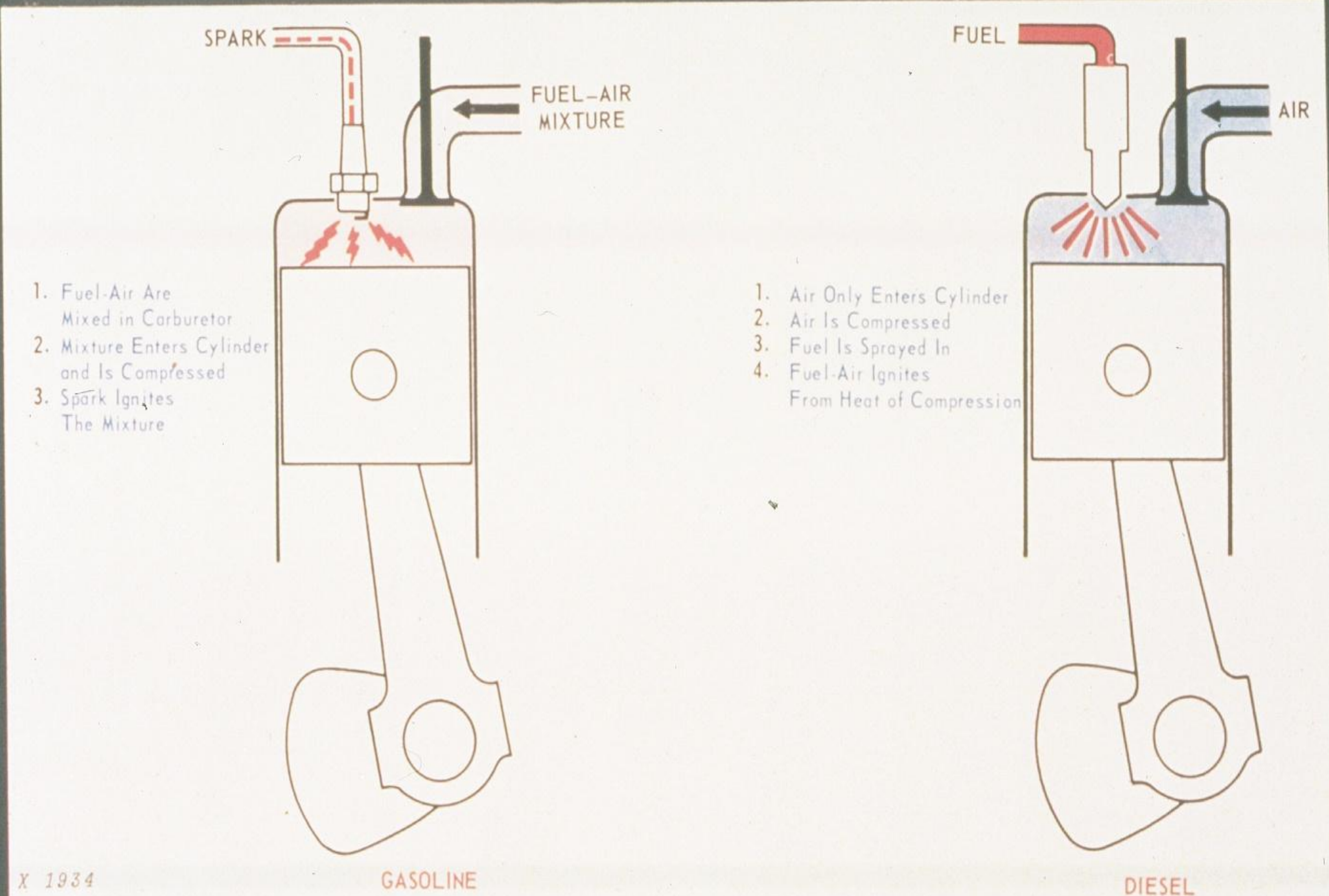


Fig. 24 — Methods Of Supplying And Igniting Fuel

Characteristics of Four Stroke Compression Ignition & Spark Ignition Engines

Characteristics	Compression-Ignition Engine	Spark- Ignition Engine
Compression Ratio	14-22 : 1	5-8 : 1
Ignition	Compression	Electric Spark
Thermal Efficiency	30-60%	25-30%
Fuel induction	Injector	Carburettor (Fuel Injection)
Fuel System	Fuel Oil / Diesel	Gasoline (LP gas)
Fire Hazard	Less	Greater
Power Variation	Increase in Fuel	Increase in Air/Fuel Mixture
Air Induction	Constant	Variable (Throttle Airflow)
Air-Fuel Ratio	15-100 : 1	10-20 : 1
Relative Fuel Consumption	Lower	Higher
Energy per litre of fuel	Higher	Lower
Manifold Throttle	Absent	Present
Exhaust Gas Temperature	482^{o} C / 900 F	704^{o} C / 1300 F
Starting	Harder	Easier
Lubricants	Heavy duty oils	Regular and Premium Oils
Speed Range	Limited (600-3200 rpm)	Wide range (400-6000 rpm)
Engine Mass per Horsepower	8 kg (17.5 lb)	Average 4 kg (9 lb)
Initial Cost	High	Much Lower
Lugging ability (Torque)	Excellent	Less