Equilibrium combustion products:
Dissociation effects

P=30 atmospheres

FIGURE 3-10
Mole fractions of equilibrium combustion products of isoctane-air mixtures as a function of fuel/air equivalence ratio at 30 atmospheres and (a) 1750 K, (b) 2250 K, and (c) 2750 K.

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Thermodynamic model of engine charge
for heat release process

• Unburned gas
  – Ideal gas of frozen composition
• Burned gas
  – At high temperature (T>1740K), as equilibrium mixture
  – At low temperature (T< 1740K), as frozen mixture
Unburned gas properties for gasoline (CH$_{1.85}$/air)

Burned gas properties for gasoline (CH$_{1.85}$/air)

Composition frozen at 1740K
Fuel-air cycle results

In the Fuel-Air Cycle, the engine processes are still modeled as ideal but the properties of the working fluid (fuel/air/residual gas mixture before combustion, and burned gases in chemical equilibrium after combustion) are described accurately.

The results from this improved cycle analysis model are useful for estimating, approximately, the effects of compression ratio, fuel/air equivalence ratio, and mixture inlet conditions on engine efficiency and performance. The following approximate relationships are useful.

1. The maximum indicated fuel conversion efficiency of an actual engine is about 0.85 times the efficiency of the equivalent fuel-air cycle.

2. Results from change of engine operating condition can be interpreted in terms of percentage change in output values.

Computer codes which accurately simulate the real engine cycle have now been developed and are widely used.

Fuel-air cycle results: \( \eta_{f,i} \)

Fuel: octene; \( p_1 = 1 \text{ atm, } T_1=388 \text{ K, } x_r=0.05 \) (Fig. 5.9)

A=SI engine at stoichiometric with \( r_c=10 \); C=Diesel at A/F=36 (\( \phi=0.4 \)) with \( r_c=15 \)

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Real Cycle Effects

1. Combustion efficiency
\[ \eta_c = 1 - \frac{\text{exhaust chemical energy as CO, H₂, HC, soot}}{\text{chemical energy in inducted fuel}} \]

2. Heat loss, finite combustion time, actual valve timing

SI engine:
- H₂ and CO ~ 1 to 2% of fuel energy
- HC ~ 1% of fuel energy
- \( \eta_c \approx 97-98\% \)

Diesel engine
- Very little unburned gas
- \( \eta_c \approx 99\% \)

Fig. 5-18
Pressure-volume diagram for actual SI engine compared with that for equivalent fuel-air cycle; \( r_e = 11 \).

Deconstruction of cycle losses

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