## Equilibrium combustion products: Dissociation effects

**P=30 atmospheres**

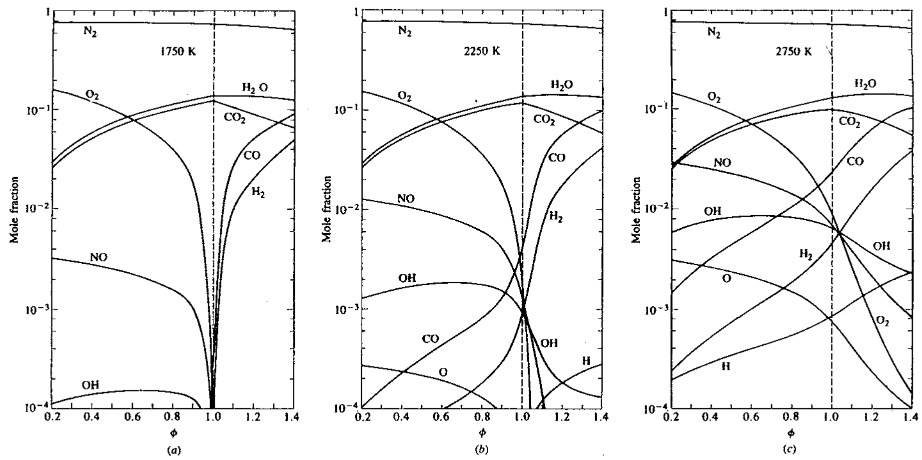


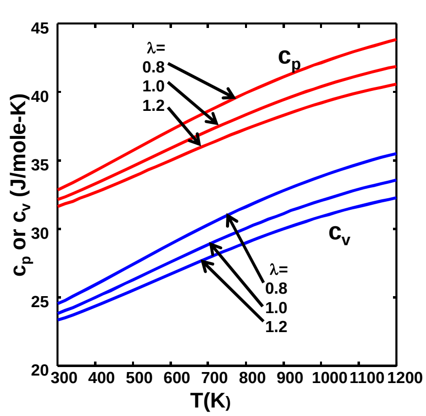

**FIGURE 3-10**
Mole fractions of equilibrium combustion products of isooctane-air mixtures as a function of fuel/air equivalence ratio at 30 atmospheres and (*a*) 1750 K; (*b*) 2250 K; and (*c*) 2750 K.

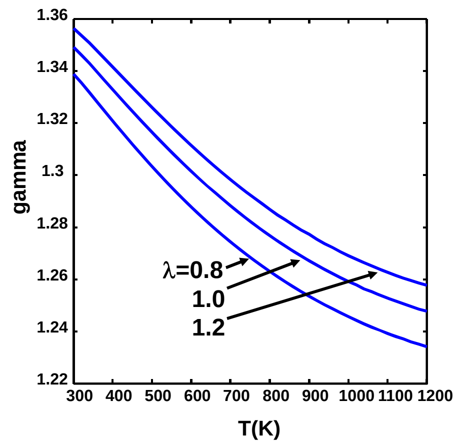


## Thermodynamic model of engine charge for heat release process

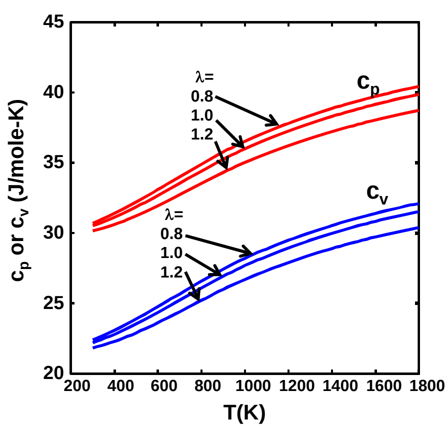
- Unburned gas
  - Ideal gas of frozen composition
- Burned gas
  - At high temperature (T>1740K), as equilibrium mixture
  - At low temperature (T< 1740K), as frozen mixture

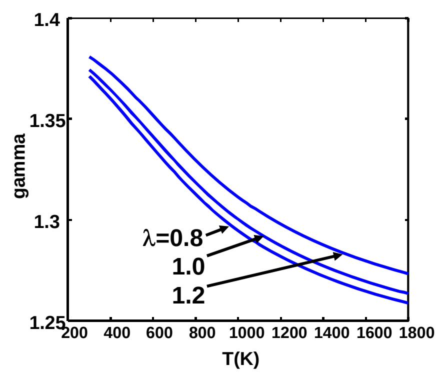
## Unburned gas properties for gasoline ($CH_{1.85}$)/air




## 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.

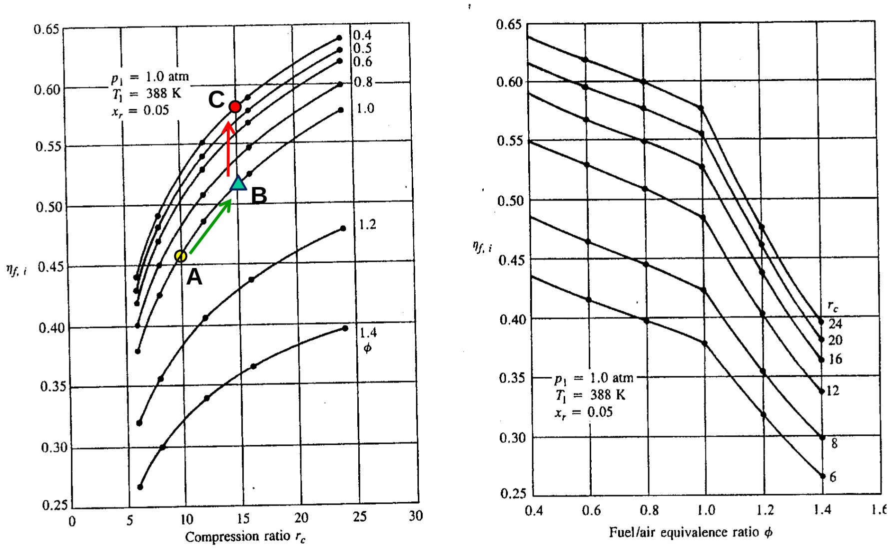
1. The maximum indicated fuel conversion efficiency of an actual engine is about 0.85 times the efficiency of the equivalent fuel-air cycle.

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 atm, $T_1$=388 K, $x_r$=0.05 (Fig. 5.9)**

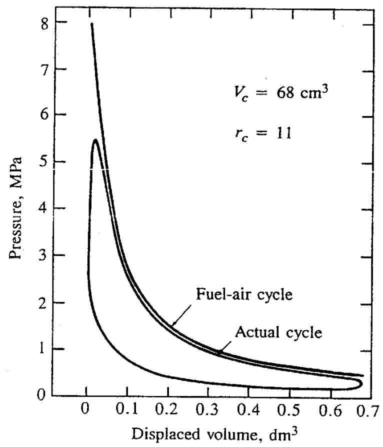



A=SI engine at stoichiometric with $r_c$=10; C=Diesel at A/F=36 (Φ=0.4) with $r_c$=15

## Real Cycle Effects

1. **Combustion efficiency** $\eta_c = 1 - \frac{\text{exhaust chemical energy as CO, H}_2\text{, HC, soot}}{\text{chemcial energy in inducted fuel}}$

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




SI engine:
$H_2$ and CO ~ 1 to 2% of fuel energy
HC ~ 1% of fuel energy
$\eta_c$ ~ 97-98%
Diesel engine
Very little unburned gas
$\eta_c$ ~ 99%

**Fig. 5-18 Pressure-volume diagram for actual SI engine compared with that for equivalent fuel-air cycle; $r_c$ = 11.**



## Deconstruction of cycle losses

SAE 2009-01-1907