Module 2: Thermodynamics of Combustion

Lecture 10: Adiabatic Flame Temperature

The Lecture Contains:

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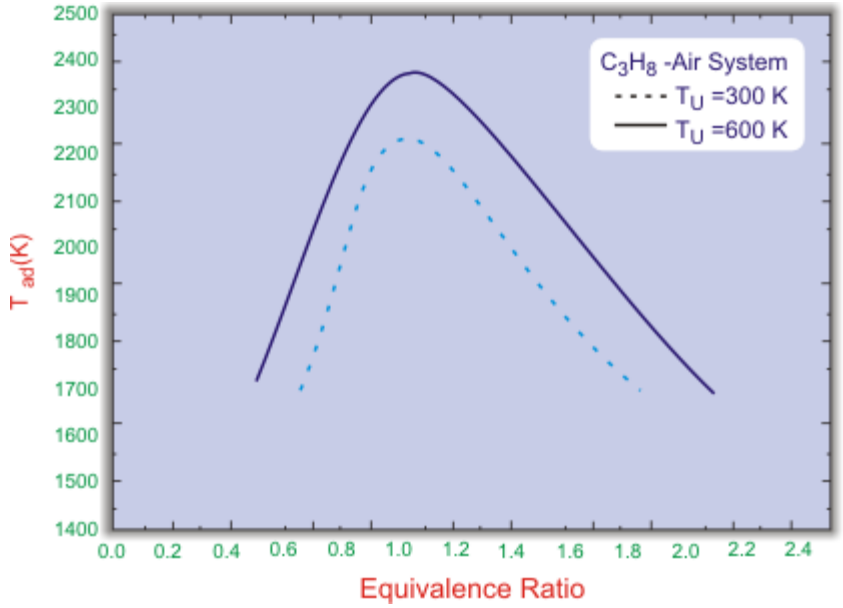
Effect of Equivalence Ratio on Adiabatic Flame Temperature



(Figure 10.1)

- Flame temperature increases with an increase in equivalence ratio till $\Phi = 1.05$.
- Beyond $\Phi = 1.05$, flame temperature decreases with equivalence ratio.
- With increase in inlet temperature from 300 to 600 K, the curve is sifted upwards.

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Adiabatic Flame Temperature

In a combustion process, the final temperature attained under adiabatic condition is known as adiabatic flame temperature (T_{ad})

Where,

$$H_R = \sum_i^R n_i h_i = \sum_i^R n_i \left[h^0_{f,T_i} + \int_{T_i}^{T} C_{p,i}(T)dT \right]$$

$$H_p = \sum_i^P n_i h_i = \sum_i^P n_i \left[h^0_{f,T_i} + \int_{T_i}^{T_{ad}} C_{p,i}(T)dT \right]$$

S.W - Shaft work
K.E - Kinetic Energy
P.E - Potential Energy

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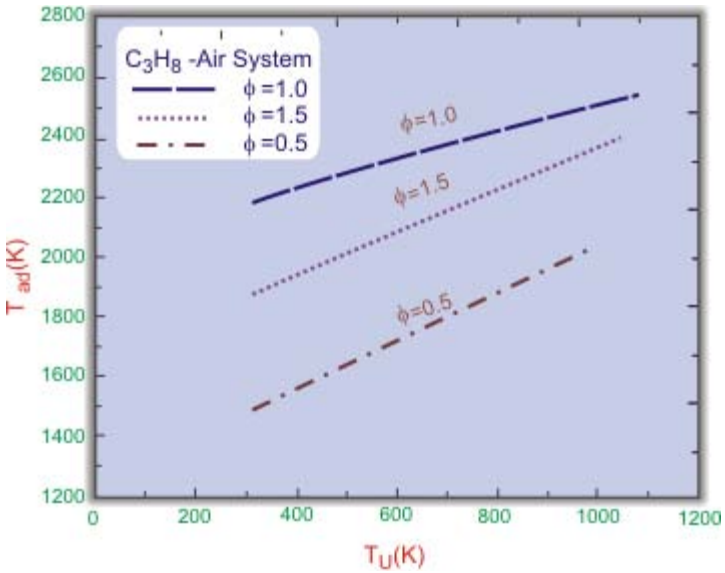
Effect of Initial Temperature on Adiabatic Flame Temperature



(Figure 10.2)

- Flame temperature increases with an increase in initial temperature.
- The increment may not change beyond 3000 K
- Beyond 3000 K, most of the liberated energy goes into dissociating the stable species.

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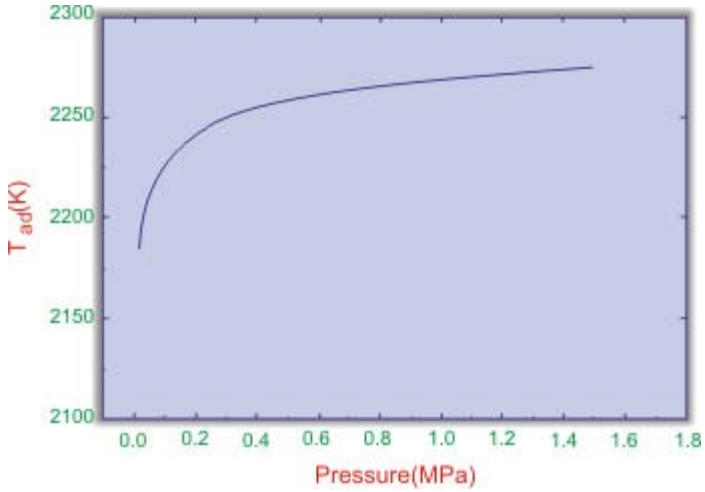
Effect of Pressure on Adiabatic Flame Temperature



(Figure 10.3)

- Flame temperature increases with an increase in pressure
- At high pressure dissociation of stable molecules decreases
- Increase in flame temperature is limited beyond 0.8 MPa
- This is due to the negligible or no change in chemical composition at high pressure

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Effect of Pressure on Adiabatic Flame Temperature

System	T_u (K)	P (MPa)	T_{ad} (K)
CH_4 Air	300	0.1	2200
CH_4 - Air	300	2.0	2270
CH_4 - Air	600	2.0	2500
CH_4 - O_2	300	0.1	3030
C_3H_8 - Air	300	0.1	2278
H_2 - Air	300	0.1	2390
H_2 - O_2	300	0.1	3080
CO - Air	300	0.1	2400

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