Questions for Class 10
Volatiles Combustion/Soot
Chemical Engineering 733

Reading:

(a) Fletcher, et al., "Soot in Coal Combustion Systems," *Prog. Energy Combust. Sci.*, **23**, 283-301 (1997). **DOI:** 10.1016/S0360-1285(97)00009-9

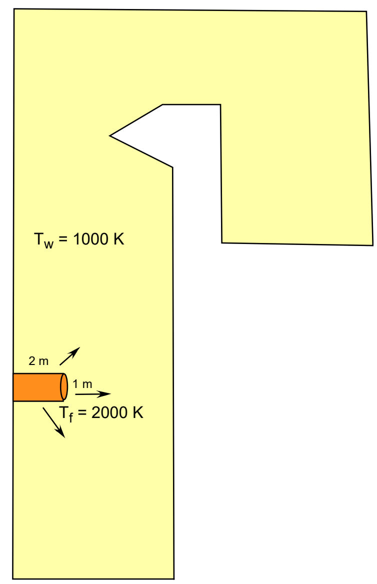
(b) Brown and Fletcher, "Modeling Soot from Pulverized Coal," *Energy & Fuels*, **12**:4, 745-757 (1998). **DOI:** 10.1021/ef9702207

(c) Ma, J., et al., "Conversion of Coal Tar to Soot During Coal Pyrolysis in a Post-Flame Environment," *Twenty-Sixth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 3161-3167 (1996). **DOI:** 10.1016/S0082-0784(96)80161-5

1. Please describe what is meant by secondary pyrolysis reactions.

2. One of the products of secondary pyrolysis reactions is soot. Please describe where this soot comes from, how much can form, and its elemental composition. How does formation of coal-derived soot differ from soot formation in a light hydrocarbon flame (like methane-air or acetylene-air)?

3. Obviously, soot might be important for near-burner radiation effects. Please do a calculation to estimate the amount of heat transferred from a cylindrical flame surface, 2.0 m long by 1.0 m diameter, that has a flame temperature of 2000 K and an effective surface emissivity of 0.2 (see accompanying figure). Assume that the flame radiates to a surrounding wall of 1000 K. What variables would influence the value of the emissivity?



4. Using the heat capacity of air at 1800 K, determine what temperature difference the heat loss calculated in Question 3 would cause. Assume a net outward velocity from the flame front of 3 m/s. Compare this result with the findings of Brown.

5. Sketch the profiles of gas temperature radially away from the particle, and the concentrations of fuel and oxidizer, all as a function of time during devolatilization in air for: (a) single particle combustion (i.e., a single particle burning in air); and (b) a cloud of particles burning (i.e., assume a diffusion flame with fuel and oxidizer contacting at the edge of the flame).

6. A typical hydrocarbon flame thickness is 0.5 to 1.0 mm. In single particle combustion, the volatiles flame is often assumed to be infinitely thin. For a 50 µm diameter particle, postulate on what errors might be associated with the thin flame assumption.