"WARM-UP EGEE 464W DESIGN PROBLEM"

Problem 13 (Peters et al., 1991, 4th ed., or 2003, 5th ed.)

DESIGN OF REACTOR FOR COAL CONVERSION TO NONPOLLUTING FUEL OIL

A plant is being designed to produce low-S oil from coal under the conditions outlined below. A major concern in the design is to minimize the volume of the reactor (why?), and you are to carry out some preliminary studies for the reactor system. Specifically, you are to determine the total volume of the reactor if it is operated isothermally at 800 ^{o}F for the case of a single ideal PFR operation and for the case of a single CSTR system with the conditions and assumptions as outlined in the following.

(What result do you expect to obtain?)

-Plant is to produce 50,000 bbl/day (reasonable?) of low-S oil (0.4 wt%... low enough?) from coal. Table C-16 gives the specs for the feed coal and the product oil.

-Coal in the slurry is 35 wt% with the balance being recycled oil of the same composition as the product oil. (Why is so much oil recycled?)

-A Ni-Mo/Al2O_3 catalyst in the form of 1/8-in. spheres is used with a desulfurization activity A_s=1.25 (units??) and a bulk density of 42.0 lb/ft^3. The relevant (simplified?) kinetic equation is

$$-r_s = k_s A_s \frac{C_s^2 p_{H,av}}{C_{so}(1 + K_{HS} p_{HS,av})}$$

(see text for exact meaning of symbols).

-Pressure is 2500 psia and there is negligible pressure drop across the reactor.

-Gaseous feed is 25,000 ft^3 (ntp) per barrel of slurry fed.

-Gas feed composition is 85% H_2 and essentially 15% CH_4, with negligible H_2S content. Neither is dissolved in the slurry.

-Product yield is 4.2 bbl/ton of coal (as received); its average MW is 301 (units?).

-Partial pressure of H_2 for the PFR can be assumed to be the arithmetic average of entrance and exit pressures. (Reasonable? Necessary?)

Hints/suggestions: Solve materials (and energy?) balances first. Then solve the two reactor performance equations analytically.