Problem 5-11

Reaction (gas-phase, elementary, irreversible):

$$A + B \rightarrow C + D$$

PBR, isothermal.

$T = 305K, W = 100kg, P_0 = 20atm, P = 2atm, F_{A0} = F_{B0} = 10\frac{mol}{min}, C_{A0} = 0.4\frac{mol}{L}$

$$X = 0.8$$

What would be X' if catalyst particle size were doubled?

Ergun equation:

$$\frac{dP}{dz} = -\beta \frac{P_0 T F_T}{P T_0 F_{T0}}$$

$$X' = \frac{\beta}{\beta'} X$$

With $\epsilon = 0$:

$$\beta = \frac{R_e}{\rho_0 g_c D_p} \left(\frac{1-\phi}{\phi^3} \right) \left[\frac{150(1-\phi)\mu}{D_p} + 1.75 R_e \right]$$

Doubling the catalyst particle diameter:

$$\beta' = \frac{R_e}{2\rho_0 g_c D_p} \left(\frac{1-\phi}{\phi^3} \right) \left[\frac{150(1-\phi)\mu}{2D_p} + 1.75 R_e \right]$$

Taking the ratio and multiplying top and bottom by D_p:

$$\frac{\beta}{\beta'} = \frac{1}{2} \frac{150(1-\phi)\mu + 1.75 R_e D_p}{75(1-\phi)\mu + 1.75 R_e D_p}$$

For turbulent flow, $R_e \geq 3500$, and for a gas-phase reaction, $\mu \approx 10^{-5}$. Therefore:

$$\frac{\beta}{\beta'} \approx \frac{1}{2} \frac{0 + 1.75 R_e D_p}{0 + 1.75 R_e D_p}$$

$$X = \frac{1}{2} X' = 0.4$$