Problem 5-11

Reaction (gas-phase, elementary, irreversible):

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

PBR, isothermal.

$$T=305K$$
, $W=100kg$, $P_0=20atm$, $P=2atm$, $F_{A0}=F_{B0}=10rac{mol}{min}$, $C_{A0}=0.4rac{mol}{L}$ $X=0.8$

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

Ergun equation:

$$rac{dP}{dz} = -eta rac{P_0 T F_T}{P T_0 F_{T0}}$$
 $X' = rac{eta}{eta'} X$

With $\epsilon=0$:

$$eta = rac{R_e}{
ho_0 g_c D_p} igg(rac{1-\phi}{\phi^3}igg) igg[rac{150(1-\phi)\mu}{D_p} + 1.75 R_eigg]$$

Doubling the catalyst particle diameter:

$$eta'=rac{R_e}{2
ho_0g_cD_p}igg(rac{1-\phi}{\phi^3}igg)igg[rac{150(1-\phi)\mu}{2D_p}+1.75R_eigg]$$

Taking the ratio and multiplying top and bottom by D_p :

$$rac{eta}{eta'} = rac{1}{2} rac{150(1-\phi)\mu + 1.75R_eD_p}{75(1-\phi)\mu + 1.75R_eD_p}$$

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

$$rac{eta}{eta'}pproxrac{1}{2}rac{0+1.75R_eD_p}{0+1.75R_eD_p} \ X=rac{1}{2}X'=0.4$$