CE 329 Class 39 Worksheet

The age function for a laboratory reactor has been measured and found to obey the equations given below, with times in ks. Calculate the average residence time in the reactor and then use a segregated flow model to find the conversion for the first order reaction A → P if the rate constant is 0.8 ks^{-1} and the reactor is isothermal.

$0 < t < 0.4$	F1(t) = 0
$t > 0.4$	F2(t) = 1 – exp(–1.25(t-0.4))

1. The problem statement provides the age function. we will also need the age distribution function. Generate the age distribution function for this problem by differentiating the age function.

$$dF = \left(\frac{dF}{d\lambda}\right)d\lambda$$

2. The age function must be properly normalized before it can be used to model a reactor. Check that the age function for this problem is properly normalized.

$$\int_0^1 dF = \int_0^\infty \left(\frac{dF}{d\lambda}\right)d\lambda = 1$$

3. Calculate the average residence time using the age distribution function.

$$\bar{t} = \int_0^1 \lambda \, dF = \int_0^\infty \lambda \left(\frac{dF}{d\lambda} \right) d\lambda = 1$$

4. The average conversion can be calculated from the age distribution function. To do so the conversion in a perfectly mixed fluid element (i. e. in a batch reactor) as a function of reaction time is needed. Write a batch reactor mole balance on species A using the rate expression given in this problem, solve it by separation of the variables and integration and use the result to write an expression for the conversion of A in a fluid element as a function of reaction time.

5. Use the expression from step 4 to calculate the average conversion using the residence time distribution.

$$\overline{f}_A = \int_0^1 \lambda \, dF = \int_0^\infty f_A \left(\frac{dF}{d\lambda} \right) d\lambda = 1$$