

## Error in Fogler: Superficial Velocity or Actual Velocity

See page 781 of the 4th edition for the external transport limited PBR derivation (no axial diffusion or radial dispersion).

Fogler states that:  $F_A = C_{A,bulk}UA_c$

where U is the superficial molar average velocity. This is defined as the velocity that the fluid would have if no catalyst were present. It can also be thought of as the velocity that would be measured immediately upstream or downstream of the packed bed.

This equation is incorrect if you consider the units, there should be an additional factor of phi, the void volume, in it. The bulk concentration should be measured by taking a fluid sample, not measuring the total amount of a component per unit volume of the entire reactor.

$F_A [=]$  moles/time

$F_A [≠]$  moles/fluid volume × reactor volume/time

The correct relationship is:

$$F_A = C_{A,bulk} \phi UA_c$$

$F_A [=]$  moles/time  $[=]$  moles/fluid volume × fluid volume/reactor volume × reactor volume/time

This is important for converting from the flowrate to the concentration correctly in a PBR.

If you want to know the residence time in your PBR, the important velocity is the ACTUAL average axial velocity of the fluid flowing in the void space, not the superficial velocity. The reduction in reactor volume by incorporating catalyst causes the residence time to be shorter than predictions using the superficial velocity. In cases where the fluid is water (constant volumetric flow rate):

$$V_{actual} = U / \phi$$

$$\tau = L / V_{actual}$$

A similar mistake with the superficial velocity is made on page 843. A simple remedy is to replace U with  $U\phi$  in these equations.