A First Course on Kinetics and Reaction Engineering Example 12.1

Problem Purpose

This example illustrates testing the assumption of perfect mixing by varying the agitator speed during a chemical reaction.

Problem Statement

As part of his M. S. thesis research at the University at Buffalo (1990), Ramaswamy studied the rate of the water-gas shift reaction, equation (1) in the presence of H₂S. The reactor he used was supposed to conform to an ideal CSTR model. The rotational speed of the agitator in the reactor he used could be adjusted. He measured the steady state CO conversion, f_{CO} , at fixed conditions except for the varying agitator speed and obtained the results below. On the basis of these results, he decided that the stirring speed should be greater than 800 in all his kinetics experiments. Can you explain why he decided this was necessary?

$$H_2O + CO \rightleftarrows CO_2 + H_2$$

(1)

N (RPM)	fco
0	0.041
200	0.042
400	0.109
600	0.221
700	0.259
800	0.260
900	0.264
1000	0.267
1100	0.259
1200	0.269

Problem Solution

The CSTR model assumes that the reactor is perfectly mixed. Since every one of the experiments reported here was run at the same conditions, the conversion should be the same in every case as long as the mixing is perfect. Looking at the data we can see that at the higher stirring rates the conversions are fairly constant (to within experimental accuracy), but below ca. 700 RPM they decline. Ramaswamy concluded that if the agitator operated below this speed, then his reactor would no longer behave like a CSTR and he couldn't use the CSTR model to interpret his data. In fact, to ensure a margin of safety, he used 800 RPM as the minimum stirring rate.