Catalytic Oxidation of Carbon Monoxide
ChE 433/434

Objective:

Find an appropriate rate expression from experiment for the catalytic oxidation of carbon monoxide over a commercial Pt-Rh /Alumina catalyst.

$$CO(g) + \frac{1}{2}O_2(g) \xrightarrow{Pt-Rh/\,Alumina\,Catalyst} CO_2(g)$$

Suggested Rate Form:

Try an empirical second order rate equation

$$-r_A' = k_o \exp\left(-\frac{E}{RT}\right) P_A P_B$$

in which A and B refer to CO and O_2, respectively.

Laboratory Reactor:

A Berty internal recycle reactor will be used. This reactor may be modeled as a CSTR. A brief instruction on its operation will be provided on site.

Suggested Experimental Conditions:

Use excess air, hence excess O_2, so that the rate equation can be reduced to

$$-r_A' = k_o' \exp\left(-\frac{E}{RT}\right) P_A$$

The total pressure should be atmospheric. The feed is a 2% CO – 98% air mixture by mole. The reaction temperatures to be studied are 225 and 250 ^oC and the flow rates to be used are 4, 6, and 8 sccm at each temperature (no more, no less). Accurate temperature control is essential to successful completion of the experiment. The reactor contains 0.25 grams of catalyst.

Report Requirement:

All written and oral reports are expected to include discussions on the objective of the experiment, the Berty reactor, the experimental setup, the experimental conditions, the experimental procedure, the analysis of the data, and the evaluation of pore diffusion effects on the catalyst performance.

ChE 434 Catalysis Lab
Operation Manual

Startup

01. Test the CO alarm (white box, mounted on board, up above).
02. Make sure the air and CO tanks are hooked up and turned off.
03. Leak-check all valves and connections. Fix any leaks found. (Ask for soap bubble jar.)
04. Make sure the exhaust hose from the reactor is out the window and down the side of the building.
05. Turn on the cooling water to the magnedrive mixer using valves marked F and G.
06. Plug in the power strip to the outlet above it and make sure it is turned on.
07. Turn on the magnedrive mixer (marked B) and set the speed at 2000 RPM.
08. Turn on the heater (marked A on photo).
09. Turn on the mass flow mixing controller (marked C)
10. Turn on the CO analyzer (marked D).
11. Make sure both channel setpoints on the mass flow mixing controller are set to 0.
12. Calibrate the CO analyzer as follows:

    12.1. Set the reading knob (marked E) to IN. This knob controls what source the CO analyzer reads from. It can read either the material coming into the reactor (labeled IN) or the material exiting the reactor (labeled OUT).
    12.2. Turn on the air tank and set the appropriate channel setpoint on the mass flow mixing controller to 100%.
    12.3. Zero the CO analyzer by unlocking the knob labeled 'zero' and adjusting it until it reads 0. Turn off the air tank.
    12.4. Turn on the CO tank and set the appropriate channel setpoint on the mass flow mixing controller to 100%.
    12.5. Adjust the span knob on the CO analyzer until it reads the desired value. (Remember, the numbers are arbitrary. But the relationship is linear so once a known value is determined any other values can be determined relative to it. The gas in the tank is a 2% CO – 98% air mixture.) Turn off the CO tank.
    12.6. The CO analyzer will need to be recalibrated with each run.

13. Turn on the heater. Note that the heater is an interval heater, meaning that it applies a constant heat for a given time interval in order to heat to a given temperature. Therefore, it is very easy to burn out the heater coils by ramping it up too fast. So, turn it up slowly. Intervals of 50°C seem to work fine. Turn it up 50°C, wait until it comes to a steady temperature, then turn it up another 50°C. Repeat until desired temperature is reached. Occasionally check on cooling water.

Getting conversion data

01. Turn on the CO tank.
02. Service the CO analyzer for reactor outlet. (Remember the inlet gas concentration is always 2% CO.)
03. Select the higher of the two assigned reaction temperatures (225 and 250°C) and let the reactor temperature come to a steady state.
04. Select one of the three gas flow rates to be studied and let the outlet CO concentration come to a steady state. Repeat the run with each of the other two flow rates.
05. Record the reactor temperature, the gas flow rate, and the outlet CO concentration.
06. Repeat steps 03 and 05 for the lower of the two assigned reactor temperatures.

Shutdown

01. Turn off the heater.
02. Turn off the CO tank.
03. Turn off the CO analyzer.
03. Turn on the air tank and flush the system for a while to purge any left over CO.
05. Turn off the air tank.
06. Turn off the mixer.
07. Unplug the tan power strip.
08. Keep cooling water running for 10 extra minutes before turning it off.