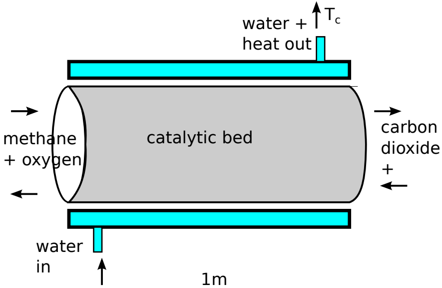
Workshop Wits 2013: The Reverse Flow Reactor

January 6, 2013

Introduction

- Most ecological emissions of methane relate directly to methanogens (methane producing microorganisms) generating methane in warm, moist soils as well as in the digestive tracts of certain animals. (Wetlands, landfills, waste water treatment plants). Also forrest fires.
- Methane as a greenhouse gas has a warming potential twenty five times greater than carbon dioxide
- Methane is a valuable energy source.
- For practical use a catalyst is required to accelerate the conversion of a methane/oxygen (or air) mixture.
- Normally preheating would is required to achieve a high enough temperature for useful conversion.
- By reversing the flow direction one avoids preheating the mixture to 'the reaction temperature'.

The Reverse Flow Reactor



The Objective: To optimise design: inflow rate, water cooling rate, catalytic bed (pore size, ...), cycle timing.

The Catalytic Bed

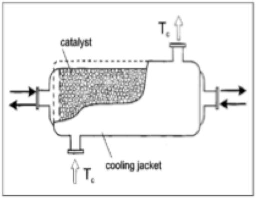
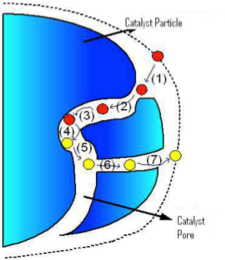


Figure 1. Cooled reverse-flow reactor.



The Chemistry

In simple terms we have:

$$CH_4 + 2O_2 + Catalyst \rightarrow CO_2 + 2H_2O + Catalyst$$

Essentially an intermediary compound is formed on the catalytic surface and this facilitates the reaction. At the end of the process the catalyst is released and so recycled.
The net effect is that we get an effective temperature dependent reaction rate as shown:

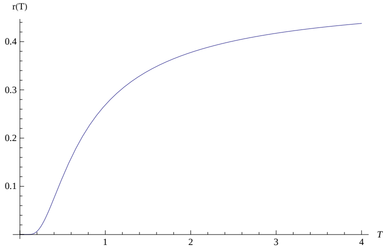


Figure : Methane Conversion Rate in the presence of a catalyst

Background Required

We need to determine the relevant equations describing the process and examine the equations.
Heat Eqn. Elementary chemical reactions.

Mathematical Tools:
Scaling ideas. ODEs. Mathematica. Numerics.
We'll work together to build up the needed skills.