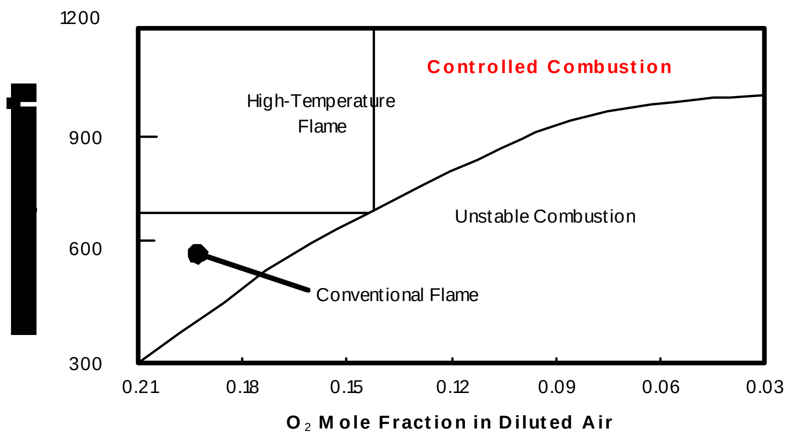
Controlled Combustion

Investigators: C. T. Bowman, Professor, Mechanical Engineering Department, N. Arora, Graduate Research Assistant

In conventional combustion devices, the chemical conversion of fuel and oxidizer to products occurs rapidly in an uncontrolled and highly irreversible process (flame). In *controlled combustion*, the rate of the fuel conversion process is varied by imposing prescribed initial conditions (temperature and mass fractions of oxidizer and diluents), leading to potential reductions in irreversibilities in energy conversion and to reduced emissions of pollutants and greenhouse gases. One example of controlled combustion is the "flameless" oxidation process in which exhaust heat recovery and exhaust gas recirculation are employed to cause combustion to occur in a more homogeneous fashion. In the present project, this concept is being extended to include diluents such as nitrogen and carbon dioxide that could be produced in separation processes and delivered to the combustion system. Carbon dioxide is particularly interesting in that it can have both a thermal and chemical effect on the combustion reaction. The regime of controlled combustion is illustrated below.

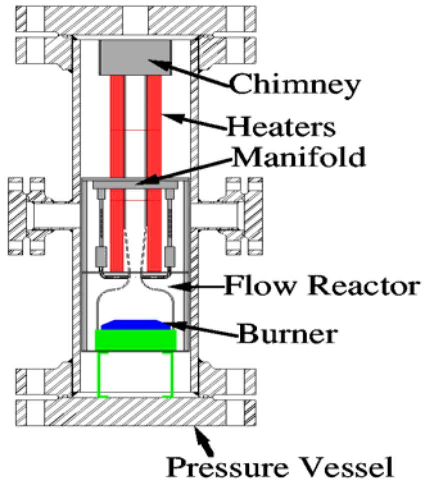


Regimes of combustion.

The controlled combustion regime lies outside the regime of conventional combustion processes and the chemical processes in the controlled combustion regime are poorly understood at the fundamental level needed for design optimization, especially for high-pressure combustion systems, such as gas turbines and diesel engines.

The regime of controlled combustion is being investigated experimentally in a high-pressure flow reactor facility, shown below, in which important parameters, such as preheat and dilution can be independently controlled. The spatial evolution of the chemical reaction is monitored by sampling for key reactant, intermediate product species and temperature. Detailed modeling of the data will yield chemical models for use in the design of controlled combustion systems and particularly for use in modeling low-irreversibility combustion engines, another project being carried out under the Global Climate and Energy Program.

Progress to date includes the redesign and fabrication of the quartz flow reactor for the expected conditions of experimental study, initial computer studies to identify the experimental regimes to be investigated, and initial measurements of tracer species injected into the reactor to determine the effectiveness of the mixing process that later will be used to inject reactant species.



High-Pressure Flow Reactor

Contact:
C.T. Bowman: ctbowman@.stanford.edu