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Title	Modeling of interaction between scalar and flow fields of confined turbulent nonpremixed flames

(800 words)

Combustion process in furnaces is a most common combustion mode in practice. Interactions among chemical process and physics of fluid flow, or other physical processes, under the confinement become interesting phenomena to be investigated. An experiment was conducted in a cylindrical furnace with a set of three concentric nozzles burner installed at the bottom of the furnace. Experimental results show the flame stretch effect due to the velocity difference between air nozzles. An increase in fuel flow rate corresponds to an increase in global equivalence ratio, thus reduces the oxygen concentration inside the furnace. Recirculation flow develops around the flame inside the confined configuration. The recirculation transports burned gases back into the flame and gives dilution effect. The above experimental results point out that the flow field has a strong relationship with the flame characteristics. The NOx characteristics of confined turbulent nonpremixed flames are described on the basis of furnace sizes and burner conditions. These interactions can be simulated in a numerical computation based on mathematical models. Therefore, we are able to design the optimum combustion operation and to predict pollutant emission.

Numerical simulations of confined turbulent nonpremixed flames were implemented by a commercial software CFX and a code KIVA-3V. The codes solve three-dimensional Navier-Stokes equations, which are Favre-averaged, with a standard k-ε turbulence model. Simulations using the CFX software give basic data in terms of of numerical parameter for confined flames. To further evaluate the confined flames, new models are introduced for turbulence model correction and chemistry modeling. For a jet issued from a round nozzle, the jet spreading stretches toroidal vortices surround the jet. This phenomenon suggests correction for standard k-ε turbulence model. The chemistry model considers statistical description of fluctuating scalar entities by means of probability density function (PDF). The PDF distributions are presumed by general mathematic functions. The construction of the presumed PDF distributions requires second order moments obtained from additional transport equations. Mean reaction rate can be retrieved by integration of the PDF distribution of temperature and species composition. The integration over multidimensional PDF consumes large computation cost. In this thesis, integration based on the crude Monte Carlo method is introduced. This method is realized by generating random particle samples to reconstruct the PDF distributions. The mean reaction rate is then calculated as the ensemble average of the sample reaction rates.