Fuel Composition, Dilution, and Pressure Effects on Laminar Burning Velocities and NO Production in H_2/CO/Air Mixtures

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OBJECTIVE
Development of validated reduced chemistry for predictions of syngas flammability limit and NO emissions.

ACCOMPLISHMENTS TO DATE
The effects of fuel composition, equivalence ratio, dilution, and pressure on the laminar burning velocities of H_2/CO/Air mixtures and NO production are, respectively, investigated experimentally and numerically. Stretch-corrected data for laminar burning velocities obtained from outwardly-propagating spherical flames using a nearly-constant pressure bomb method are presented for hydrogen concentrations in H_2/CO of 0-100% by volume, CO_2 dilution of 0-30% by volume, equivalence ratios of 0.55-2.2, and pressures of 1-30 atm. The measured data are only in good agreement with the prediction of GRI-Mech 3.0 over a limited range. These data indicate increasing laminar burning velocity with increasing hydrogen concentration, decreasing pressure, and decreasing dilution. Kinetic impact of CO_2 addition on flame speeds of H_2/CO/Air mixtures was investigated by employing a chemically inert fictitious CO_{2x} species which has the same transport and thermal properties but does not participate in reactions. The chemically inert fictitious CO_{2x} species yields higher flame speeds for equivalent CO_2 dilution, indicating the kinetic effect of CO_2 dilution in reducing the flame speed. All measurements performed for pressure comparison used 40% He dilution to suppress flame instabilities.

Numerical simulations using a counterflow configuration were performed to study NO production. For the same temperature, increasing hydrogen concentration in the fuel yields smaller amounts of NO, due to the weakened N_2O intermediate route. The NNH and N_2O intermediate routes were determined to be the most significant pathways of NO production at atmospheric pressure and flame temperature of 1730 K. Of the three dilutents chosen for investigation in this study, H_2O proved to be the most effective for reducing NO emissions, followed by CO_2, followed by N_2.

An accurate spectral dependent radiation model is developed to predict flame speed and flammability of H_2/CO/ CO_2/ H_2O/Air mixtures. The results showed that radiation reabsorption significantly extended the flammability limits. It was also demonstrated that accurate prediction of coal syngas flammability is not possible without appropriate consideration of radiation absorption by CO_2 and H_2O.

FUTURE WORK
Measurements of the flame speeds and flammability limits of syngas at elevated temperatures and pressures

LIST OF PAPER PUBLISHED

1. Z. Chen, X. Qin, B. Xu, Y. Ju and F. Liu, "Studies of radiation absorption on flame speed and flammability limit of CO_2 diluted methane flames at elevated pressures," Proc. of Combustion Institute, Vol. 31, 2006, In press.

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