The 6th ASME-JSME Thermal Engineering Joint Conference
March 16-20, 2003

TED-AJ03-580

THE EFFECTS OF OPPOSING GAS COMPOSITION AND TEMPERATURE ON LEAN FLAME IN COUNTERFLOW FLAMES

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Keywords: Stratified Mixture, Flame Propagation, Lower Flammability Limit, Supported Flame, Counterflow Flames

ABSTRACT

The direct injection stratified charge (DISC) spark ignition engine has the advantages to improve the thermal efficiency of spark ignition engines. It is important to understand the combustion characteristics of the stratified charge for further improvements of this system. In order to investigate the flame propagation through the stratified mixture, numerical analyses of the counterflow premixed flame were carried out in this study.

In our previous experiments, the stratified mixture was formed in the constant volume bomb by the injection of gaseous fuel into the lean mixture charge. The stoichiometry of the mixture charge was set less than the lower flammability limit of the premixed mixture. It was found that the flame generated in the rich area of the fuel jet propagated into the lean mixture charge. However, the flame was quenched before it would reach the chamber wall and some lean mixture remained unburned. The flame seemed to propagate into the lean area by the "inertia" of the rich flame until its decay.

In this study, the propagating flame into the lean mixture and the burned gas behind it were linked to the counterflow flame configuration of the lean mixture and the opposing gas. The flame propagation into the lean area of the stratified mixture was investigated numerically by simulating the counterflow flame of the lean mixture. Nitrogen, burned gas and fuel-air mixtures were opposed to the lean mixture varying their temperature and composition. And the stoichiometry of the lean mixture was also varied widely.

Then the effects of the opposing gas composition and temperature on the lean flame in the counterflow flames were examined in order to clarify the interaction between the rich flame and the lean mixture.

The reaction rate of the fuel in the lean mixture depended on both the opposing gas composition and temperature. In the case that nitrogen was opposed to the lean mixture, the reaction rate of the fuel, $\Sigma\omega_F$ and the heat release rate, $\Sigma\omega_H$ increased with increasing the opposing N_2 gas temperature, T_{OP} at all the equivalence ratio of the lean mixture, ϕ_L except for ϕ_L=0.67. When the burned gas of the stoichiometric mixture was opposed at its adiabatic flame temperature, $\Sigma\omega_F$ and $\Sigma\omega_H$ were larger than those in the case nitrogen was opposed at the same temperature as the burned gas. When the fuel-air mixtures in the flammable range were opposed, $\Sigma\omega_F$ and $\Sigma\omega_H$ increased as the opposing mixture became rich from 0.8 to 1.2 in the equivalence ratio.

The results show that the rich flame and the high temperature gases affect the reaction in the lean mixture. The fuel reaction of the lean mixture far below the lower flammability limit was supported by the transport of heat and radicals.

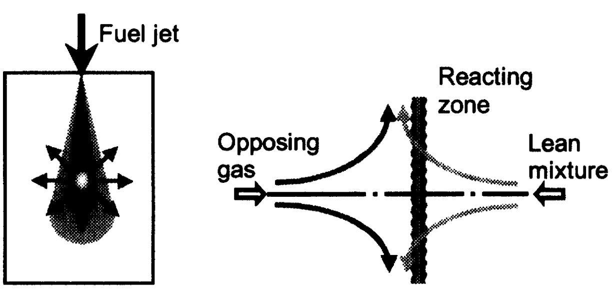

Fig. A-1 Flame Propagation in Stratified Mixture and Counterflow Flame

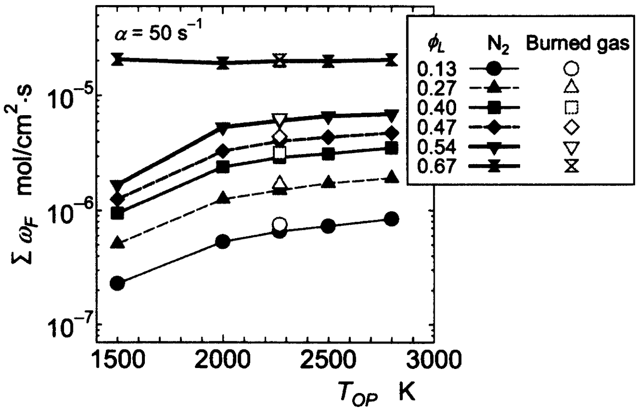

Fig. A-2 Reaction rate of fuel, Opposing N_2 and burned gas