

IGNITION CHARACTERISTICS OF A TWO-COMPONENT CONDENSED FUEL IN A STAGNATION-POINT FLOW

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Two-component condensed fuel ignition behavior is observed in a hot stagnation-point air flow. Fuels utilized in this study are mixtures composed of hexane and solid paraffin with high and low volatilities. At time zero, the mixed fuel is exposed to a hot air stream directed downward onto the fuel surface at room temperature. When the external air flow velocity increases at a fixed flow temperature (1083 K), the ignition time reaches a minimum point, and then it increases again until it goes to infinity for a certain critical flow velocity. This ignitable limit is based on a critical Damköhler number for ignition. The variation of the ignitable limit with fuel composition under fixed air flow conditions, displays a characteristic curve. As the hexane percentage increases, the critical velocity reaches a maximum around 40 wt% and a minimum around 50 wt%. A supporting ignition time tendency is also obtained. Finally, a qualitative discussion of this type of ignition behavior for binary fuel mixtures is given. The phenomenon described here is readily apparent when the difference of the volatilities of the component fuels is quite large.

1. Introduction

The combustion characteristics of multi-component fuels, including water-oil emulsions, have been studied in order to improve efficiency and reduce NO_x emissions and soot formation in engines. Further field research on these problems is necessary since most fuels used in practical combustors are not completely refined, and various methods must be developed for the fire protection of the residual sludge or bilge oil, depending on the type of oil. The important feature of multicomponent fuels (or water-oil emulsions) is that they are mixtures of fuels with different volatilities. From this point of view, droplet vaporization or combustion of the fuel mixtures has been treated theoretically¹⁻⁵ and experimentally.⁶⁻⁸ Reviews of such findings have been conducted by Dryer⁹ and Law.¹⁰ Most investigators, however, have focused their attention on the disruptive atomization and burning of the droplet; consequently studies on the ignition phenomena of a fuel blend are rare.

If the chemical reaction time of gasified fuel and atmospheric oxygen is quite short, the ignition time is nearly equal to the gasification time. Even if the reaction time increases, ignition/non-ignition de-

pends on the gas-phase condition attained by heating. The gas-phase condition is formed in a very complicated manner; the gasification process is governed by the equilibrium equation for the gas-liquid interface, which depends on the initial composition of the fuel and the surface temperature. Since in a multicomponent condensed fuel, it is mainly the more volatile component that evaporates during heating, ignition is basically controlled by the vaporization of this component. However, the complete process is not so simple. For instance, although fuel containing a high percentage of volatile matter may vaporize rapidly, the gasified fuel temperature may not be high because the gasification temperature is lower near the boiling point. This being the case, if the gasification process or the mixing region of gasified fuel and oxidant possesses certain mixed fuel characteristics, ignition may occur in a complex manner. To understand the phenomena, a steady (or quasi-steady) gasification field and long ignition time behavior (obtained by extending the reaction time) are needed. (It is difficult to lengthen ignition time by slow vaporization because a long gasification period causes the gasified fuel to disperse, precluding ignition.)

The ignition source adopted here is a hot stag-