THE SUMMARY OF Ph. D. DISSERTATION

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Title

The influence of temporal and spatial inhomogeneity of continuous spray on ignition phenomenon

Abstract

Because spray ignition is a probabilistic phenomenon, forced ignition of fuel spray have multiple result, i.e. successful ignition and failed ignition, though the time-average fuel concentration is constant. This uncertainty is due to a spatially inhomogeneous dispersion of fuel drops in spray. Therefore, it is aimed to clarify the effect of spatial inhomogeneity of spray on ignition phenomenon. For this purpose, a large number of forced ignition tests of fuel spray were carried out. For this ignition test, Mono-dispersed spray was used to eliminate the effect other than the spatial inhomogeneity of spray, and spray concentration was adjusted to be leaner than lean ignition limit of premixed mixture since spray ignition becomes more probabilistic when the concentration of spray becomes lean.

At first, the effect of static characteristics of spray on ignition phenomenon such as drop size, fuel spray concentration and fuel vapor concentration were obtained. Methanol was used as sample fuel. Though the concentration of fuel spray is leaner than lean ignition limit of premixed prevaporized methanol mixture, it is possible that fuel spray is successfully ignited and it makes propagative flame. Even if the fuel spray is not successfully ignited, it has an ability to make non-propagative flame (initial flame) by the assist of discharged spark energy. Ignition probability increases with the increase of both fuel spray concentration and fuel vapor concentration. When the fuel vapor concentration is kept constant, ignition probability and its increasing rate by fuel spray concentration increase with the decrease of drop size. However, it needs much higher concentration then that of premixed prevaporized mixture to realize successful ignition certainly. Further, the optimum and the worst ratio between liquid and vapor fuel concentration for ignition exist.

Further, it is understood that simple probabilistic-ignition model is applicable for macroscopic evaluation of ignition phenomenon. This model is assumed that the ignition is deterministic by the instantaneous liquid fuel concentration just before ignited and therefore ignition probability can calculates from the fluctuation of spray concentration. In this experimental condition, when the fuel spray is successfully ignited, drop number in certain volume, which is named as reference volume, is constant and it does not depend on drop size. On the contrary, when the initial flame is generated, liquid fuel mass in reference volume is constant.

Next, the spatial inhomogeneity of spray was evaluated by both the number density fluctuation of spray drops and its scale. Further, the Inhomogeneity Index, which indicates the intensity of spatial inhomogeneity of spray as the ratio between the number density fluctuation and its random state value, was introduced since the spray drops disperse and finally dispersion of drops becomes random state. The inhomogeneity index is not affected by both the number density and evaluation scale.

In the observed sprays, drops does not distribute at random and intensity of inhomogeneity of spray is stronger than that of when the drops distribute at random. This fact means that the above mentioned probabilistic-ignition model is not adequate for microscopic evaluation since this model lacks a consideration of inhomogeneity. Therefore, it is necessary to observe the fuel spray of when it just ignited and evaluate its inhomogeneity to understand the spray ignition phenomenon more clearly.

In addition, the relation between spatial inhomogeneity of fuel spray and its ignitability was obtained. Ignitability of fuel spray is affected not only by the instantaneous spray concentration just before ignited, but also by other probabilistic factors based on an inhomogeneity in spray. The ignition process can be classified into two processes, i.e. flame generation and flame propagation. The flame propagation process becomes major control factor of the result, as the discharged energy is sufficiently large. Further, the propagation process is strongly affected by inhomogeneity. Results also suggest the existence of optimum intensity and the scale of inhomogeneity for ignition.

Further, to obtain the effect of volatility of fuel spray on ignition, forced ignition tests were carried out for low-volatile n-Decane fuel spray. Optimum intensity of inhomogeneity for ignition of n-Decane spray is lower than that of methanol spray. The size of generated luminous flame is small and almost constant when the fuel spray concentration is low. And, it increases sharply when the fuel spray concentration becomes higher and fuel spray is certain to be successfully ignited. Spatial inhomogeneity of spray enlarges the area of luminous flame. The optimum scale of spatial inhomogeneity that makes the area of luminous flame maximum exists.