Effect of Disturbance of Inlet Spray Velocity on Flame Structure

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Abstract

From the viewpoint of environmental protection and energy security, it is extremely important to reduce CO_2 emitted by the consumption of fossil fuels in internal combustion engines such as gas turbine engine and diesel engine for energy conversion and propulsion devises. In order to optimally design and operate such equipments, precise prediction of the combustion behavior is essential. However, since combustion is a complex phenomenon, the prediction of the combusting flow behavior has been based on the engineers' experiences and the reliable prediction technique has not been well developed yet. In particular, spray combustion is a complex phenomenon in which liquid fuel is used and the dispersion of the liquid fuel droplets, their evaporation, and the chemical reaction of the fuel vapor with the oxidizer take place interactively at the same time. Hence, the underlying physics governing these processes has not been well understood [1],[2],[3],[4]. One of the most important issues of combustion research is the prediction and suppression of combustion instabilities. In spite of a large number of studies, however, the mechanism of the combustion instabilities has not been well clarified yet e.g.[5]. In particular, the mechanism of combustion instabilities for spray combustion is hardly understood. Recently, de la Cruz Garci'a et al. [6] investigated the self-excited oscillation in a kerosene spray flame by experiment and found that frequency of the self-excited oscillation depends on the degree of mixing of air and fuel droplets. However, the trigger of the self-excited oscillation is not clear.

In tis study effects of disturbances of inlet flow and spray velocities and internal pressure on spray combustion field are investigated by means of two-dimensional direct numerical simulation (DNS). n-decane ($C_{10}H_{22}$) is used as liquid spray fuel, and evaporating droplets' motions are tracked by a Lagrangian manner. The pressure perturbation is captured by employing a pressure-based semi-implicit algorithm for compressible flows [7]. The frequency and magnitude of the inlet disturbance are set at 800 Hz and up to 50 %, respectively, and the internal pressure is set at 0.1 or 0.5 MPa.

The main results obtained in this study are summarized as follows. Firstly, the pressure perturbation in the spray combustion filed is enhanced by combustion reaction and increase in internal pressure, but it is not affected by disturbances of inlet flow and spray velocities very much. Secondly the frequency indicating the peak of power spectra of pressure perturbation depends on neither the inlet disturbance nor the internal pressure.

References

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