Airblast spray characteristics of planar liquid films in longitudinal gas-phase shear layers at various ambient pressure conditions

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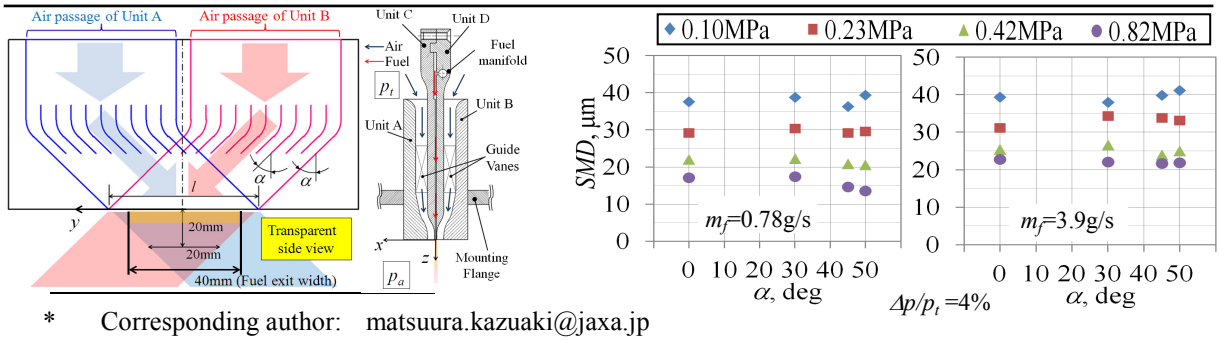
Abstract

Recently, the present authors investigated the effects of swirl combinations on the spray characteristics of a double-swirl filming-type airblast atomizer in relation to aero-engine applications. For a normalized air pressure drop across the atomizer ($\Delta p/p_t$) of 4%, they showed that when changing the outer swirl vane angle (*OSA*) from +20 to +60deg with the inner swirl vane angle (*ISA*) fixed at -45deg (counter swirl combinations with circumferential shear), the minimum *SMD* is obtained at *OSA* between +45 to +50deg. Possible explanations for this tendency would include (a) the effects of the intensity of circumferential shear, (b) weaker interaction of the liquid film with the outer swirling air for larger *OSA*, (c) the effects of deceleration of air velocity downstream by spreading of the swirling flows and so on. However, what is the dominant factor on atomization quality is not well identified yet.

The motivation of the present study is to obtain a clue for a better understanding of the results above, by firstly focusing on the effects of shear intensity on atomization characteristics. For this purpose, a planar airblast atomizer was developed with which the effects (b) and (c) caused by centrifugal forces are eliminated. It was designed so that the two air streams, having the same axial velocity but opposite spanwise velocity components to each other, meet up at the exit of the atomizer to form a longitudinal shear layer to which a planar kerosene liquid film is injected and atomized, as schematically illustrated in the left figures below. The shear intensity was varied by changing the angles of the guide vanes and the air passages (α) of 0, 30, 45 and 50deg.

The performance of the atomizer in terms of air flow field characteristics was firstly evaluated by single-phase numerical simulations. The spanwise non-uniformity of the absolute velocity and the flow angle is to acceptable degree and the atomizer was proven to be working almost as expected.

Its spray characteristics were then investigated by the phase Doppler anemometry, at various test conditions including elevated ambient pressure cases (p_a=0.10-0.82MPa). The results for $\Delta p/p_t$=4% are mainly discussed. As a result, the clear tendency on the effect of shear strength on atomization enhancement is only observed for the higher ambient pressure and the lower fuel flow rate cases (m_f=0.78g/s), as shown in the right figures below. This is mainly due to the relative population increase of small droplets rather than the decrease of the large ones. For the rest, the tendency is not clear. A comparison of the present results with those of the counter-swirl airblast atomizer above suggests the clear effects of swirl combination on the droplet sizes observed in the previous work is not primarily due to the local circumferential shear intensity near the atomizer lip but to other effects such as widely distributed vorticity field by the swirl and/or the centrifugal effects. In addition to this main conclusion, it was also revealed that the effects of p_a and $\Delta p/p_t$ on *SMD* are primarily explained by those of air momentum, a single parameter, and that those of the height of fuel flow passage (0.2 and 0.5mm) are small.



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