Understanding the effect of external acoustic forcing on impinging jet atomisation used in liquid rocket combustors

Due to the simple design, better atomisation and mixing characteristics, the impinging jet configuration has been a preferred injection system for storable liquid propellant rocket engines. The major problem associated with liquid propellant rocket engines using the impinging jet injector configuration is combustion instability. Acoustic oscillations in the combustion chamber affects the process atomisation leading to oscillatory sheet breakup and spray formation. This further causes unsteady heat release favorable for sustaining the combustion instability. Therefore, understanding the effect of acoustic field on the liquid sheet atomisation is essential for effectively controlling instabilities.

Experiments are being carried out to study the liquid sheet atomisation process in the presence of controlled external acoustic field. The effects of acoustic frequency and sound pressure level on sheet characteristics are studied using high speed imaging technique.

Outcomes

- External acoustic excitations changed the smooth sheet to violently flapping sheet resulting in the reduction in sheet breakup length and sheet width.
- Amplified waves due to external oscillations leads to the formation of droplet clusters, which lead to sharp and unsteady heat release pattern.
- Existence of coherence between the external excitation frequency and frequency of amplified waves on the surface of liquid sheet is observed.

Figure A

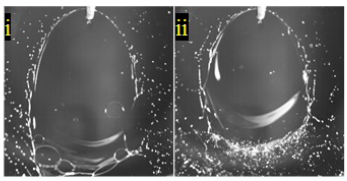

Figure B

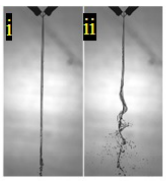

Figure C

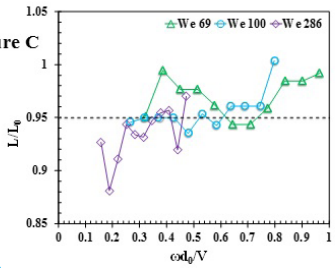

Figure D

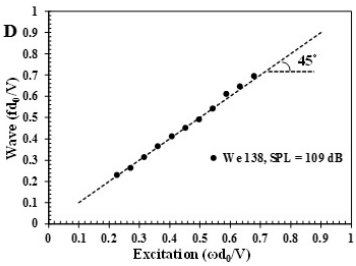

Fig. A: shows high speed front view photograph of liquid sheet without (Fig.A.i) and with (Fig. A.ii) acoustic oscillation. Weber number 286, excitation frequency 100 Hz, sound pressure level 106 dB.

Fig. B: shows high speed shadowgraphic side view of surface waves on liquid sheet with (Fig. B.ii) and without (Fig. B.ii) acoustic oscillation. Weber number 138, excitation frequency 100 Hz, sound pressure level 106 dB.

Fig. C: shows effect of excitation frequency on glycerol-water sheet breakup length for different flow conditions, sound pressure level 109 dB. L and L_0 are the sheet breakup length with and without excitation, ω=2πfe, fe-excitation frequency, V-jet velocity and d_0–jet diameter.

Fig. D: shows the effect of excitation on the frequency of surface waves formed on the sheet.

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