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Research Fields: Microgravity Science

Research Categories: Phase 1B Research

Research Theme: Effects of fluctuation on droplet combustion in high-pressure surroundings

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Summary of Research:

Combustion fluctuation due to acoustic disturbances is a possible cause of oscillation in combustors of engines and boilers. The project experimentally clarifies the mechanism of the coupling between acoustic field and combustion and to quantify the influence. A simple model using droplet combustion in standing wave replaces the diffusion combustion of liquid fuels in intense acoustic fields that destroy combustors.

Two following coupling mechanisms are considered and experimentally examined.

2. Rapid combustion due to evaporation instability near critical pressure

An n-decane droplet of 1.5 mm in diameter was combusted under sound pressure level of up to 150 dB in a high-pressure chamber (see Fig. 1). Microgravity were employed to accurately determine the combustion promotion by the convection, getting rid of natural convection. These were done with the drop shaft of MGLAB.

The outcomes are as follows:

1-1 Thermo-acoustic streaming occurs
1-2 The convection is driven by acoustic radiation force due to density difference.
1-3 Similarity exists between the convection and natural convection.
1-4 The convection promotes droplet combustion. It can be quantified introducing a newly defined "acoustic Grashof number". Based on theoretical analysis and the present data (see Fig. 3), the excess burning rate can be calculated for various ambient pressure, SPL, frequency, droplet diameter and droplet position.

2-1 Combustion instability was not observed near critical pressure. Experiments cannot
reproduce theoretical assumption of quiescence. We always observed the streaming. 

\[ Gr_a = \frac{(\rho_e - \rho_i) D^4 g_a}{\rho v^2} \]

Fig. 1  Experimental apparatus

Fig. 2  Flames blown by thermo-acoustic streaming (Pa = 0.5 MPa, f = 900 Hz)

Fig. 3  Gr\_dependence of combustion promotion (excess burning rate $Gr_0 = 0.5$ or $0.25$)

9.  Publication List


10.  URL non