1. Title

2. Research Term
FY2002-2003

3. Research Fields
Microgravity Science

4. Research Categories
Germinating Research

5. Research Theme
Development of a Multipurpose Homogeneous Spray Burner for Microgravity Experiments and Study on the Flame Structure of Partially-Vaporized Spray

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8. Summary of Research
Combustion of partially-premixed fuel sprays was studied experimentally. Flames stabilized in a mono-sized and monodispersed spray stream were employed as a simple model of partially-premixed spray flame. A homogeneous spray burner was newly developed in this work, and experiments of spray generation and combustion were done. Homogeneous spray was generated by the condensation method using rapid pressure reduction of saturated fuel vapor-air mixtures. Microgravity experiments were performed for large droplet sprays because large droplets fall down during spray generation process at normal gravity.

Figure 1 shows the newly-developed spray burner. A coaxial flow nozzle burner was applied to obtain uniform flow velocity distribution in a spray stream. The spray burner consists of a rapid expansion chamber, a piston, a nozzle and a lid. The stagnation plate was inserted in the spray stream to stabilize a flame. The inner diameter of rapid expansion chamber is 80 mm and height is 80 mm. The nozzle exit is 8 mm in diameter. The piston pushed out the homogeneous spray after rapid pressure reduction of a saturated fuel vapor-air mixture. Flow velocity was controlled by changing piston speed. Sauter mean droplet diameter was used as a mean droplet diameter of a homogeneous spray and measured by LDSA (Laser Droplet Size Analyzer, Tohnichi computer applications Co., Ltd.). Droplet spatial distribution was observed by the laser sheet method. In order to observe flame behaviors, direct images of the flame were taken by a
color CCD camera (exposure time: 1/30 s, frame speed: 30 fps).

Spatially-uniform laminar spray streams were generated successfully. The mean droplet diameter was almost constant during run. The width of mean droplet diameter distribution was narrow. The spray characteristics of total equivalence ratio $\phi_t$, liquid equivalence ratio $\psi_l$ and mean droplet diameter $d_m$ were controlled successfully. Flames were observed under normal and microgravity conditions with varying the spray characteristics of $\phi_t$, $\psi_l$, $d_m$ and the flow velocity at the nozzle-exit. The summary of the results is as follows.

1. The mean droplet diameter was able to be varied within the range of 3-120 $\mu$m.
2. Microgravity conditions are necessary for the generation of spray streams of large mean droplet diameter because large droplets fall down during spray generation process by gravity.
3. Mean droplet diameter of spray stream was stable under normal and microgravity conditions.
4. A flat flame was realized successfully in the laminar spray stream with the stagnation plate. The appearance of the spray flame of $\phi_t = 0.9$ was similar to that of the fuel-rich premixed flame.
5. In the case of stretched flow field, the burning velocity of the spray flame of $\psi_l = 0.3$ and $d_m = 3 \mu$m exceeds that of the premixed flame on the fuel-lean side, and the inequality is reversed on the fuel-rich side.
6. In the stretched flow field of $\phi_t = 0.9$, the burning velocity of spray flame increases as the liquid equivalence ratio increases as shown in Fig. 2.
7. Flashback of the spray stream of $\psi_l = 0.3$ and $d_m = 3 \mu$m occurs at larger nozzle-exit flow velocities than that of the premixture of the same total equivalence ratio.
8. In the case of $d_m = 7.5 \mu$m, the dark zone between the flame and fuel droplets was observed from the laser sheet images. A sample was shown in Fig. 3. This result suggests that sprays of $d_m < 7.5 \mu$m evaporate almost completely in the preheat zone.

9. Publication List

10. URL
N/A