Descending motion of vortex associated with candle flame oscillation: Convective flow visualization, motion enhancement, and velocimetry

Hiroyuki Zuiki[1], Koki Otaka[1], Yuko Nagamine[1], Hidetoshi Miike[2], and Atsushi Osa[1]
[1] Graduate School of Science and Engineering, Yamaguchi University, Yamaguchi, Japan
[2] Organization for Research Initiatives, Yamaguchi University, Yamaguchi, Japan

As one of the simple systems of a nonlinear oscillator, the oscillatory combustion of a set of candles was found by Ishida and Harada [1]. Recently, Kitahata et al. [2] reported that two candle oscillators can couple with each other, resulting in both in-phase and antiphase synchronization depending on the distance between the two candles. In the report, the proposed model indicates that the oscillatory combustion is induced by a lack of oxygen around the burning point. They also suggested that thermal radiation can be an essential factor of the synchronization. However, they did not discuss a possible contribution of turbulent coupling in convective flows associated with candle flame oscillations.

In this report, we investigated the turbulent coupling effect to realize the synchronization of candle flame oscillation by measuring the convective flow above the candle flame. We introduced several flow visualization methods such as Mach-Zehnder interferometer, thermograph (thermal vision), and shadowgraph. We also developed an image sequence processing method to realize the motion enhancement based on human visual function of the motion sharpening [3]. The contrast enhanced image sequence was analyzed by the spatial filtering velocimetry. We found a descending motion of vortex associated with candle flame oscillation. We recognized that the interaction between two vortices can be a key mechanism to realize the synchronization between two candle flame oscillators.

We also carried out comparison of velocities between convection induced by candle flame oscillator and upward current of steam from a hot water surface [4]. Curious results of several velocity peaks having very high speed (0.4 m/s and 1.2 m/s) were observed in the convective flow induced by the candle flame oscillation. We will discuss the details of the velocity peaks and its mechanistic explanation in the conference.

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