Paper ID: 68885
student

IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

Author: Ms. Wonjeong Hyun
Konkuk University, Korea, Republic of

Prof. Changjin Lee
Konkuk University, Korea, Republic of

IGNITION DELAY AND THERMOACOUSTIC COUPLING IN HYBRID ROCKET COMBUSTION

Abstract

Hybrid rocket engines (HRE) require the installation of a post-chamber to induce additional combustion of unburned fuel that may be expelled without participating in combustion. And many studies confirmed that the additional mixing and combustion of unburned fuel in the post chamber substantially improves the combustion efficiency. Nonetheless, the post chamber seems to be a possible source of generating LFI (Low frequency Instability) by providing the favorable environment for thermoacoustic coupling between pressure (p') and heat release (q') fluctuations. Examining previous experimental studies (PMMA/GOX), it was observed that p' and q' were coupled 15 to 18 times per second while the LFI persists. In this study, combustion visualization was performed to analyze the local behavior of additional combustion flow in the post chamber. In the visualization images (with LFI), it is observed that combustion flow bounces back toward the main chamber after colliding with the nozzle wall. The bounced back flow then again collides with the incoming flow creating a counter flow near the center of the post chamber. It is noteworthy that the additional combustion in the post chamber does not occur simultaneously at the collision on the nozzle wall. At this time, it is observed that some ignition delay and re-ignition occur in the counter flow region. Interestingly, these ignition delay and re-ignition phenomena are discontinuous and have a periodic cycle (15 18 Hz). Meanwhile, Culick et al. proposed a mathematical model for the occurrence of thermoacoustic instability using vortex impinging on chamber walls in a cavity-shaped premixed combustor. Their model suggests that each time a premixed reactant trapped in a separate vortex collides with the cavity wall, a periodically discontinuous "energy kick" occurs, leading to combustion instability. Since there are significant similarities between the kicked oscillator model and post chamber combustion in hybrid rocket, one of the possible scenarios can be energy kicking by vortex collision on the wall in the post chamber. Therefore, the main purpose of this study is to investigate under what conditions the vortex collision develops into energy kicking. For this, combustion in the post chamber was visualized using high speed camera to understand the effect of wall impingement of the shedding vortex on the formation of positive coupling of p' and q' and the occurrence of the LFI. Also, by modifying the energy kicking model to include ignition delay observed in the experiments, the occurrence of low-frequency thermoacoustic coupling will be investigated.